CANADA
DEPARTMENT OF MINES
HON. W. A. GORDON, MINISTER; CHARLES CAMSELL, DEPUTY MINISTER

BUREAU OF ECONOMIC GEOLOGY
GEOLOGICAL SURVEY

MEMOIR 183

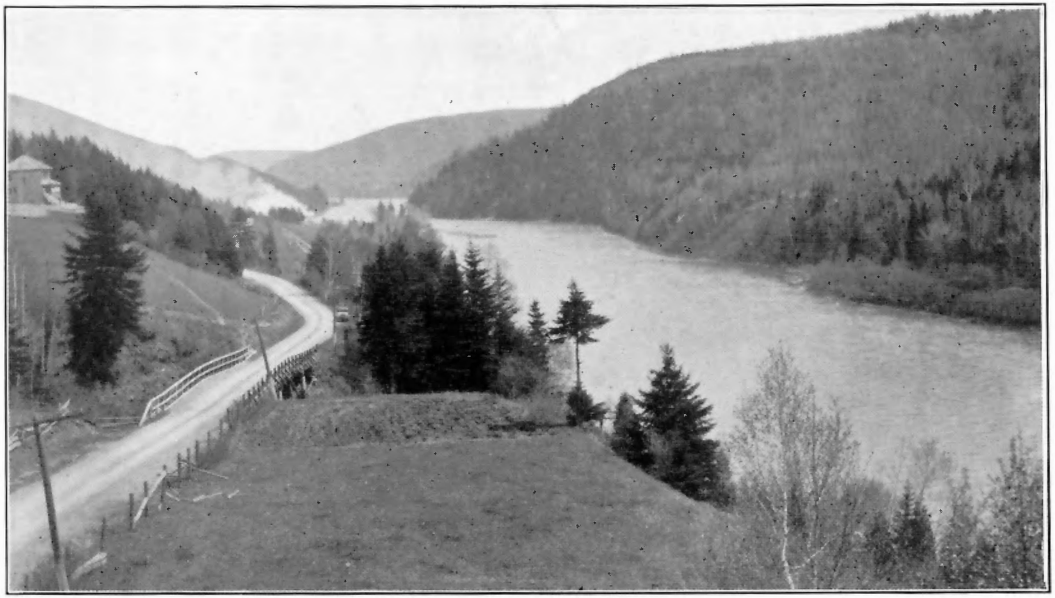
Geology of Chaleur Bay Region

BY

F. J. Alcock

OTTAWA
J. O. PATENAUDE, I.S.O.
PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
1935

Price, 50 cents No. 2398



72507 The lower part of Matapedia valley.

CANADA
DEPARTMENT OF MINES
HON. W. A. GORDON, MINISTER; CHARLES CAMSELL, DEPUTY MINISTER

BUREAU OF ECONOMIC GEOLOGY
GEOLOGICAL SURVEY

MEMOIR 183

Geology of Chaleur Bay Region

BY
F. J. Alcock

OTTAWA
J. O. PATENAUDE, I.S.O.
PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
1935

Price, 50 cents No. 2398

CONTENTS

Illustrations

Illustrations—*Concluded*

Geology of Chaleur Bay Region

CHAPTER I

INTRODUCTION

GENERAL STATEMENT

Chaleur bay and the lower part of its main tributary, Restigouche river, form the eastern part of the boundary between the province of New Brunswick on the south and Gaspe peninsula of the province of Quebec on the north. Geologically, the surrounding region is of interest on account of the rock sections that are exposed along the shores of the bay and the rivers that flow into it. Northern New Brunswick and southern Gaspe form a geological unit the key to whose history is furnished by these sections. For this reason the geology of Chaleur bay and of the Restigouche and Matapedia valleys has been studied in considerable detail and it has been deemed advisable to assemble the information in a single volume.

PREVIOUS WORK

In 1842 the Restigouche and Chaleur Bay region to the west of Bathurst was explored geologically by Abraham Gesner, provincial geologist of New Brunswick. In 1843 and 1844 William E. Logan, founder of the Geological Survey, Canada, undertook the examination of the rocks of Gaspe peninsula. His work was continued by Murray, Richardson, Bell, Low, and Ells in the period up to 1880. The surface geology of the region was studied and mapped by Robert Chalmers between the years 1874 and 1886. In 1865 the Government of New Brunswick published the results of geological explorations undertaken by Professor H. Y. Hind. In 1900 John M. Clarke of the New York State museum became interested in the geology of Gaspe and the Chaleur Bay region and for many years he made almost annual visits. His publications include descriptions of the geology, palæontology, geography, history, and local colour of the region. G. A. Young in 1908 and 1909 mapped topographically and geologically an area in the vicinity of Bathurst. In 1918 and 1919 A. P. Coleman studied the physiography and glacial geology of Gaspe peninsula.

RECENT FIELD WORK

In 1923 Miss J. Doris Dart, under the supervision of Professor Charles Schuchert, studied the stratigraphy and faunas of the Silurian rocks at Port Daniel, and in the following summer Professor Schuchert continued field work at Port Daniel and Black Cape. S. A. Northrop, another pupil of Professor Schuchert, in 1927 carried out further work at these two localities and in 1928 mapped the intervening belt of country for the Geological Survey. In 1924 W. V. Howard studied the Lower Devonian rocks in the vicinity of Dalhousie, New Brunswick, and in 1925 mapped geologically the remainder of the Escuminac map-area. In connexion with this work E. M. Kindle, in 1925, carried out stratigraphic studies and in 1928 and 1929 continued geological investigations of coastal sections of Gaspe, in particular supervising the work of C. H. Kindle who was charged with the geological mapping of a belt of coast from Port Daniel east to Gaspe bay. In 1929 and 1930 G. W. Crickmay studied the rocks of Matapedia valley.

The writer began field work in Gaspe in 1921 with the investigation of the geology of the zinc and lead field of Lemieux township in the central part of the peninsula. Geological mapping in the same field was continued in 1923 and 1924, resulting in the publication of the Mount Albert map and memoir. In 1924 other areas of geological interest in Gaspe were also investigated. In 1927 a more detailed map was prepared of a section of the Lemieux township zinc-lead field, including the more important mineral properties. In 1928 the writer supervised the field work of S. A. Northrop and of C. H. Kindle for part of the season and commenced the areal mapping of the Belledune and Charlo sheets on the south side of the bay. In 1929, 1930, and 1931 mapping on both sides of Chaleur bay and Restigouche river was continued, considerable attention also being given to checking and correlating the work that had already been done in various areas throughout the region.

Surveys were also made by the topographical division of the Geological Survey. H. N. Spence in 1926 and 1927 surveyed the Escuminac area and in 1929 carried out control surveys for the Charlo and Belledune sheets and part of the Bathurst sheet. In 1930 J. V. Butterworth surveyed the Campbellton map-area.

ACKNOWLEDGMENTS

In 1928 the writer was assisted in the field by S. A. Northrop and H. Johnson; in 1929 by G. W. Crickmay, H. Johnson, R. O. Monahan, L. C. Robinson, and J. S. Murray; in 1930 by H. Johnson, L. C. Robinson, C. S. Longley, and R. C. Hart; in 1931 by C. H. Kindle and R. C. Hart.

The writer is under obligation to officers of the International Power and Paper Company of New Brunswick for copies of their surveys of sections of the company's limits and to many other people of the region for courtesies extended to him.

73511 A. Looking north across Restigouche valley to Gaspe plateau.

B. Looking east along Restigouche valley at Matapedia, Que.

CHAPTER II

GENERAL CHARACTER OF THE REGION

TOPOGRAPHY

The main topographic feature of the region is the great depression occupied by Chaleur bay and the lower Restigouche. As will be shown later a synclinal trough existed here in late Devonian time and in the Pennsylvanian period a depression occupied much the same site as the one today. This depression forms the boundary between what are commonly called the Appalachian and Acadian regions of eastern Canada.

Chaleur bay from the mouth of Restigouche river to its eastern limit, a line from Macquereau point in Gaspe to point Mya on Miscou island, has a length of 80 miles. Its greatest width is 25 miles and its average about 15 miles. Its greatest depth is between 40 and 50 fathoms. It has a fairly regular outline, the main indentations being Cascapedia bay on the north and Nipisiguit and Caraquette bays on the south. The western limit of the bay is marked by Maguasha point in Gaspe and cape Bon Ami near Dalhousie where the depression narrows abruptly. This contraction is due to geological control, the belts of hard volcanic rocks that determine the width of the depression along the lower part of the Restigouche ending at this point.

South of Chaleur bay the country is of low relief, rising gently from the coast. Looking southward from the Gaspe coast, or from an elevation such as Tracadigash mountain at Carleton, the New Brunswick skyline presents an almost straight-edge regularity. In the region underlain by flat-lying Carboniferous rocks, east of Nipisiguit river, the relief is particularly low. East of Janeville, cliffs bordering the shore have a height up to 130 feet and back from the cliffs the country is a low plain with an elevation of less than 250 feet. Miscou and Shippigan islands rise less than 50 feet above the sea. To the southeast of Bathurst the Carboniferous belt reaches an elevation of 500 feet 12 miles from the coast.

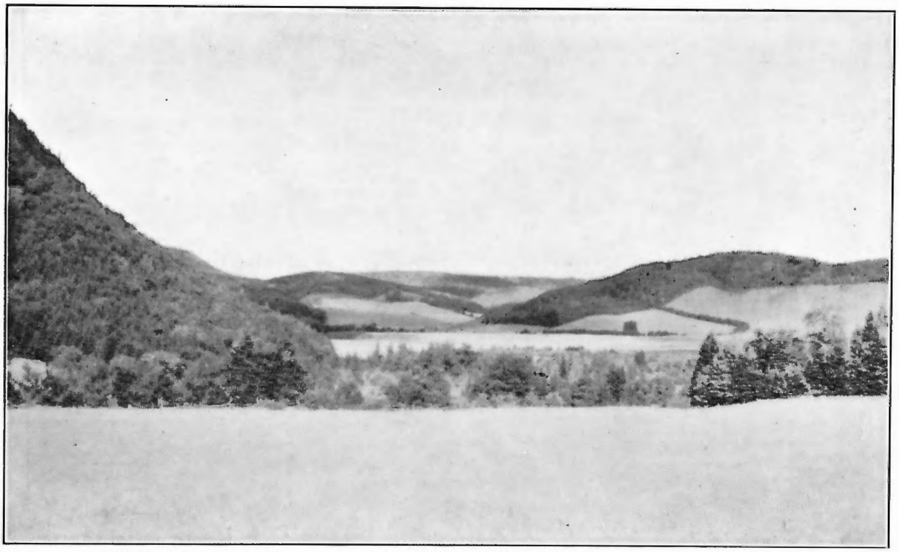
From Bathurst west of Dalhousie the region is also of low relief, but its surface shows considerably more irregularity than that of the Carboniferous area mentioned. This is chiefly due to the fact that it is developed on rocks of varying degrees of hardness. The shore of this section is bordered by beaches with local stretches of low cliffs and from it the surface rises gently southwestward until at a distance of 8 to 10 miles from the coast its elevation ranges from 600 to 800 feet. The highest point of this coastal belt is Blue mountain, composed of hard volcanic rock lying between the headwaters of Jacquet and Benjamin rivers, 12 miles as the crow flies from the coast. From the lookout tower on the summit, 1,600 feet above the sea, the country in all directions appears as one of low relief, being made up of irregularly shaped ridges separated by deep valleys. The highest land is to the southwest where the interior highlands of New Brunswick some 40 miles away reach elevations up to 2,689 feet.

The lower part of Restigouche river is bordered by hills that rise steeply to elevations around 900 feet. This region is underlain by a belt of rocks consisting of resistant volcanic necks and flows and more easily eroded tuffs, breccias, and interbedded sediments. Sugarloaf mountain at Campbellton has an elevation of 929 feet and Mann mountain, one of the highest summits north of the river, has a height of 1,567 feet. Both to the north and to the south of this volcanic belt is a plateau developed on sedimentary rocks. In Gaspe its surface rises gently to the north. On the New Brunswick side the plateau has an elevation around 1,000 feet. Rising above it are a few hills and ridges where resistant masses of intrusive igneous rock cut through the sediments. Squaw cap, 10 miles southwest of Tide Head, is a sharp peak with an elevation of 1,585 feet, and Slate mountain, an adjacent ridge also composed of intrusive rock, rises to a height of over 1,300 feet.

Along the north side of Chaleur bay there is a greater difference of relief than along the New Brunswick coast. Much of the Gaspe side of the bay is bordered by a belt of little disturbed Carboniferous sediments, back of which there is a rise to the plateau surface developed on the older rocks. This is strikingly shown along the west side of Cascapedia bay where hills composed of volcanic rocks and hard sediments rise abruptly from the coastal border developed on the softer Carboniferous strata. Tracadigash mountain at Carleton has an elevation of 1,830 feet and from the New Brunswick side this section of the Gaspe coast appears quite mountainous. From the top of Tracadigash and other summits the whole Gaspe region appears as one of low ridges and broad flat areas separated by valleys, with here and there a peak rising slightly above the general level.

A striking feature of the region is that the valleys are comparatively deeply incised. The valley sides are steep and there is commonly a rather abrupt change from their slopes to the flat tops of the interfluvial areas. Some of the streams flow through gorges. The Tetagouche and the south Charlo of New Brunswick and the Hall river of Gaspe are examples of streams occupying canyons with precipitous walls of rock. The streams are uniformly swift with local rapids and falls where some hard bed or belt of rock crosses the valley. Along the lower parts of most of the streams outcrops are numerous. The small headwater streams commonly show a type of topography quite different from that of the deep valleys farther down. They have a gentle gradient and flow through broad, gentle valleys in which outcrops are few or absent and in which alder swamps, ponds, and even lakes are encountered. Many of the small tributaries show an abrupt "fall zone" where the gently flowing stream becomes a succession of falls and rapids before it joins the lower main stream.

The lower parts of some of the larger streams show terraces developed in the unconsolidated material of the valley bottoms. A very striking terrace is seen in the lower Nouvelle valley at an elevation of 100 feet and a similar one at about the same elevation borders the Cascapedia and other valleys. Other terraces occur at lower levels. On Grants brook and Nigadu river, terraces are reported by Young at elevations up to 350 feet. On Matapedia river terraces occur at elevations up to 500 feet.



73505

A. Terraced farming land along the lower part of Little river, Gaspe.

B. Looking south from the summit of Tracadigash mountain, Carleton, Que., showing the cuspate bars, Heron island and the New Brunswick mainland in the background.

The Chaleur Bay coast presents a considerable variety of shore features. Sand and gravel beaches are almost continuous, the most striking being at places where glacial material or easily eroded rocks form the bordering coast. In places the beaches are narrow zones in front of cliffs and it is impossible to pass certain parts of these at times of high tide. Other beaches form broad zones bordering a gently sloping coast. Sand embankments built by longshore currents across the mouths of subsidiary bays are common. They take the form of spits, baymouth bars, and cuspate bars. Good examples of spits are to be seen at Caron and Alston points, Bathurst, at the mouths of Nigadu and Jacquet rivers, and on the Gaspe coast near St. Omer and at the end of Maguasha peninsula. Baymouth bars, or embayments extending across a bay, completely enclosing it except for a small tidal inlet, are very characteristic features. In Chaleur Bay region the lagoon back of such bars is known as the "barachois" and the tidal inlet is called the "tickle." At the mouth of Eel river a bar a mile long carries the main coast highway. Along the west side of Nipisiguit bay a bar over 2 miles long forms the lagoon into which Grants brook and Millstream river empty. On the Gaspe side baymouth bars are to be seen at the mouth of Harrison brook, at Maria where Glenburnie brook enters Chaleur bay, at the mouth of Bonaventure river, and at the mouth of Nouvelle river near St. Godfroi. Cuspate bars are developed at Paspebiac, Carleton, and New Carlisle on the Gaspe coast and at Belledune point and at Belledune lighthouse in New Brunswick. At Paspebiac the bar has been formed by a spit which, advancing from the east, curves back towards the mainland enclosing a triangular barachois with a base about a mile long. At Carleton two spits have grown out from the shore towards each other, a narrow tickle separating them. The southward extending spit, which is about $1\frac{1}{4}$ miles long and which was built by outgoing currents, has reached its limit of length. The other spit, which has about the same length, extends slightly south of west and overlaps the former. The cuspate bar at New Carlisle is formed by two spits of nearly equal length. Those at Belledune point and at Belledune lighthouse are both triangular, with bases each about three-quarters of a mile long, and both enclose lagoons whose outlets are to the west by small streams.

POPULATION AND INDUSTRIES

The majority of the people of Chaleur Bay region are of French origin and speak the French language. The proportion of French on the Gaspe side is greater than on the New Brunswick side. There are, however, important English-speaking settlements at New Carlisle and Port Daniel West and smaller groups at other places along the Gaspe coast. In some places originally settled by English-speaking people the English language has been largely replaced by French. On the New Brunswick side in the larger centres such as Campbellton and Bathurst, English is the chief language; in the rural parts French predominates. Reservations for the remnant of the Indian population are located at Cross point and near the mouth of Cascapedia river.

Agriculture is carried on along both sides of the bay. In Gaspe the farming belt is locally only a narrow strip along the coast. North of

Cascapedia bay, into which empty the Grand and Little Cascapedia rivers, and eastward to Port Daniel there is a broader belt of farming country extending 5 to 10 miles back from the coast. Settlements extend up some of the other valleys, for instance the Bonaventure, Nouvelle, and Scauminac, and in a few places, such as along the Kempt road north of Broadlands and at Louis Mountain settlement north of St. Omer, agriculture is carried on to a limited extent on the plateau summit. On the New Brunswick side farming country extends 5 to 10 miles back from the coast, the more important section being along the main highway following the coast.

The lumber and pulp industry forms one of the main activities of the region. At Dalhousie, Campbellton, and Bathurst are large mills which derive their pulpwood from either side of the bay. There are also small lumber mills at the mouths of many streams that enter the bay and small temporary mills have been active at many places inland.

Fishing and lobster-trapping are important industries. Cod, salmon, mackerel, and smelts are all important catches. The larger streams are noted for their salmon and many are leased for fly-fishing.

The care of the tourists who in increasing numbers each year go to summer places on either side of the bay, the assistance required by the salmon and trout fishermen and the moose and deer hunters, some local rock quarrying, a certain amount of fox and mink farming, and the canning of lobster meat and salmon are other activities of the region.

CHAPTER III

GENERAL GEOLOGY

The consolidated rocks of Chaleur Bay region are chiefly and perhaps entirely of Palæozoic age. Those that have been dated by fossils range in age from Upper Cambrian to Pennsylvanian. The largest belt of Pennsylvanian rocks lies east of Nipisiguit river and forms part of a much larger region underlain by similar strata and comprising much of the eastern half of New Brunswick. This belt is of low relief, and the beds are for the most part marked by flat or low dips. They overlie unconformably the pre-Carboniferous sediments and volcanics and in places they rest on weathered granite which intrudes these older rocks. Along Chaleur bay are patches of another Carboniferous formation called the Bonaventure, believed to be of early Pennsylvanian age. Its base is exposed at a number of localities where it rests unconformably on the pre-Carboniferous complex. Though nearly everywhere undisturbed it is tilted at several places and at one place is intruded by a basic dyke.

Along the shore of Scauminac bay, Upper Devonian strata, only slightly disturbed, rest unconformably below Bonaventure beds. Middle Devonian sandstone and conglomerate beds in places border both sides of the lower part of the Restigouche and locally they have dips up to 90 degrees.

Lower Devonian and Silurian rocks cover considerable areas. They consist of limestone and clastic beds and with the sediments of both series, particularly the former, there are interbedded volcanic rocks. The strata are folded and extensively broken by faults and the working out of detailed structure even where the outcrops are abundant is, as a result, most difficult. The Lower Devonian beds are separated from those of the Silurian by an erosional unconformity. The granitic rocks of the region intrude all the strata up to and including those of the Lower Devonian.

Ordovician rocks cover extensive areas and, though fossils are scarce in them, it is known that more than one division of the Ordovician is represented. Middle Ordovician graptolites have been found in Port Daniel and Bathurst regions and local beds in a complex along Matapedia river carry a fauna of Upper Ordovician age. Beds similar to the latter, and carrying local fossiliferous zones, cover considerable areas of southern Gaspe and northern New Brunswick. For the most part they are considerably more highly deformed than the Silurian and Lower Devonian rocks and much of them shows a well-developed cleavage. Volcanic rocks are associated with the Middle Ordovician strata in Bathurst region.

Upper Cambrian rocks are known in a small area near Percé. A group, the Macquereau, which appears to be still older, outcrops in the region between Port Daniel and Chandler on the Gaspe coast. It underlies unconformably Middle Ordovician rocks and is cut by serpentine and granite, neither of which penetrates the adjacent Ordovician beds. The sediments are chiefly altered quartzites and their age in the absence of fossils is inferred to be either Cambrian or Precambrian.

The most abundant rock exposures are to be found along the coast and the streams. Over much of the inland region there is a mantle of unconsolidated material consisting of weathered rock, glacial drift, and stratified gravels, sands, and clays, locally carrying marine shells.

Table of Formations

Cenozoic	Quaternary	Recent	Alluvium Marine clays
		Pleistocene	Stratified gravels Glacial drift
Mesozoic (?)	Triassic (?)		Basic dykes
Palæozoic	Carboniferous	Pennsylvanian	Clifton formation Bathurst formation Cannes de Roche formation Bonaventure formation
	Devonian	Upper Devonian	Escuminac formation Fleurant formation Pirate Cove formation
		Middle Devonian	Malbaie formation Gaspe sandstone Heppel formation
			Granitic intrusives
		Lower Devonian	Murailles formation Causapscal formation Mont Joli formation Dalhousie formation
	Silurian	Niagaran	Indian Point formation West Point formation Bouleaux formation Gascons formation La Vieille formation Clemville formation
	Ordovician	Upper Ordovician	Matapedia group White Head and Pabos formations
		Middle Ordovician	Tetagouche series Mictaw series
	Cambrian	Upper Cambrian	Murphy Creek formation
Precambrian (?)	or Cambrian (?)		Granite, pegmatite Serpentine, amphibolite Macquereau group

DESCRIPTION OF FORMATIONS

Macquereau Group

Distribution. The Macquereau group extends along the Gaspe coast for some 15 miles from a point near the railway water tower east of Gascons, where it is overlain by Silurian strata to a point east of Chandler and disappears under rocks of the Bonaventure formation. North of Port Daniel, the Mictaw beds of Middle Ordovician age overlap the group, the contact between the two following closely the north branch of Port Daniel river and at several places crossing it. To the north the rocks disappear under Silurian strata. Altogether the Macquereau group outcrops over an area of some 125 square miles. This region, as a whole, is uneven, hummocky country, with abundant exposures and with only local areas suitable for agriculture. Lakes and swamps are numerous in the depressions.

Lithology. The group consists of altered quartzose sediments and minor amounts of volcanic rocks. These rocks are cut by serpentine, amphibolite, granite, pegmatite, and quartz veins. The sediments can readily be distinguished from those of the younger formations by their more metamorphosed appearance. The chief variety is a hard arkose-quartzite, consisting chiefly of quartz fragments but usually also containing considerable orthoclase and plagioclase. Fragments of reddish feldspar can be seen in some hand specimens. Locally the rock is conglomeratic, the most abundant variety of pebbles being quartz, but granite, granite-gneiss, greenstone, and schist pebbles also occur, as for example in a belt intruded by serpentine in the upper North Port Daniel River region. There are all gradations from these conglomeratic quartzose rocks to hard, dense quartzose argillites, and from massive types to schistose micaceous and chloritic varieties. Slates, too, are common and red and green shales may be seen on the main highway a quarter of a mile west of Anse aux Canards river and also on the west side of Grand Pabos bay. East of Chandler are schists with ferruginous bands from ½ to 1 inch thick and arenaceous beds in which are scattered fragments of red argillite and hematite. Some of the irregular, red fragments appear to represent disrupted argillitic interbeds, but others appear to be true pebbles. Limestone also occurs locally in the group. On North Port Daniel river, about 2½ miles north of the Club House, a zone of buff-weathering carbonate rock outcrops on the left bank of the river. The rock is hard, siliceous, and contains carbonaceous matter.

In thin section the quartz of all the rock types is broken, veined, and shows undulatory extinction. It also shows evidence of recrystallization, the majority of the boundaries between individual crystals being sharp, irregular, and mutually interpenetrating. Another common feature is the presence of finely crushed material around quartz and feldspar fragments. In many sections there is considerable secondary sericite and also chlorite.

Dense, dark green to black igneous rocks are locally associated with the sediments. Examples may be seen in a railway cut at Newport, and on a road back of Chandler about one-quarter of a mile north of the geodetic monument. A thin section of a specimen from the latter locality shows the rock to be an andesite consisting of a glassy matrix in which are a few crystals of striated feldspar, and a felt of feldspar laths. The rock appears to be a surface flow rather than a dyke or sill.

Associated with serpentine bodies intruding the sediments in Weir township are hornblende-bearing rocks which in places, at least, appear to be altered Macquereau sediments. They occur chiefly along the borders of the serpentine intrusions, and are black, massive rocks. Some are composed largely of hornblende and others are hornblende schists consisting of hornblende and quartz. In places there appears to be a gradation from the ordinary quartzose sediments to hornblende schists, as if the former had been altered by the injection of basic igneous material. In thin section the hornblende is seen to consist of two varieties, a pale type, which is clearly secondary, and a darker green type which is probably primary. Considerable quantities of chlorite, epidote, and plagioclase are present, and in the hornblende schist varieties quartz is abundant. Small stringers of carbonate or serpentine and carbonate are locally present.

Age. The Macquereau group lies unconformably below the Mictaw series which, as will be shown later, is of Middle Ordovician, probably Upper Trenton age. At the contact of the Mictaw and Macquereau on North Port Daniel river, about 3 miles above the Club House, are outcrops of a coarse conglomerate whose boulders are practically entirely Macquereau rocks. A similar conglomerate is exposed at the contact of the two assemblages on Lake à l'Appelle brook. These are regarded as the basal beds of the Mictaw. The boulders are rounded and consist of hard, metamorphosed rocks identical with the Macquereau as they are exposed in place today. Evidently the Macquereau beds were altered to their present condition in pre-Mictaw times.

The evidence of the intrusives points to the same conclusion. The Mictaw rocks are locally cut by fresh, dark, massive dykes probably of Devonian age. They are not, however, cut by the serpentine, the muscovite granite, or the numerous quartz veins, all of which traverse the Macquereau sediments immediately adjacent to the Mictaw beds. On the upper waters of North Port Daniel river, between the main mass of serpentine and the overlying Silurian strata to the north, there is a zone of conglomerate which on account of its similarity to the Mictaw conglomerate exposed farther down stream is believed to be also of that age. This conglomerate contains boulders of grey muscovite granite similar to that which cuts the Macquereau beds and the serpentine. It is concluded, therefore, that the granite is pre-Mictaw and all available evidence indicates that the serpentine is also pre-Mictaw. This means that in pre-Trenton times there was a revolution of considerable magnitude during which the Macquereau beds were folded, intruded by basic and later by acid intrusions, and altered, and were then subjected to erosion sufficient to uncover the intrusions.

The Macquereau sediments contain no fossils, so that the problem as to whether they are of Lower Ordovician, Cambrian, or Precambrian age must be attacked by using other lines of evidence. The only formation in southern Gaspe that has been definitely dated from fossil evidence as older than the Mictaw is the Murphy Creek formation which covers a limited area near Percé. This has furnished a fauna of Upper Cambrian age and consists of limestones and limy shales much fresher and less deformed than the Macquereau rocks. They were nowhere seen to be cut by serpentine, granite, or pegmatite. In fact, in the degree of deformation undergone, these Upper Cambrian rocks are much more like the Upper Ordovician sediments than the Macquereau. It would appear, therefore, that the Macquereau rocks are pre-Upper Cambrian.

The rocks of Gaspe that most nearly resemble the Macquereau lithologically form a belt that outcrops along the northeast side of lake Matapedia (Alcock, 1926a). These consist of arkose-quartzites with interbedded volcanics. Like the Macquereau beds they locally contain numerous pebbles and fragments of red argillite. They are locally sheared to schists and most of the rock types of the Macquereau can be duplicated. They overlie a thick series of shales, argillites, quartzite, etc., whose age may be Cambrian and underlie unconformably fossiliferous Silurian beds. A later visit in 1931 confirmed the conclusion that they cannot be Precambrian. In the midst of the arkose-quartzite belt, on the small point north of the island opposite Val Brillant, is a hard, white, dense quartzite with an interbedded conglomerate band. The latter consists of quartz, gneiss, limestone, and shale fragments in a sandy matrix. Two of the limestone boulders were found to contain fossil fragments. Etching of a fragment of one of these boulders revealed numerous fossil remains of microscopic size, but nothing determinable. That the boulder is of Palæozoic age, however, is certain. The formation must, therefore, be at least as young as Cambrian.

If the Macquereau rocks are to be correlated with this belt, and if their degree of metamorphism is sufficient evidence that they are older than the Upper Cambrian Murphy Creek formation, their age is narrowed down to the Lower or Middle Cambrian. This involves the conclusion that during the Cambrian there was a period of considerable deformation and also that the age of the intrusives is Cambrian.

Serpentine, Granite Dykes, Etc.

Serpentinized peridotite intrudes the Macquereau sediments in Weir township along the upper waters of North Port Daniel river. The largest mass, which has a length of about 1 mile and a greatest exposed width of about 1,000 feet, lies immediately south of the Silurian belt whose rocks rest unconformably on the Macquereau sediments and the intrusives. The strike of this intrusion is about east and west; a number of smaller masses have a similar orientation.

The rock forms buff-weathering hills. On the freshly broken surface it is dark green. In thin section it is seen to consist largely of serpentine traversed by small veins of chrysotile. Chlorite is present in considerable quantities and probably represents an alteration product of some pyroxene mineral. Secondary epidote and scattered grains of magnetite and chromite are also present.

As already mentioned, the serpentine intrusions commonly show a border of amphibolite, part of which, at least, appears to be a diffierentiate of the serpentine.

Several pits have been opened in the serpentine in the hopes of finding workable deposits of asbestos. Some fibre was found, but it is so short and its proportion to the rock so small that there seems to be little probability of any quantities of commercial importance being opened up.

Cutting the Macquereau, the hornblende schists, and the serpentine are dykes of granite. The largest crosses the western headwater branch of North Port Daniel river, extending in a northeast direction for approximately half a mile. Its greatest width is 300 feet and its average about 200 feet. Where it crosses the river it forms a fall and canyon. Several smaller granite dykes occur in this same general region. They cut across and contain inclusions of the sediments and hornblende schists and at the contact with the serpentine masses the latter are heavily sheared, whereas the granite is fresh and massive.

The granite is white to pinkish; though for the most part massive, it is locally gneissic. The largest dyke is coarse grained; the smaller are finer grained. Both in hand specimen and in thin section the granite is seen to be a muscovite variety. The constituent minerals are orthoclase, albite, quartz, and muscovite, orthoclase being the most abundant.

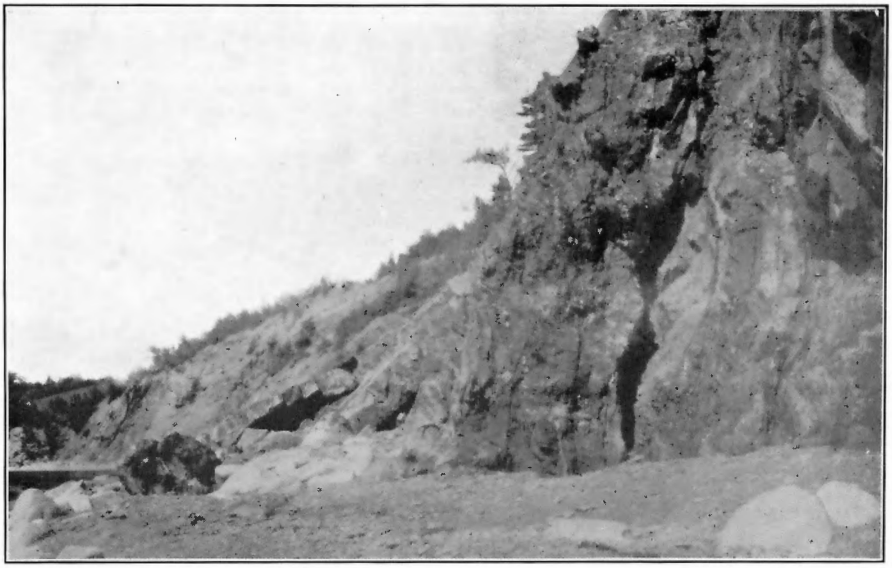
Pegmatite dykes cut the Macquereau at a number of places. Examples may be seen along the coast in the region of Macquereau point and at Gascons near the place where the rocks are overlaid unconformably by Silurian strata. The latter do not show any such dykes. The pegmatites consist dominantly of quartz with, however, considerable coarse, reddish orthoclase.

Quartz veins, apparently related to the granite intrusions, are numerous. In places they follow planes of bedding and schistosity; in others they cut across the rocks in an irregular manner. They range in size from small stringers to veins several feet in width.

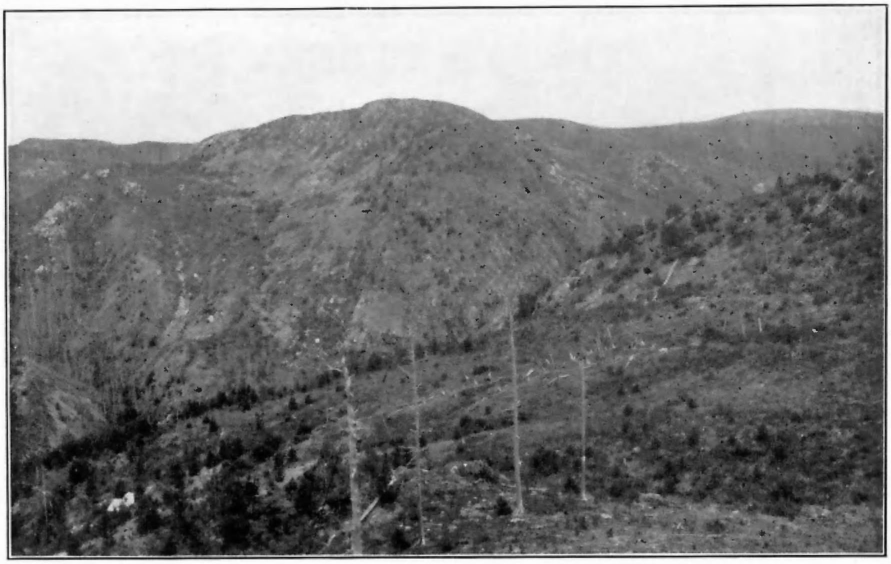
Pebbles of the granite occur in what is supposed to be the basal conglomerate of the Mictaw series. This series is of Middle Ordovician age. The Macquereau group, for reasons already given, is judged to be probably of Lower Cambrian age, and to have been deformed prior to the deposition of the Upper Cambrian Murphy Creek formation. The granite intrusion thus appears to have taken place in Middle Cambrian time and the basic invasion now represented by the serpentine at some earlier date.

Murphy Creek Formation

In 1929, C. H. Kindle collected a late Cambrian fauna from an outcrop on Murphy creek about 6 miles northwest of Percé. The writer visited this locality in 1931. It is readily reached by following the Lemieux highway from Percé to range IV south, Malbaie township, and then crossing the railway and descending to the brook. The outcrop extends along the strike of the rocks, and follows in the stream for about one mile. It consists of hard, grey limestone in beds up to over one inch in thickness, separated by ribboned, shaly limestone. The strata dip to the south at an angle of 65 degrees and are cut by numerous calcite veins and stringers. A conglomerate carrying some corals and brachiopods and representing the basal beds of the Upper Ordovician overlies the formation. It is best developed



A. Unconformity, Silurian strata (left) resting on vertical Macquereau beds (right).



B. The serpentine country at the headwaters of North Port Daniel river, Weir township.

in a ridge south of the highway 200 to 300 yards across the strike from the fossiliferous Cambrian exposures. The intervening space is probably occupied by the Cambrian beds.

The Cambrian fauna includes a graptelite, a sponge, a linguloid brachiopod, and about twenty species of trilobites of which many are small forms. This fauna appears to be of about the same age as that of the Marysville limestone of the southern Appalachians and the Eau Claire sandstone of Wisconsin.

MIDDLE ORDOVICIAN

Mictaw Series

Two areas in Chaleur Bay region are known from fossil evidence to be underlain by rocks of Middle Ordovician age. The first of these is in the neighbourhood of Port Daniel, Gaspe, where the beds have been termed the Mictaw series. The other lies some 50 miles to the southwest on the opposite side of the bay, in the district west of Bathurst. Here the rocks have been termed the Tetagouche series.

Distribution. The Mictaw series receives its name from Mictaw river, a branch of Middle Port Daniel river. Good exposures occur along the former and along the main branch of the latter for about 7 miles above its mouth. To the south and west the series is overlaid by Silurian strata. It extends northeastward to North Port Daniel river where it rests with a nearly vertical contact on the Macquereau group. The contact between the two assemblages closely follows this stream for some 7 miles. Altogether the Mictaw series is exposed over 25 square miles.

Lithology. On Middle Port Daniel river the main rock variety is a dark grey to black shale which breaks readily into small angular fragments. In certain zones where shearing has taken place the shales are altered to shining black material. The beds have very irregular strikes and dips and they lack distinctive horizons that might be used for zoning purposes. It is impossible, therefore, to determine the thickness of the series. The shales locally contain a fauna of graptolites and brachiopods. Logan records having collected graptolites here in 1843.

Associated with the black shales on Middle Port Daniel river are limestone beds and also some fine, conglomeratic layers. About a quarter of a mile below the mouth of Mictaw river a conglomerate zone with a thickness of 15 feet holds boulders up to 10 inches in diameter consisting of basic volcanics, quartz, green schist, and arkose. Rounded masses of pyrite as much as 2 inches in diameter occur in the conglomerate.

On North Port Daniel river outcrops of the Mictaw beds continue for 2 miles above the bridge and mill at the end of the motor road. Here the chief type of rock is a well-bedded, fine-grained arkose, showing an abundance of small, weathered fragments of feldspar and feldspathic rock. Interbedded with it is shale similar to that along Middle Port Daniel river, and also greenish sandstone. At a place where exploration work for coal has been carried out, black carbonaceous shale is associated with sandstone.

About 5 miles upstream from the above-mentioned bridge the river has cut a gorge through a coarse conglomerate along the contact between the typical Macquereau and Mictaw sediments. The conglomerate contains boulders up to 2 feet across, most of them consisting of Macquereau rocks, but some of quartz, granite, and reddish gneiss. The boulders are subangular and do not appear to have travelled far. The rock is considered to be the basal conglomerate of the Mictaw. Two miles farther upstream, on a sharp bend of the river, a similar conglomerate is exposed. It, too, is made up of coarse, angular Macquereau fragments, some 1½ feet long, and is interbedded with shale and arkose.

The brook that drains lake à l'Appelle and that joins North Port Daniel river 2 miles above the bridge at the end of the motor road shows a similar conglomerate 1¼ miles up from its mouth. The conglomerate rests on typical Macquereau arkose-quartzite and is itself made up of Macquereau fragments. Seventy feet downstream are exposed beds of typical Mictaw arkose and these continue to the mouth of the brook. The conglomerate appears to have been formed from an old Macquereau regolith.

Age. Graptolites were collected on Middle Port Daniel river by S. A. Northrop in 1927, by E. M. Kindle in 1928, and by the writer in 1931. Concerning the last collection R. Ruedemann reports: "They are very well preserved but unfortunately not any of them is a distinct horizon marker. They are: *Dicellograptus minimus* var.; *Dicranograptus* sp.; *Diplograptus (Orthograptus) rugosus* Emmons, var. *apiculatus* E. and W. var.; *Climacograptus* cf. *tenuis* Rued.

"*Dicellograptus minimus* is similar to *D. rumilus* Lapworth, of the British Hartfell shales; *Climacograptus tenuis* Rued. is a species of the Utica shale of New York; *Diplograptus* (*Orthograptus*) *rugosus apiculatus* occurs in Great Britain, in Zone 10 (Zone of *Climacograptus peltifer* and *Mesograptus multidens*) which is the uppermost zone of the Glenkiln shales.

"The combination of fossils of Middle Port Daniel river is not conclusive of any particular horizon, but it would suggest an age not far above the Normanskill shale, that is Black River to Trenton age."

Other fossils collected by the writer from this locality include the brachiopods, *Schizambon* sp., and *Lingula* cf. *progne* and a species of Conularidae, probably *Conularia* sp., allied to some British Ordovician forms rather than American.

The age of the Mictaw beds is concluded to be late Middle Ordovician.

Intrusives. Intrusives cutting Mictaw strata were observed at two places on North Port Daniel river. On the west bank of the river near the shaft where exploration work for coal was carried on, is a dark green to black, fine-grained intrusive. In thin section the rock proved to be highly altered, consisting of altered feldspar, epidote, chlorite, and carbonate. Remnants of augite crystals, and magnetite are present also.

The second intrusive occurs 3 miles farther upstream, at the mouth of a brook that joins the North Port Daniel from the northwest. It is a similar, massive, dark green rock in which crystals of feldspar, pyroxene, and sulphides can be distinguished with the naked eye. In thin section it proved to be less altered than the preceding rock. The feldspar is andesine so that the rock may be termed an augite diorite. The age of these basic intrusives is not definitely known, but since volcanism took place in the Silurian and again on a still grander scale in the Lower Devonian, it is presumed that they are related to one or other of these periods of igneous activity.

Tetagouche Series

Distribution. The Tetagouche series is characteristically developed along Tetagouche river. The part of it whose age is definitely known consists of black slates which outcrop on the north bank of the Tetagouche immediately to the west of the railway bridge. There the rocks have yielded a graptolite fauna of Middle Ordovician age. With these rocks, however, are associated others that are considered to belong to the same series, and that cover a wide belt extending north to Millstream river and southeast to the granite mass of Nipisiguit River region. North of the Silurian belt west of the Petit Rocher shore section is an area on Elmtree river that has been mapped as belonging to this series, but whose age and relationships are known with less certainty.

Lithology. The characteristic rocks of the series are dark-coloured slates and argillites, in places black, in others dark grey, and locally bluish to greenish. With the slates are bands of hard, quartzose sandstone and narrow zones of red argillaceous rocks. In places the strata are lustrous due to shearing. Pyrite is commonly present giving a rusty appearance to weathered exposures. Below Tetagouche falls the slates are locally graphitic.

A striking rock that occurs in the series is a deep red argillite closely resembling the black, slaty rocks except for its colour. It occurs in bands from a few to several hundred feet thick. Locally it shows a faint colour banding, but the more typical variety is an even-coloured rock breaking along cleavage surfaces. In some places the rock is soft and slaty, in others it is hard and cherty. The latter variety furnishes the deep red pebbles so characteristic of the Silurian and Devonian conglomerate of northern New Brunswick. Their presence in these conglomerates affords conclusive evidence of a period of deformation and subsequent erosion in post-Tetagouche, pre-Middle Silurian time. These red rocks apparently owe their colour to finely disseminated hematite. They are also locally manganiferous and in places are traversed by small seams of manganite. Exposures may be seen on Grant brook about 3 miles from its mouth and on the Tetagouche immediately below Tetagouche falls.

With the slates are associated beds of coarser quartzose material, forming hard sandstone, arkose, and quartzite, and some local beds of conglomerate. One conglomerate zone containing well-rounded granite boulders is exposed on the west bank of Tetagouche river, about half a mile south of the graptolite locality. There are all gradations from the sandstones to the feldspar-bearing arkoses. Locally, as in places along Grant brook, the sandy beds form the dominant sediment, having associated with them only thin bands of black, argillaceous material.

The rocks on Elmtree river, which are mapped as Tetagouche, consist of dark, cherty slates and hard, conglomeratic bands. The latter contain as pebbles quartz, volcanics, granite, and quartzites, similar to the Macquereau rocks. These rocks do not look like any that occur in the Silurian sections and though they somewhat resemble those in the neighbourhood of Hodgins, which have been mapped as Lower Devonian, they are considered as Ordovician for the following reasons. They appear to underlie the Silurian rocks of the lower Elmtree River region; the Devonian conglomerates near Hodgins contain pebbles similar to rocks exposed at the Elmtree zinc property which lies within this belt; and, lastly, the absence of fossils and the degree of metamorphism are both features that are more characteristic of the Ordovician than of either the Silurian or Devonian formations.

Structure and Age. Bedding planes in the Tetagouche series are commonly well marked by good colour banding and by changes in texture. In places the beds are drag-folded to such a degree that strikes and dips mean little or nothing. In all the rocks, except some of the harder quartzose varieties, a good cleavage is developed. Generally it follows a direction parallel to the axial planes of the drag-folds. At one place on the Tetagouche, however, well-bedded, dark argillites showing good colour banding have small folds normal to whose axial planes a good fracture cleavage, the most pronounced structural feature of the rock, is developed. This would appear to indicate deformation at two periods in which the stresses that produced the one deformation acted in a direction normal to those that produced the other. In places, too, the slates have a lustrous appearance and locally along the cleavage planes have a ribbed effect, suggesting a movement after the cleavage had been developed. The lack of good sections, the absence of horizon markers, and the degree of metamorphism render it impossible to zone the series or to definitely establish the succession. It is quite possible that the series includes rocks of more than one formation.

The presence of graptolites in shales on Tetagouche river above the railroad bridge was first reported by Ells. Later, Ami determined a collection from this locality. His list is as follows:

Diplograptus foliaceus Murchison
Diplograptus truncatus Lapworth (or a very nearly related form)
? *Lasiograptus* sp. indt.
Climacograptus bicornis Hall
Cryptograptus tricornis Carruthers
Dicellograptus anceps Hall
Orthograptus quadrimucronatus Hall
? *Didymograptus superstes*

Besides the above graptolites there was found with them a brachiopod, *Leptobolus* sp.

Concerning this fauna Ami states:

"These black and at times pyritiferous shales appear to be synchronous or homotaxial with the shales of Normanskill, near Albany, N.Y.; of the city of Quebec; of the north shore of the island of Orleans; of the Marsouin river, and of numerous other localities in Gaspe peninsula." He also adds the following statement:

"List of species of graptolites determined by Professor Lapworth from the collection sent him by the writer some years ago, obtained along the Tetagouche river, Gloucester county, New Brunswick, by Dr. R. W. Ells:

Lasiograptus mucronatus Hall
Climacograptus bicornis H. with branch of *Dicranograptus*
Cryptograptus tricornis Carruthers
Diplograptus aculeatus Lapworth, or *D. Whitfieldi* Hall
Diplograptus cf. *D. Whitfieldi* Hall
" allied to *D. quadrimucronatus* H.
" *foliaceus* Murchison
" sp. "

In 1929 the writer made a collection here, also, which was forwarded to Rudolf Ruedemann. The latter determined the following species.

Dicellograptus sextans Hall
Climacograptus modestus Ruedemann (most common species)
" sp.
Diplograptus cf. *acutus* Lapworth
" *euglyphus* Lapworth
" cf. *incisus* Lapworth
Cryptograptus tricornis Hopk.
Glossograptus ciliatus Emmons
Lasiograptus bimucronatus Hall

Ruedemann states that this fauna is undoubtedly of Normanskill age.

Contact Types. Along the course of Middle river in the midst of the area underlain by the Tetagouche slates there is a belt of altered sediments which extends for about 4 miles along the borders of Nipisiguit River granite stock. Outcrops occur on the river, along the road that parallels it, and in the adjacent fields. The rocks are dense, hard, and in thin section are seen to consist of a mass of secondary minerals chiefly biotite, quartz, muscovite, and pyrite. The biotite is very abundant, reddish brown, and consists of small crystals oriented in a common direction. The muscovite crystals, which are much scarcer, commonly lie at angles to this general direction. The pyrite is disseminated throughout the rock or concentrated along certain lines or bands. These rocks may best be described as hornfels, but they pass into biotite schists and locally have a banded gneissic appearance. They are traversed by numerous quartz veins and at several places are cut by aplite and granite dykes.

Associated Igneous Rocks. Associated with the Tetagouche sediments is a series of igneous rocks which have been described under the name Fournier group (Young, 1911, page 47). On Grant brook and Millstream and Tetagouche rivers and in the region between Grant brook and the Tetagouche are numerous exposures of dense, dark, basic rocks, some of which are amygdaloidal and clearly represent interbedded flows. Their composition ranges from andesite to basalt. The amygdules consist of quartz and calcite and some have a diameter of half an inch. Other exposures may represent sills or dykes. Owing to the fact that these rocks are harder than most of the sediments with which they are associated, most of the outcrops between the Tetagouche and Grant brook consist of these igneous rocks. Tuffaceous rocks, locally sheared to schists, also occur in this region and on Millstream river.

The largest area underlain by the Fournier group extends along the coast from Limestone point northward to north of Fournier brook and inland to Belledune River region. The best and most readily reached exposures are along the coast. The group is here a complex of volcanic, intrusive, and stratified rocks. A common variety is a dense, dark, altered volcanic containing irregular streaks and masses of epidotized material, and cut by numerous quartz veins. Coarser grained types include gabbro, diorite, and granite. Banded tuffs, red and green shales and slates, and greenish sandstones, occur in subordinate amounts. Altered varieties including hornblende schists are also present and dark diabase dykes locally cut the massive intrusives.

Certain exposures along the shore north of Limestone point suggest that here a complex of volcanics and sediments was intruded and altered by granite. All gradations from little altered volcanic types to schistose varieties are cut by dykes of granite. The volcanics have locally been altered to hornblende schist and the alternation of zones of hornblende schist and crushed granite gives rise to a well-banded, gneissoid rock.

That the volcanic and sedimentary complex is of Ordovician age is suggested by two lines of evidence. As already mentioned, similar dense volcanics, some of which are amygdaloidal, are interbedded with Tetagouche sediments farther south. Secondly, the Silurian conglomerate exposed near Petit Rocher is made up largely of dense volcanics of these types; the rocks that furnished these boulders must, therefore, be pre-Silurian. The intrusive rocks, on the other hand, are probably of Devonian age. South of the mouth of Hendry brook, near the contact of the Fournier rocks with Silurian strata, fossiliferous Silurian beds are cut by two small dykes. It is to be inferred, therefore, that some of the intrusives, at least, of the Fournier group are also post-Silurian. Moreover, although the Silurian conglomerates of Petit Rocher contain many varieties of fine-grained, volcanic rocks, they do not contain the coarser plutonic types. This also suggests that the latter are post-Silurian. It would seem most probable, therefore, that the Fournier complex consists of an interbedded series of flows, tuffs, and sediments of Ordovician age, altered by dykes and masses intruded in Devonian time.

UPPER ORDOVICIAN

Older than the Silurian and Devonian rocks of the lower Restigouche River region is a complex of sediments that have locally yielded Richmond fossils. These will be described under the term Matapedia group. Rocks that present many lithological similarities to them extend along the north side of Chaleur bay, except where concealed by younger formations, to Percé. At Percé they have yielded a considerable Richmond fauna and at various other places a few species concerning which all that can be said is that they are Ordovician. Throughout most of these rocks, however, fossils are very difficult to find, so it is quite possible that more than one formation may be thus grouped together as Upper Ordovician. For this reason the members towards the eastern end of the region will be referred to under the names White Head and Pabos formations rather than under the term Matapedia. Some of the rocks may be the equivalent of the Mictaw and Tetagouche and, therefore, of Middle instead of Upper Ordovician age.

Matapedia Group

MATAPEDIA RIVER AREA

The type area of the Matapedia group is the Matapedia valley where outcrops are almost continuous between Ste. Florence and Matapedia. This belt of rocks has been studied by G. W. Crickmay and a description of it will be given first.

The group is made up of limestone, slate, and quartzite. Limestones are confined to the southern part of the valley, from mile-post 21 on the railway to Matapedia and along Restigouche river. They are dense, dark grey, and argillaceous and are associated with calcareous slates. In many places hard limestone beds 1 to 2 inches and more in width are separated by argillaceous partings. At other places the limestone is massive and the bedding indicated only by fine colour banding. In a few places the thin-bedded limestones are accompanied by lenses and beds of coarsely crystalline limestone with large sand grains and abundant broken crinoid columns. In one exposure, on the highway about half a mile north of Matapedia station, dark grey limestone lenses contain, in addition to a few crinoid columns, what appear to be fragments of trilobite tests. Similar fossiliferous limestone beds occur on Restigouche river opposite the mouth of the Matapedia.

Between Millstream and Ste. Florence is exposed a series of slates and phyllites of unknown thickness. These vary only slightly in composition, some of the slates being calcareous and others arenaceous. The commonest rock is a black argillite in which the bedding can only locally be observed. In the calcareous slates the bedding is commonly indicated by colour banding, and, where sand is a constituent, by finely crossbedded, sandy layers.

The argillites vary greatly in the degree of metamorphism they exhibit. Everywhere they show a slaty cleavage. On Assemetquagan river near its junction with the Matapedia the cleavage planes are closely spaced and cut across the bedding planes at various angles. At Bellavance station a well-developed cleavage is about parallel to the bedding. At mile-post 24, 1½ miles north of Millstream, the cleavage is well developed only in certain zones. As a result the rock here is more massive and resistant to erosion, a feature that is reflected in the narrow character of the valley and the prominent rock outcrops at this point. In the vicinity of Ste. Florence the rock passes into a phyllite with a silky lustre due to secondary mica. The bedding planes here are almost totally obscured.

The Matapedia group has yielded fossils at two localities near Matapedia. On the left bank of Restigouche river, 2 miles downstream from the mouth of the Upsalquitch, fossils occur throughout some black, calcareous slates. The beds here dip at an angle of 60 degrees to the northwest and the dip of the slaty cleavage is in the same direction but slightly steeper. The following species were collected:

Cyclopyge sp., identified by G. A. Cooper from a single crushed specimen of the glabella and eyes, as similar to, and probably identical with, *Cyclopyge* n. sp. from the Ordovician of Percé.

Cyclospira n. sp., identified by G. A. Cooper as similar to, but specifically distinct from, *Cyclospira* n. sp. from the Ordovician of Percé.

Winnepegoceras n. sp., identified by A. K. Miller as congeneric with, and having close affinities with, *Winnepegoceras laticuroatum* (Whiteaves).

Irregular fucoid markings of the type Buthotrephis are common.

This fauna indicates a late Ordovician age. The genus Cyclopyge is unknown in this continent except in the late Ordovician rocks of Percé. The genus Winnepegoceras is known from no horizon other than equivalents of the Richmond.

On the right bank of Restigouche river opposite the mouth of the Matapedia, fossils occur in coarsely crystalline lenses and beds, interstratified with thin-bedded, argillaceous limestone and slates. Subangular sand grains are abundant in the crystalline limestone, here and there making a calcareous sandstone. The fossiliferous beds are not sheared, most of the deformation apparently having been confined to the surrounding incompetent beds. Their recrystallization is the only evidence of their metamorphism. The fossils are for the most part fragmentary. They include:

Atrypa sp. cf. *A. marginalis* (Dalman). Several fragments of these shells and one nearly complete mould of a dorsal valve were found. This species is probably quite distinct from *A. marginalis* (Dalman), but is very close to the form referred to that species from the Ordovician beds of Percé.

Illaenus sp. cf. *Illaenus* n. sp. from Percé. The species is quite common, but the fragmentary nature of the specimens does not allow close comparison with the species from Percé.

Calymene sp. A glabella and pygidium of this species are present, but the material does not permit of more than a generic determination.

There are many broken or imperfectly preserved tests that cannot be placed generically. These include a nearly flat valve of a strophomenoid, trilobite fragments, crinoid columns, bryozoans.

This fauna, although small, suggests a late Ordovician age for the beds. Regarded in conjunction with the fossils collected farther up the river, these beds seem to be the direct equivalents of the late Ordovician beds at Percé.

The slates and phyllites exposed between Ste. Florence and Millstream have yielded only a single fossil, a pelecypod, according to Crickmay, possibly belonging to the genus Ctenodonta or Nucula, a form of little value in determining the age of the beds. A consideration of the lithology, the degree of metamorphism, and the structural relations leads to the conclusion that they are pre-Silurian. They are tentatively placed with the limestones of the Matapedia group, although it is possible that they are of greater age, perhaps equivalent to the Mictaw and Tetagouche formations.

NORTH SIDE OF CHALEUR BAY

Ordovician rocks form a continuous belt in the southern part of Gaspe from Matapedia river eastward to Little Cascapedia river, where they disappear under Silurian strata. To the south of them lie fringing bands of Silurian and Devonian rocks. Good exposures of the series continue along the north side of Restigouche river for 5 miles east of Matapedia where the beds are overlain by Silurian rocks. East of this the best exposures are seen along the streams to the north of the Silurian belt.

The Kempt road and the various branches of Little river show a continuation of the limestone and argillite rocks that occur along the Matapedia. The belt was followed north to the Assemetquagan tower, 15 miles from the coast. No fossils were observed and no attempt was made to subdivide the complex.

The upper branches of Escuminac river drain a region underlain by Ordovician rocks. From the road that follows the north side of the river one may cross from the fossiliferous Silurian belt into the Ordovician complex by ascending Butlers brook, the North Escuminac, or the main river itself. The Ordovician rocks consist of hard, bluish limestones and slates, characterized by irregular dips and strikes, secondary cleavage, and numerous calcite veins and stringers.

North of the Silurian belt on Nouvelle river the rocks are hard, cherty limestones, shales and slates, and locally grits. Good exposures also occur along Mann brook. Certain zones consisting of interbedded shales and limestones in beds 1 to 2 inches thick closely resemble the Matapedia rocks.

Along Stewart river, above the East branch, is exposed a group of black shales, locally calcareous, sandy shales and limestones highly fractured and cut by numerous calcite veins, and thinly bedded black shales alternating with thick beds of grey grit and sandstone and a few layers of limestone. The absence of distinctive horizons and the fact that the strata are highly folded make it impossible to determine thickness or even be certain of the succession. Along the East branch and the main river below the mouth of Samuels brook outcrops a different assemblage of rocks; this includes a zone of grey, cherty limestone about 600 feet thick overlain apparently by a series of grey slates with some limestone bands. No fossils were found in any of these rocks.

Back of Carleton and associated with the shales and limestones is a broad belt of conglomerate, grit, and finer grained clastic rocks. This belt forms the top of Tracadigash mountain, Carleton mountain, and good exposures of it can be seen on the upper waters of Glenburnie and Miuse brooks. The conglomerate is hard and well cemented. On its freshly broken surface it is usually dark in colour, in places greenish. The pebbles are rounded to angular and vary up to 4 inches in diameter. They consist of quartz, greenish blue chert, volcanics, quartzite, granite, and gneiss. Where crossed by Miuse brook the belt shows a lower and an upper conglomerate separated by thinly bedded shales containing sandy and calcareous layers and a few thin layers of limestone. Farther north, in the region west of the east branch of Green river, the belt contains progressively less conglomerate and more grit and finally the latter gives place to shale. The estimated thickness of these clastic and associated beds is over 2,000 feet. The strata contain few fossils. On the flank of Tracadigash mountain a zaphrentis-like coral was collected and a large boulder of conglomerate similar to that of Tracadigash mountain found near St. Jules furnished a coiled cephalopod, some gasteropods, and other forms that were pronounced by E. M. Kindle to be Ordovician.

West of Louis Mountain settlement similar conglomerates and grits are associated with shales on Cloche brook and, as will be mentioned later, a belt also occurs on the east side of Cascapedia river extending towards the Little Cascapedia. It is possible that these belts represent deltas deposited in the Upper Ordovician sea.

The lower part of McKeen brook flows through a region of Helderberg shales, but a short distance above its junction with Miuse brook begin outcrops of limestones resembling those of the type Matapedia section. A few fossils were collected from these beds, which were determined by Alice E. Wilson. They include a *Calapoecia* coral, large crinoid stems, a Rhynchonellid brachiopod, and a *Cycloceras,* forms suggestive of Upper Ordovician age.

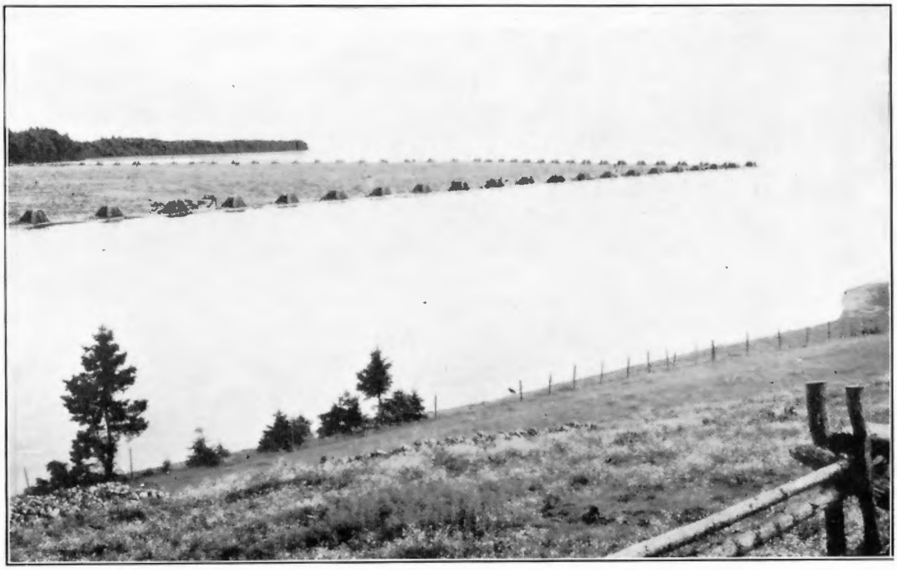
The road that follows the west side of Cascapedia river northward from St. Jules church passes over a hill composed of conglomerate and igneous rock; and in a field 1½ miles north of the church the contact between fossiliferous Silurian beds and black, hackly slates and argillites can be located within a few feet. On the several branches of Boudreau creek, which joins the Cascapedia half a mile north of this point, are numerous exposures of similar argillites with which are associated some conglomerate and limestone beds. On one of the northern headwater branches of this brook these rocks yielded a few fossils which were pronounced by E. M. Kindle to be Ordovician.

The road that ascends the valley 2 miles to the west of the Cascapedia, passes Lincoln Mills post office, and leads to a point on Skimenac river three-quarters of a mile above its junction with the Cascapedia, shows still better exposures along this contact zone. The rocks up the western side valley, known as Blueberry gulch, and for half a mile farther north, are Silurian shales and limestones, locally fossiliferous. On the east side of the stream that parallels the road, about a quarter of a mile southeast of the mouth of Blueberry brook, outcrops of a white sandstone, locally quartzitic, also carry Silurian fossils. The exact contact of the Silurian and Ordovician beds is not exposed. The first exposures of the latter north of the contact consist of the rocks so commonly seen in the Matapedia series, hard limestone beds separated by thin, shaly interbeds. From one bed of crystalline limestone about 6 inches thick were collected numerous fossil fragments which were identified by Alice E. Wilson as follows:

Corals: Cup coral of the *Streptelasma* type, cf. *Calapoecia* sp., *Halysites* sp.
Bryozoa: an undetermined branching form
Brachiopods: *Orthis* sp., *Camarotoechia* sp., *Platystrophia* (?) sp.
Trilobites: *Calymene* (2 sp.), *Illaenus* (2 sp.), *Proetus*

Though this fauna contains nothing conclusive, its similarity to that collected from Upper Ordovician rocks at other localities suggests that it is probably of that age.

Northward the limestones give place to black and bluish shales, shaly limestones, argillites, and slates, which break readily into small angular fragments. In places a good, slaty cleavage is developed and in places the bedding planes are crumpled and contorted. At Skimenac river these rocks pass into hard, grey quartzites and quartzitic argillites. These have a fracture cleavage and are locally much contorted and cut by numerous small veins and stringers of calcite. Though no definite succession or thicknesses



73497

A. The mouth of Cascapedia river. The boom of logs for the mill at Dalhousie indicates one of the major industries of the region.

73494

B. Cascapedia river about 4 miles above Cascapedia.

can be given to all these Ordovician rocks owing to the deformation they have undergone, it would appear probable that the general succession is downward from the limestone zone through shaly sediments to the more quartzitic varieties.

The road up the east side of Cascapedia river affords many good outcrops where these Ordovician rocks may be studied. The first exposure is on the east side of the road at the creek that crosses it one mile north of Cascapedia station. The beds consist of greenish grey shales which break into small, irregularly shaped fragments. A few Ordovician fossils consisting of ostracods and trilobite fragments were found here. North of this valley a high ridge of conglomerate and sandstone stretches in a southeast direction. The conglomerate is hard, well cemented, and contains well-rounded boulders of quartz, volcanics, quartzite, limestone, and chert. The beds at several places along the strike yielded Upper Ordovician fossils, including Halysites, cup corals, and a few brachiopods. To the north in the region along the Jonathan road these conglomerates are underlaid by quartzitic shales interbedded with softer shales. The next good exposures are along White brook where hard limestones and grey quartzitic argillites with irregular strikes and dips form numerous outcrops. Similar rocks are exposed farther upstream along the Cascapedia. At Duthie pool on the Cascapedia hard, bluish limestones and dark argillites are cut by numerous calcite veins and intruded by dark, basic dykes, reddish porphyry dykes, and by a syenitic granite. At Jack the Sailor pool a 2½-foot vein of pure white calcite traverses similar rocks. Opposite the mouth of Turner brook hard, quartzitic rocks have a good, slaty cleavage crossing the well-defined bedding planes. Where hard and softer beds alternate the cleavage is confined to the softer beds which apparently have taken up the shearing stresses leaving the harder beds undeformed. The Ordovician beds continue to a point near the mouth of Joshua brook, a mile south of the Matane-Bonaventure county line, where they disappear under Devonian strata.

Dark, hackly shales, sandy shales, and shaly limestones outcrop on either side of the Little Cascapedia north of the belt underlain by the Bonaventure formation. On the southeast side of the river the lower parts of the tributary streams flow through shale. The high country to the east where they rise, however, consists of southeastwardly dipping Silurian strata overlying the shales. The contact is towards the base of the steep slope of this cuesta. A few fossils were found at several places in these shales. Two outcrops along the road that follows the west side of the river yielded the following forms, which were determined by Miss Wilson.

Brachiopoda: Atrypa-like form, small, with radiating striæ
Conularida: *Conularia* sp.
Trilobita: *Ceraurus* cf. *Tretaspis*

Near the mouth of Mill brook the shale yielded a single pelecypod, Ctenodonta or Nucula. The very fine, concentric striations are crossed by minute, transverse striations, a type of ornamentation found on *C. fecunda* of the Richmond of the Mississippi valley. Other forms collected here are the gasteropod *Sinuites* n. sp. and a small, broken trilobite pygidium, probably *Dionide* sp.

NASH CREEK AREA

Rocks mapped as Matapedia outcrop along the lower part of the west branch of Nash creek and extend northward outcropping on the Chaleur Bay shore about three-quarters of a mile south of Black point.

The rocks on Nash creek are limestones and shales, in places in alternating beds giving a ribbed effect. The limestone beds are hard, grey-blue, and vary in thickness up to 6 inches. The rocks are so dragged and broken that strikes and dips mean little. They are also cut by numerous calcite stringers. No fossils were found in them. The less altered fossiliferous Devonian rocks on either side dip away from them showing an anticlinal structure.

In the shore section, south of Black point, similar hard limestones with thin, shaly partings have a dominant northward dip which would place them below the Silurian rocks of the Clemville division that outcrop immediately to the north. The actual contact is, however, covered. Their lithological character and this apparent relationship to the basal Silurian form the evidence for mapping these rocks as Matapedia group.

ASSOCIATED VOLCANICS

In one locality only were volcanic rocks found that appear to be contemporaneous with Matapedia sediments. The occurrence is in a low hill about one-half mile south of Ste. Marguerite on the Kempt road some 8 miles east of Causapscal.

The rock is grey and in places vesicular and amygdaloidal. The amygdules consist of quartz and some reach an inch in diameter. Grains and laths of feldspar, the latter up to an eighth of an inch in length, can be distinguished with the naked eye. In thin section the rock is seen to be an augite andesite with phenocrysts of plagioclase and augite in a trachytic groundmass of feldspar. The augite crystals are largely altered to chlorite. The latter form large, pale yellow masses only slightly pleochroic. The plagioclase is basic andesine. A little black iron oxide is present and also some secondary carbonate.

No contact of this rock with the surrounding sediments was seen. The latter, however, are all members of the Matapedia group, standing on edge or at high angles. It is, of course, possible that the volcanic represents a flow of later age. Lower Devonian volcanics are exceedingly abundant in the lower Restigouche region. If this is a volcanic of Lower Devonian age infolded with the Ordovician strata, one would expect to find associated with it some Devonian sediments. As stated above all the sediments of the surrounding area appear to be Ordovician. Devonian rocks are not seen until the fault line is crossed that separates the Matapedia sediments from the Heppel formation 2 miles to the north. It would appear probable, therefore, that the volcanic is of Upper Ordovician age.

Pabos Formation

North of the Silurian belt that extends from the Little Cascapedia to Port Daniel and which swings around north of the Macquereau belt to a point near Chandler is a group of Ordovician sediments which have been traced up the Grand river by C. H. Kindle for some 15 miles, and which have been named by him the Pabos formation. A short distance east of Grand river these strata disappear under the Bonaventure formation. At Percé a slightly different assemblage of Ordovician rocks appears and extends in a westerly direction from Percé, being covered on the south by Bonaventure and on the north by a narrow belt of Silurian strata. These beds are referred to under the name White Head. Their relation to the Pabos is not definitely known.

The Pabos consists of grey limestones, shaly limestones, and shales. Neither the top nor the bottom of the formation was seen. The thickness is certainly great, but the absence of horizon markers or definite zones that might be distinguished from each other renders it difficult to make even an approximate estimate. It is even possible that the beds may include more than one formation. Along the Grand river limestone conglomerate occurs in several places.

Only a few fossils were found in the Pabos beds. A *Tretaspis* head from the second range road east of Brèche à Manon indicates that the beds are of Ordovician age. Bryozoan impressions from Little River East and from a quarry 1½ miles up Little Pabos river are reported by R.S. Bassler to indicate a horizon of Mohawkian or later age. A pebble from the limestone 3 miles below the upper fork of Grand river was found to be composed of a specimen of Halysites in a black shale matrix. This indicates a late Ordovician age for at least this part of the Pabos. It would seem, therefore, that these rocks are to be correlated with the Matapedia strata farther west.

White Head Formation

The White Head formation is composed of much deformed strata of considerable lithologic variety including thin-bedded limestones and shales with minor amounts of black shales, sandstones, basal and intraformational conglomerates. The base of the formation is exposed on Murphy creek where Upper Cambrian beds are overlain by a quartz pebble conglomerate grading up into shale and fine-grained sandstone. The shore section from White Head to Percé crosses the strike of the formation, but for the middle third of this distance the strata are concealed by Bonaventure beds. In addition the rocks are greatly deformed by thrusting and folding so that their proper sequence is not apparent.

Fossils have been collected from many localities. Professor Schuchert and Dr. G. A. Cooper have collected and reported on the White Head fauna in the vicinity of Percé (1930). On the south flank of mount Joli, 112 feet southwest of the overthrust fault between the Ordovician beds to the west and the Lower Devonian beds to the east, is a zone containing *Tretaspis* specimens abundant in the upper 5 feet and less common in the next 20 feet. *Lonchodomas* is sparingly found where *Tretaspis* is abundant. Fossils were collected from strata of the same horizon in the nearby vertical limestones at White Head. Other fossiliferous localities mentioned by Schuchert include the light blue limestones and shales near the mouth of the small brook which at Grande Coupe follows a deep ravine on the side of mount Ste. Anne about a mile north of Percé, and White mountain north of the Grande Coupe.

The fauna is considered to be of middle or upper Richmond age. A striking feature in connexion with it is the large number of European forms present, particularly the trilobites, *Lonchodomas, Tretaspis, Cyclopyge,* and *Holotrachelus,* and the brachiopods, *Bilobites, Ptychoglyptus,* and *Plectatrypa.* Among the collection made by C. H. Kindle is an ostracod which Dr. R. S. Bassler says is of European affinities. The beds are considered by Schuchert and Cooper to be of the same age as the English Head and the Vauréal of Anticosti, but owing to their different faunal assemblages they are thought by them to have been deposited in a different basin.

SILURIAN

Two main groups of Silurian rocks occur in the region covered by the present report—those in the immediate vicinity of Chaleur bay where they have been described by various writers under the name Chaleur Bay series, and those in the Matapedia valley below lake Matapedia where the succession can only in a general way be related to the type Chaleur Bay section.

The two main areas where the Chaleur Bay series is exposed are Port Daniel and Black Cape, both on the Gaspe coast. Detailed study of these two sections was carried out by Professor Schuchert first at Port Daniel where local names were applied to the formations based on lithological character into which he divided the series. It was found that the same subdivisions could be recognized at Black Cape, though there the upper member is missing and the thicknesses vary from those in the type locality. The structure at Black Cape is simple, however—a regular succession of beds forming one limb of a syncline—in contrast with the complicated structure at Port Daniel, and it is to be regretted that the zoning was not done originally at Black Cape in order to make it the type section. On the New Brunswick side of Chaleur bay the best sections are exposed at Jacquet River and Petit Rocher, with more fragmentary ones at Blacklands, Black Point, and Belledune.

PORT DANIEL AREA

The Silurian succession at Port Daniel in descending order is as follows (Schuchert and Dart 1926, page 37):

	Feet
Indian Point formation,,	194
West Point or *Crotalocrinus* limestones	1,445
Bouleaux formation of thin-bedded limestones, coral reefs, and breccias; and shales	800
Gascons or *Taonurus* muddy and shaly sandstones	1,800
La Vieille limestone or *Stricklandinia* beds	285
La Vieille sandstones and conglomerates	170
Clemville formation	385
Total Silurian	5,079

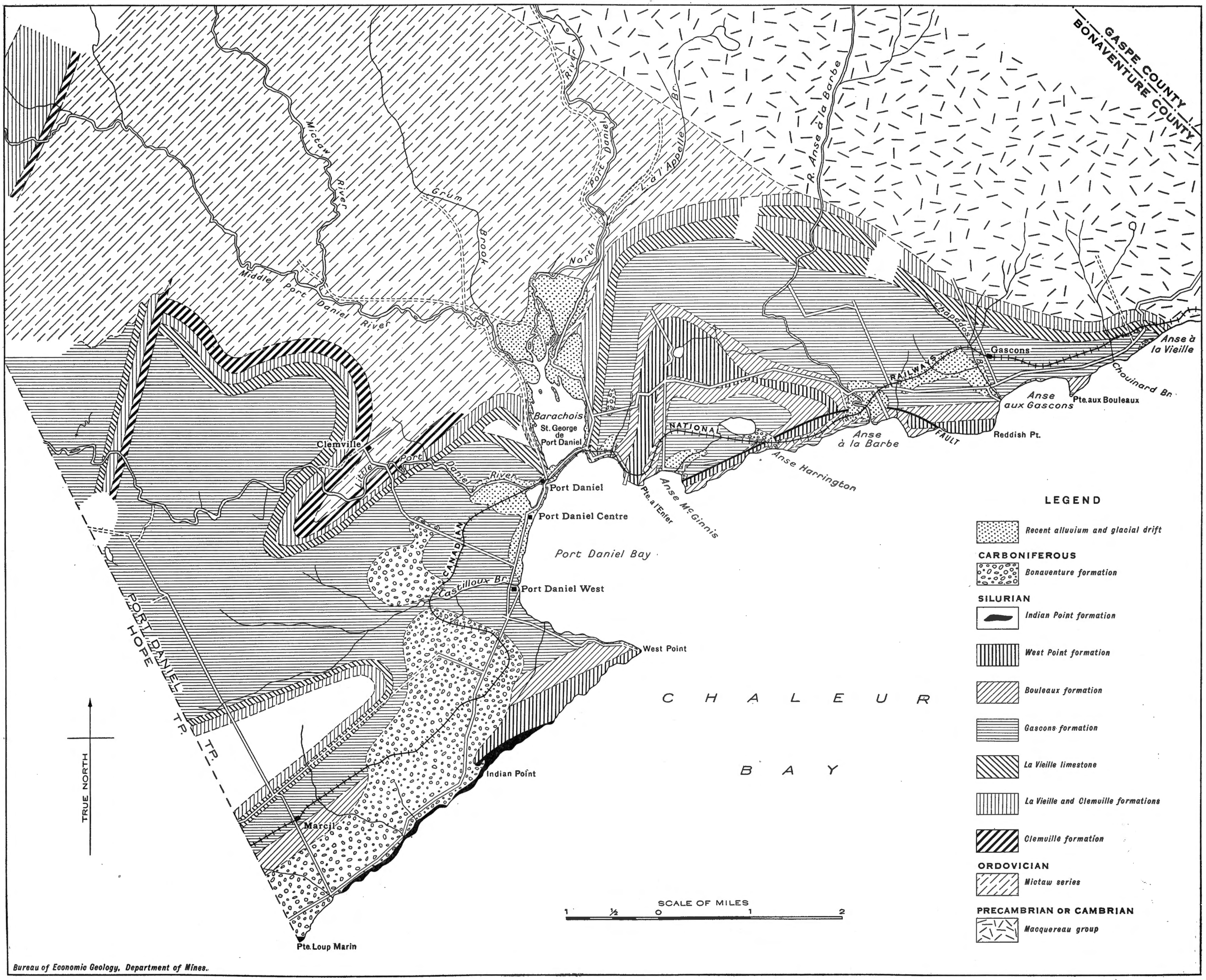


Figure 1. Port Daniel area, geology by Charles Schuchert and J. Doris Dart, modified by S. A. Northrop.

A. The Silurian country at Port Daniel, Que.

72513

B. Part of the Silurian section at Black cape.

Clemville Formation

The Clemville, the lowest member, is not exposed along the coast but does outcrop inland at Clemville, 2 miles northwest of Port Daniel, along the banks of Little Port Daniel river (Figure 1). The river here cuts across an anticline in the middle of which are Mictaw shales and sandstones bordered to the north and to the south by the Silurian formations, Clemville to Bouleaux. A good section of the Clemville is exposed along the southern bank about one-quarter of a mile above the bridge at Clemville where the wagon road crosses the stream. The succession in descending order according to Schuchert and Dart (1926, page 45) is as follows:

	Feet
Soft, blue-black, crumbling shale that toward the top has interbedded thin sandstones, the transition zone to the La Vieille sandstones. Dips 65 degrees south, 20 degrees east. Thickness about	150
Blue-green, sandy shales with a few, thin, arenaceous limestones abounding in Tentaculites	40
Similar shales regularly interbedded with thin sandstones	35
Blue-green, sandy shales with fossils	30

Here occur *Zaphrentis stokesi*, *Halysites catenularia microporus*, *Favosites gothlandicus*, *Heliolites*, *Stromatopora*, *Cornulites*, *Orthis flabellites*, *Dalmanella rogata*, *Rhipidomella uberis*, *Leptaena rhomboidalis*, *Rafinesquina ceres*, *Plectambonites transversalis*, *Schuchertella*, *Pecten*, *Stricklandinia* small sp., *Camarotoechia janea*, *C. fringilla*, and *Atrypa reticularis*.

	Feet
Green shales becoming more calcareous and knobby	80
Soft, green shales with light blue, dense, thin-bedded limestones, some of which abound in *Monticuliporas* and *Hebertella* cf. *fausta*	50
Total thickness for the Clemville	385

La Vieille Formation

The La Vieille formation is made up of a lower sandstone and shale division and an upper limestone portion. The type locality is Anse à la Vieille where the Silurian beds dip off the Macquereau sediments. The succession of the sandstones and shales in ascending order is as follows: (Schuchert and Dart, 1926, page 45.)

	Feet
Macquereau folded and peneplained	...
Light green, coarse, vein-quartz conglomerate with the subrounded pebbles up to 3 inches. Variable from 2 feet to	4
Sandy conglomerate	4
Greenish sandstones with zones of quartz conglomerate in which the pebbles are of sizes up to one-half inch. Here and there occur *Stromatopora*, *Heliolites*, and *Palaeofavosites asper*	10
Green, muddy sandstones that weather hackly. Fossils appear here in more abundance: *Syringopora compacta*, *Palaeofavosites asper*, *F. favosus*, *Heliolites*, *Orthis flabellites*, *Platystrophia biforata*, crinoid columnals, *Buthotrephis* (exceedingly common), and *Taonurus* (rare)	15
Thick-bedded sandstones with very little conglomerate, having a dip of 20 degrees to 30 degrees southwest (the regulation dip up to the highly disturbed faulted area farther west along the shore)	25
Thinner bedded, greenish, muddy sandstones, but almost without shale partings	30
Green shales with less and less of sandstones, *Palaeocyclus rotuloides*, *Syringopora compacta*, *Orthis flabellites*, *Atrypa reticularis*, etc	35
Dark green shales that become more and more knobby and calcareous upward. Fossils rare	45
Total thickness of La Vieille sandstones	168

The sandstones are succeeded by a thick series of more or less muddy limestones that become more and more knobby upwards and finally pass into almost pure limestones. At one place in the shore section a fault with a throw of probably less than 100 feet greatly disturbs and twists the strata.

The La Vieille limestones may be seen to best advantage in the cuts along the railway west of the water tower, where a thickness of 285 feet is exposed. These limestones are rich in fossils, particularly the lower 150 feet; they contain *Stricklandinia gaspiensis,* many fine corals, *Uncinulus, Rhynchotreta cuneata americana,* large *Actinoceras siphuncles (Huronia),* and *Strombodes pentagonus.*

The Stricklandia limestones are also well shown at the Catholic church of St. Georges de Port Daniel, in the adjacent railway cut, and also along the beach below the wagon road. The western end of the railway cut for about 135 feet shows the limestones undulating and rising eastward to the crest of an anticline; the eastern end for a length of 185 feet shows the beds either vertical or slightly overturned.

Other good exposures of these limestones cross Little Port Daniel river just south of Clemville. At least 150 feet of knobby limestones are here exposed and the total thickness appears to be over 300 feet, the upper part being less knobby and less fossiliferous than elsewhere. Downstream these are overlaid by the red-weathering Gascons sandstones.

Small exposures of the knobby limestones beneath the north-going road along the southwestern side of the Port Daniel barachois afford a good place to collect La Vieille fossils. Here the groundwaters have decomposed the shales and loosened the corals and other fossils so that they wash out on the beach. Fossils collected here by Schuchert include twenty-five species of corals and in addition, *Orthis flabellites, Rhipidomella uberis, Leptaenisca, Schuchertella subplana, Stricklandinia gaspiensis, Rhynchotreta cuneata americana, Huronia, Illaenus grandis* (?), *Bronteus,* etc.

Gascons Formation

The Gascons formation consists of argillaceous, fine-grained sandstones, marked by gasteropod trails and especially by worm-burrows known as cauda-galli or Taonurus. It may be seen at Anse à la Barbe, from Gascons east to Anse à la Vieille, and at scattered places back from the coast. Fine exposures occur also on the southwest side of Port Daniel bay from Port Daniel Centre outwards towards West point. Here the beds weather red but within are greenish. They are also closely folded and as a result are repeated.

A zone carrying *Monograptus* and another marked by 35 feet of thin-bedded limestones serve as horizon markers. The total thickness of the formation according to Schuchert and Dart is 1,860 feet. It grades without break from the La Vieille below to the Bouleaux above.

Bouleaux Formation

On either side of the small pointe aux Bouleaux to the east of Anse aux Gascons about 700 feet of strata of the Bouleaux formation are exposed. These consist of an upper 200 feet of thin-bedded, grey limestones containing numerous corals and a lower 500 feet of green, sandy shales and limestones that weather red and pass without break into the Gascons formation, the transition zone, which is well exposed to the west of the mouth of Chouinard brook, consisting of 40 feet of rippled beach sandstones in thin, slabby beds.

A good exposure of the formation occurs along the southwest shore of Port Daniel bay, westward from West point for half a mile. Here there is more limestone than in the Point Bouleaux section and zones of coral breccias are numerous. The formation is also well exposed along the western side of McGinnis cove to the east of the quarry in the West Point limestones of pointe à l'Enfer. The beds consist of sandstones, sandy shales, limestones, and coral breccias. The sandstones and shales are to a large extent laminated, thin-bedded, sun-cracked, and rain-pitted, which, along with the coral breccias, indicate that the sea was here shallow at the time of their deposition. Detailed descriptions of these two sections are given by Schuchert and Dart (1926, pages 49-51).

West Point Formation

The West Point formation is characterized by pink limestones containing an abundance of *Crotalocrinus* columnals. The type section is along the steep cliffs that extend southwest from West point. The coast here cuts across the strike of the formation at a low angle for 1½ miles and proceeding westward the stratigraphic succession is upward. The following is an ascending section from West point westward (Schuchert and Dart, 1926, page 52).

	Feet
(1) Lower, pink, thick-bedded limestones that weather more or less reddish and are replete with *Crotalocrinus* columnals. They reach West point, on which the little lighthouse stands. Probably one-half of the limestone is made up of *Stromatopora*, and slender, branching *Cladopora* are also common. Dip about 65 degrees south. Thickness estimated at..............	200
(2) Lower, intermediate, thin and thick zones of knobby, coraliferous limestones, interbedded with zones of laminated, sandy limestones that usually have current ripples and are more or less sun-cracked and muddy sandstones. The whole series becomes more and more shaly and sandy upward. Measured as..............	230
(3) Lower, greenish, sandy shales that weather red, interbedded with some sandstones weathering yellow. Estimated at..............	120
(4) Middle, intermediate, thin-bedded limestones replete with *Stromatopora*, *Eridophyllum*, and other corals, separated by thin zones of shale, the whole weathering red. As these strata strike with the coast, they extend westward for three-fourths of a mile. Strike north 90 degrees east, dip 55 degrees south. Estimated thickness..............	560
(5) Middle, pink, thick-bedded limestones. Thickness estimated at..........	60
(6) Upper sandy shales, weathering red. Thickness estimated at..............	150
(7) Upper, pink, thick-bedded limestones on which the cormorants nest each year. The dip rises in the east from about 60 degrees to 15 degrees overturned at the west, and strike along the coast for one-fourth of a mile and also flatten down considerably. Estimated thickness..............	125
Total thickness for West point..............	1,445

The West Point limestones may be readily seen at pointe à l'Enfer east of Port Daniel pier where they have been quarried for shipment to the pulp mill at Bathurst. The strata here stand on edge and are folded into a closed syncline that strikes about north 25 degrees east. The formation is also exposed for nearly a mile along the coast at the Gros Morbe between Anse à la Barbe and Anse aux Gascons.

Indian Point Formation

The Indian Point formation, the youngest of the Port Daniel Silurian, outcrops along the seacoast east of Indian point. Beyond the upper pink limestone of the West Point formation may be seen the following strata (Schuchert and Dart, 1926, page 53).

Top of upper pink limestone	Feet
Covered zone	14
Crinoidal limestone	3
Covered zone	22
Thin-bedded, fossiliferous limestones beside the private road to lower farm. Dip 25 degrees south 40 degrees east. Corals, *Leptaena rhomboidalis*, *Gypidula*, *Camarotoechia*, 3 sp., *Meristina*, *Atrypa reticularis*, etc.	35
Muddy, fine-grained, deep green sandstones, weathering red, interstratified with local lenses of impure limestones up to 4 feet thick. It is in these limestone lenses that most of the fossils occur. *Taonurus* is again common, and in the limestones occur corals and *Crotolocrinus* columnals. It is interesting to see here how corals and bryozoans grow in single heads on the mud bottoms, but eventually are turned over by the storm waves. Estimated depth out to low tide	120
Total sum of Indian Point formation	194

Age and Correlation

These formations, Clemville to Indian Point, are the equivalents, according to Schuchert and Dart, of all that is now included in the Niagaran series, that is, the Clinton and the Lockport groups, and they are thus different from the Silurian of Anticosti where there are no strata younger than Clinton. They were apparently deposited in shallow-water seas and tidal flats of the St. Lawrence geosyncline. Their faunas are quite different from the Silurian Arisaig series of the Acadian trough. Both of these seas had European connexions, the St. Lawrence with North Europe (Gotland) and with the interior of North America as well, and the Acadian trough with central Europe (Wales) and the southeast coast of the state of Maine.

BLACK CAPE

The Black Cape section is on the Gaspe coast about 45 miles west of Port Daniel. It shows a continuous succession of strata, dipping 60 degrees to the southwest, along nearly 2 miles of coast. The basal beds begin about 1 mile east of Little Cascapedia river. At the eastern end of the exposure the Black Cape limestones are involved with marine lava flows that end in land flows of great thickness. The section has been described by Logan (1863, page 447), Ells (1883, page 13), Clarke (1912, page 120, 1913a, page 110), and Schuchert and Dart (1926, page 57). The following is the succession of beds in ascending order as given by Schuchert and Dart.

	Feet
Base of the Silurian not visible. The lowest Silurian seen here is not as old as the oldest beds of the Port Daniel section.	
La Vieille formation of Port Daniel section, 990 feet thick.	
Thin-bedded, impure limestones with zones of shale and sandy limestones. Fossils very scarce except at about 190 feet above the visible base, where occur *Coelospira hemispherica*, *Chonetes*, and *Dalmanella rogata*.	225
Thin-bedded, knobby, impure limestones with greatest abundance of *Stricklandinia gaspiensis*. Corals occur also	35
Knobby limestones that become more and more muddy upward. Some layers sun-cracked. The slender-tubed *Syringopora compacta* is common and is identical with one collected at Anse à la Vieille east of Port Daniel. Thickness, estimated	310
Thin-bedded, shaly, impure limestones, much rippled and sun-cracked. Also some rain-pitting. Thin zones are made up of small *Stromatoporas* or calcareous algæ. Thickness, estimated	125
Thin-bedded and more or less nodular, impure limestones, showing 80 feet of thickness up to the crest of the anticline which strikes along the coast for an eighth of a mile.	80
Market headland composed of hard, dark blue, nodular limestones. Has a *Camarotoechia* zone 15 feet across	100
The knobby limestones become more and more impure to the east of the headland, pass into calcareous shales, and finally into sandy mudstones. They abound in fine corals and the beach here is strewn with them	115
It appears that Clarke made this thickness about 1,500 feet, but the writers could not estimate it as greater than 1,000 feet. The difference may be due to the presence of the anticline and the strike of the beds along the shore.	
Gascons formation of Port Daniel section, 3,400 feet. Greenish, somewhat sandy shales that weather yellowish, with scattering, thin zones of impure limestones across the Howatson property to Mr. Service's dock. *Taonurus* is common, but other fossils are very scarce. Average dip 60 degrees southeast. About	1,700
Sandy, greenish shales and sandstones, weathering yellowish, with zones of coral breccias and impure limestones. These beds extend east of Service's dock to two nodular limestone zones shown on Clarke's illustrated section of the Black Cape coast	1,700
Bouleaux formation of Port Daniel section, 2,670 feet thick:	
Sandy shales with zones of coral breccia 3 feet thick, and beds of impure, nodular, and even-bedded limestones	200
Sandy shales with an occasional impure, thin limestone	750
Laminated, sandy shale with a coral limestone	25
Sandy, calcareous, greenish shales with several coral breccias and impure limestones, showing current ripples and many sun-cracks just above the limestones.	90
Sandy, calareous shales, much sun-cracked and rippled. There is one bed of corals, and another in a breccia of fossils	60
Sandy, laminated, and much sun-cracked and rippled, calcareous, greenish shales, with a bed of calcite concretions. About 70 feet from the top of this zone there is an ash bed about 1 foot thick	165
Shale with four ash beds (lowest 8 inches; No. 2, 3 inches; No. 3, 6 inches; and the highest one about 30 inches)	6
Greenish, sandy shales beneath Black Cape section	700
Green shales that weather red, with sun-cracks and rain-pittings, up to a headland....	108
More of the same red-weathering, sandy shales up to the brook near the centre of Black Cape beach	375
Red-weathering, sandy, laminated, calcareous shales, much sun-cracked and rain-imprinted. Lower 25 feet with impure limestones having wave-washed and broken fossils. *Crotalocrinus* columnals. Strike north 30 degrees east; dip 60 degrees southeast	190
West Point formation of Port Daniel section, 325 feet of sediments and nearly 4,000 feet of basalt flows.	
Impure limestones, more or less sun-cracked, with scattered corals and one bed having an abundance of Leperditia	150
Two beds of slightly baked and hardened limestones or coral breccias	6
First marine basalt flow, more or less replete with amygdules, large and small masses of white limestone, and many fragments of shale	100
Crotalocrinus limestone (3 feet), followed by shale	10
Second marine basalt flow	20
Crotalocrinus limestone with a 2-foot flow of basalt	50
Third marine basalt flow and breccias with inclusions of limestone and shale	380
Interbedded limestone and shale of Macrea cove. Dip 90 degrees	100
Fourth or great and final basalt flow, about	3,500
Near the centre of this mass is Lazy cove, backed with about 75 feet of red clay, probably of the Bonaventure formation. Clarke gives the sea-face of this fourth flow as about 4,000 feet long. Great break in section. Devonian mountain-making followed.	

JACQUET RIVER SECTION

The Jacquet River section extends along the New Brunswick coast from a point one-half mile east of the mouth of Armstrong brook eastward for 3 miles. The section consists of a major syncline with one limb, the western, much better shown than the other. The section is disturbed by faults and local folds, is concealed in some places by the overlying Bonaventure series and in others by the gravel and sand of the shore. It is, however, possible to recognize certain members of the Silurian of the Port Daniel and Black Cape sections and even to form some fairly definite ideas regarding their thicknesses and structure. The range is from Clemville to Gascons, and the most striking feature is the great thickness of the Clemville. The fossil collections from this and subsequent sections were determined by E. M. Kindle and Alice E. Wilson.

At the east end of the section the first exposures of Silurian rocks are 3,600 feet east of Belledune pier (Figure 2). These rocks, which are covered at high tide, consist of hard, red sandstones striking from north 15 degrees east magnetic to north 21 degrees magnetic and dipping at angles from 33 to 50 degrees to the west. The exposures occur over a horizontal distance of 650 feet, which corresponds to a thickness of approximately 400 feet. No fossils were found in these sandstones, but they are considered to be Clemville.

For the next 1,035 feet along the shore normal to the strike of the rocks there are exposures of Bonaventure conglomerate, but none of Silurian. Then for 950 feet across the strike are exposed a series of limestones striking north 17 degrees east magnetic to north 60 degrees east, the average being north 30 degrees east. The beds dip to the northeast at angles ranging from 23 to 54 degrees, the average being 35 degrees. The rocks are grey to bluish limestones in beds up to 14 inches thick, and in places decidedly knobby. The lower 170 feet have a regular strike and dip and contain the following fossils: *Atrypa reticularis,* large type; *Stricklandinia* sp.; *Brachyprion* sp.; *Coelospira* sp.; *Favosites* sp.; *Zaphrentis* (?) sp.; large crinoid columns. Above these beds is a zone in which the limestones have a less regular structure, being locally broken, faulted, and dragged. One bed is marked by the presence of *Leperditia* sp. The thickness of this broken zone is ±200 feet. It is overlain by 170 feet of knobby limestone with a regular strike and dip and with the following fossils: *Heliolites interstinctus; Favosites* 3 sp.; bryozoa; gasteropods; stromatoporoids; brachiopods. The limestones with a thickness of ±540 feet belong to the La Vieille or perhaps in part of the transition from Clemville to La Vieille.

From the last exposure of these limestones to Belledune pier is a distance of 850 feet and from the pier west to the next exposure 650 feet. Assuming this interval to be underlain by Silurian beds having an average dip of 35 degrees the thickness of the concealed strata would be ±800 feet.

The next exposures are continuous over a horizontal distance of 500 feet. Their strike is north 33 degrees east magnetic. The dip of the lower beds is 25 degrees to the northwest, but higher up it increases to 45 degrees. The rocks are grey, sandy shales with thin beds of bluish limestone grading up into reddish, sandy shales with limestone interbeds. They contain

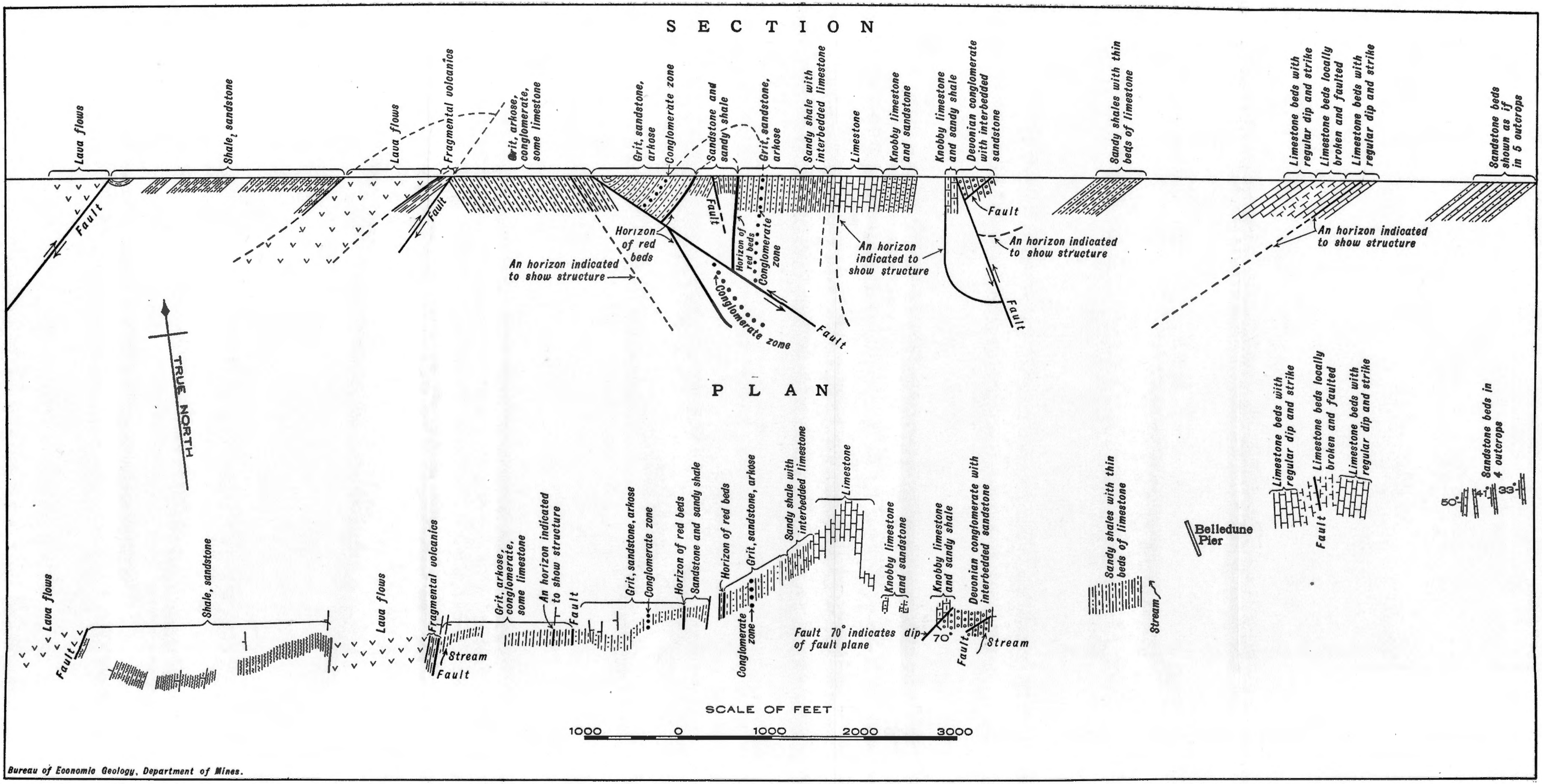
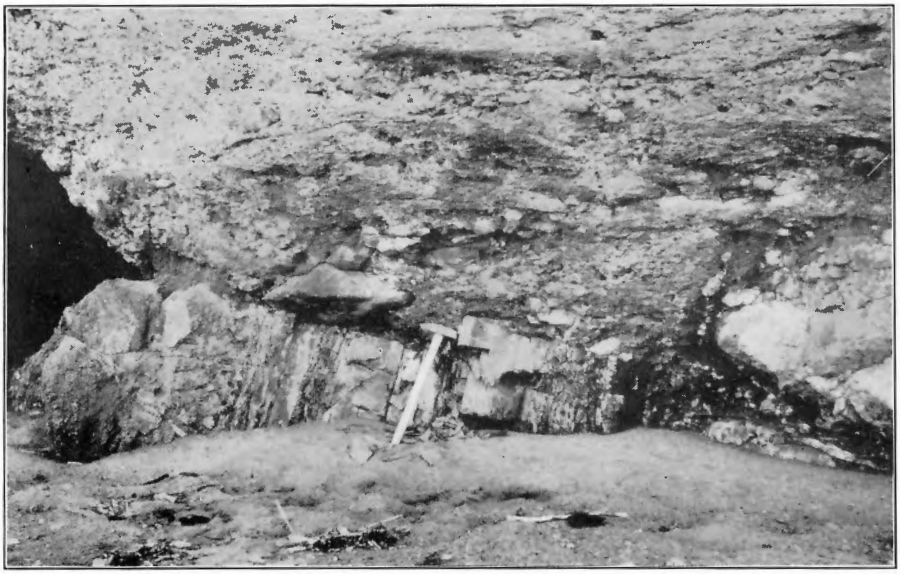
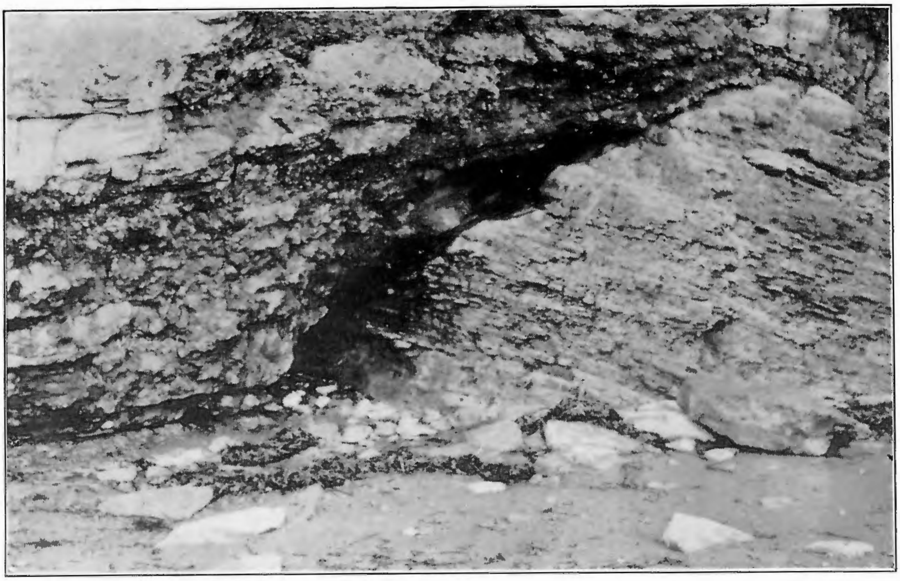


Figure 2. Geological section near Jacquet River, New Brunswick.



A. Bonaventure conglomerate resting unconformably on Silurian strata near Jacquet River.



B. A sea cave near Jacquet River showing Bonaventure conglomerate deposited against and over old cliffs of tilted Silurian strata.

brachiopods and corals including big *Favosites, Halysites, Syringopora, Alveolites,* Zaphrentoid types, *Atrypa reticularis,* and several species of bryozoa. The stratigraphic position of these beds and their characteristic lithology suggest a correlation with the Gascons.

Outcrops are again missing for a distance of 1,600 feet; at a point near the mouth of a small stream they begin again. The rocks here consist of conglomerate with finely banded sandstone layers. The boulders in the coarser beds are well rounded to subangular and consist of dense, reddish porphyry, dark volcanics, limestone, chert, serpentine, and a few are granite. Thirty-five feet west of the creek is a fault which brings reddish sandstone and conglomerate alongside grey sandstone. To the west of the fault the conglomerate is dominantly red, is interbedded with reddish and grey sandy beds, and is cut by veins of calcite and small stringers of siderite. The strike of the beds is north 33 degrees east and the dip is 80 degrees southeast. The beds are overlain unconformably by the horizontally lying red Bonaventure conglomerate. An interesting feature in the vertical conglomerate beds is the presence of water-worn corals occurring as boulders, and a few, well-rounded pebbles of limestone carrying Silurian fossils. The conglomerate is regarded as the basal beds of the Devonian. Other occurrences of similar beds will be described later in connexion with the Lower Devonian rocks.

At a distance of 430 feet west of the creek mentioned above, the Devonian conglomerate is brought by a fault into contact with vertical Silurian strata which strike north 33 degrees east, magnetic. The fault plane strikes northeast and dips 70 degrees to the southeast. The Silurian beds to the west of the fault consist of knobby limestone in beds 2 to 4 inches thick separated by beds of reddish, sandy shales. These are considered to represent the transition from the La Vieille to the Gascons. We are now on the western limb of the syncline.

For the next 170 feet the only outcrops are Bonaventure formation. The Silurian beds then begin to appear from beneath the Bonaventure, striking north 33 degrees east and dipping from 85 degrees to 90 degrees northwest. The eastern portion consists of knobby limestones separated by beds of reddish sandstone. To the west of this lie 500 feet of heavy-bedded, bluish limestones forming a prominent point. The beds have a steep dip to the northwest, but that they are overturned so that their upper side really faces southeast is shown by the attitude of the fossils. Stromatoporoids and corals are both very numerous and of large size, many being over a foot across. The tops of all the former and a large majority of the latter point to the southeast, showing that the beds have an overturned dip in that direction and that the whole series to the east has the form of a syncline. In the bay to the east of the point is a dyke 15 feet wide cutting the limestone, and at low tide to the west of the point is exposed a similar intrusive, possibly a continuation of the same dyke. The limestones on the point are highly fossiliferous. Towards the base of the limestones there is a zone marked by numerous specimens of *Stricklandinia gaspiensis,* the diagnostic fossil of the La Vieille. Other types include: *Atrypa reticularis, Leptaena rhomboidalis, Camarotoechia* sp.; *Brachyprion* sp.; *Schuchertella* sp.; *Wilsonia* sp.; numerous corals including, *Halysites, Favosites, Heliolites; Syringopora;* Zaphrentoid types; also bryozoa, trilobite fragments, and a few gasteropod and pelecypod species.

The heavy La Vieille limestones are followed to the west by sandy shales with interbedded limestones, the latter containing reefs of *Halysites, Syringopora,* and *Stromatoporoids.* This zone has a thickness of 300 feet and represents the top of the Clemville or the transition of the Clemville upward into the La Vieille. Westward or stratigraphically down in the section there is a great thickness of clastic beds with nearly vertical dips. They consist of grey grits, yellow and reddish to dark brown sandstones and arkoses, and one zone of conglomerate and interbedded arkose useful as a horizon marker. This zone is about 25 feet thick and contains well-rounded boulders and pebbles composed of volcanic rocks chiefly, but also of quartz and red and green chert. Above the conglomerate is a shaly sandstone containing a few pelecypods.

Beneath the conglomerate are more grey grits and yellow to brown sandstones. At a distance of 300 feet from it, immediately to the west of a small creek, is a horizon in this zone which, owing to its distinctive lithology, can be recognized again 400 feet farther west. It consists of deep red beds 15 feet thick underlain to the west by chocolate brown and grey beds. An interval of 90 feet with no outcrops follows. The next exposures lie beneath a capping of Bonaventure conglomerate and consist of grey, red, and brown sandstones and sandy shales which have been dragged and faulted. Three hundred feet to the west of the fault is the distinctive set of beds referred to above, which show that in this part of the section there is a local anticlinal roll. Though it is difficult, owing to local faulting, to be sure of thicknesses it would appear that there is approximately 1,100 feet of Clemville beds between the base of the La Vieille limestone and the axis of this anticlinal roll.

The western limb of this roll shows the same red, brown, grey, and mottled grits and sandstones as the eastern limb, but dipping about 60 degrees to the west. Two hundred and fifty feet stratigraphically above the key horizon mentioned above, the conglomerate zone is repeated at the place to be expected. It consists here of an upper bed 25 feet thick and a lower 10 feet thick separated by 10 feet of reddish sandstone. West of the conglomerate for 500 feet is an ascending series of coloured grits and sandstones. Beyond this the beds bend into a syncline pitching north, and on either side of its axis they are fossiliferous. On the western limb the dip of the beds to the east is 75 degrees; on the eastern dip to the west is only 20 degrees. For 1,620 feet westward from this axis the dips are eastward at angles of from 50 to 65 degrees, and it is evident that the beds are a descending series once more. The rocks consist of red, grey, yellow, and greenish grits and arkoses, with local limestone beds containing *Coelospira* and in places also *Favosites* corals. These rocks are underlain by 400 feet of dark brown to red grits and gritty conglomerates, a zone which is not repeated in the section. These in turn are underlain by yellowish grits and fine conglomerates which extend to a fault.

West of the fault the beds dip at angles of about 30 degrees to the west and consist largely of fragmental volcanic material. These are succeeded above by massive, dense, dark green to black lavas containing large amygdules of calcite and cut by calcite veins and stringers. The massive volcanics represent more than one flow. Near their base is a good contact between dense, dark green lava and an underlying amygdaloidal lava. The upper flow carries fragments of the lower. The massive lavas and the underlying fragmental volcanic material have a total thickness of 600 feet and extend along the shore for 1,050 feet. To the west above the volcanics are yellow and reddish shales and sandstones containing some fragmental volcanic material; and these are succeeded by reddish and yellow, sandy beds with which are interbedded limy bands containing crinoid columns and a few brachiopod fragments. The Silurian beds are capped, and in places concealed, by flat-lying beds of red Bonaventure conglomerate. About 1,500 feet along the shore west of the volcanic belt the dip of the Silurian sediments flattens out and farther on becomes reversed, forming a syncline. Altogether, an estimated thickness of some 800 feet of sediments, considered to be Clemville, are exposed above the volcanic band. West of this synclinal axis the section is cut by another fault, to the west of which are easterly dipping beds underlain by massive volcanics. This volcanic zone extends along the shore for 800 feet until it passes under Bonaventure rocks. Its thickness, therefore, is not known but is probably over 500 feet.

It is possible that the two zones of volcanics in this western part of the section are really the same horizon. The sediments lying above the eastern band of volcanics are clearly Clemville, both lithologically and faunally. Since no way was discovered of determining the throw of the fault that brought the eastern zone of volcanics to the surface it is not known how much of the Clemville succession is cut out. There is at least, however, 2,700 feet of beds below the conglomerate horizon, giving a minimum thickness for the whole Clemville of the section as 3,400 feet, without counting the volcanic zone.

CULLIGAN SECTION

Three-quarters of a mile south from the eastern part of the Jacquet River section the continuation of the same rocks is exposed in the railway cuts on either side of Culligan station. The railway traverses the section almost normal to the strike of the beds (Figure 3). The lowest rocks exposed outcrop in a field to the north of the railway track 2,300 feet east of the station. They are reddish sandstones dipping 48 degrees to the west, and a thickness of 200 feet is exposed. The next exposure is a low outcrop of calcareous sandstone on the south side of the track 1,600 feet east of the station. For the next 1,070 feet there are no exposures. Then from a point 450 feet east of the station to a point 270 feet west of it outcrops of limestone dipping 45 degrees to 48 degrees to the west are continuous. Towards the base is a zone containing specimens of *Stricklandinia gaspiensis.* The limestone is the nodular La Vieille and here contains specimens of *Atrypa reticularis, Spirifer* sp., *Tentaculites* sp.; *Schuchertella* sp., and large crinoid stems.

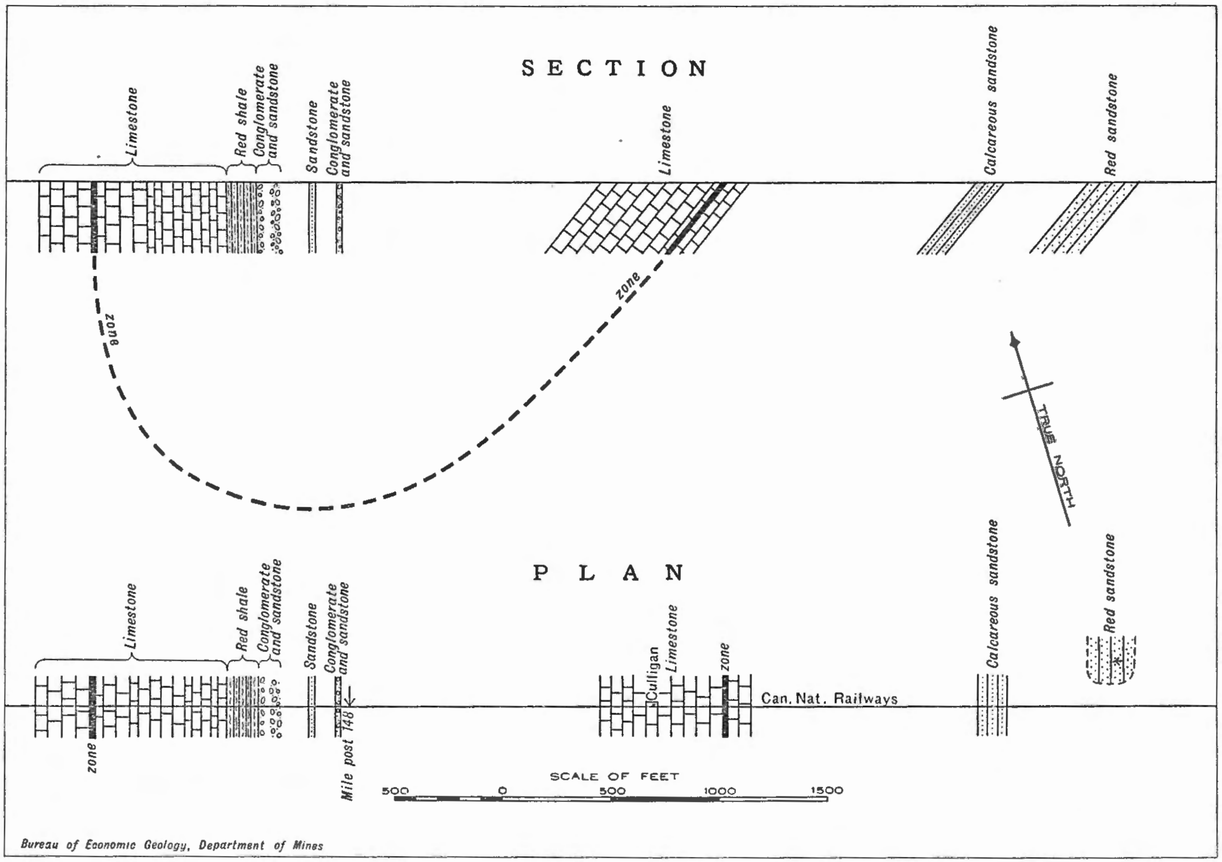


Figure 3. Geological section along railway at Culligan, New Brunswick.

West of these limestones the first exposures occur at distances of 30 and 110 feet respectively to the west of mile-post 148; these are two small outcrops of red sandstone, probably Gascons. The next exposures are conglomerate composed of boulders of volcanics, reddish porphyry and limestone, and pebbles of quartz. Some of the boulders have a diameter of 2 feet. The limestone boulders contain Silurian corals and in addition the conglomerate has water-worn, rugose corals and boulders of well-worn favosites. It is evidently the same horizon that was regarded as probably Devonian in the Jacquet River section. West of the conglomerate is a zone of reddish shales grading downward into a zone of nodular limestone beds alternating with red, shaly bands. This lower portion contains stromatoporoid reefs, big syringoporas, coiled gasteropods, etc. It represents a downward transition from Gascons to La Vieille. Below it are the typical La Vieille limestones. Towards the western end of the exposure is the zone containing many specimens of *Stricklandinia gaspiensis*.

The section, checking up as it does with the shore outcrops, helps to establish the synclinal structure of the Silurian rocks at this point. The syncline pitches to the north. The La Vieille limestone bands on the two limbs are farther apart in the shore section than in the railway section. The western limb evidently corresponds to the Black Cape section on the Gaspe shore.

BLACK POINT

Silurian rocks are exposed on either side of the volcanic mass forming Black point and outcrops continue westward for a mile from the point to the mouth of Dickie creek (Figure 4). The fragmentary character of the exposures and the irregular structure due to folding and faulting render the section of little value for determining succession or thicknesses.

At the mouth of Dickie creek the rocks are calcareous shales, thin-bedded and hard, interbedded with bluish limestone. The rocks are plentifully ripple-marked and show abundant dendritic markings that may be worm burrows. The beds strike north 71 degrees east magnetic and dip 78 degrees northwest. To the east they become more calcareous. A sill of dense, dark, igneous rock about one foot wide intrudes the series at one place. Fossils collected from these beds include: *Zaphrentis* sp.; *Favosites* sp.; *Orthis* cf. *flabellites; Stricklandinia* sp.; *Pentamerus oblongus; Atrypa reticularis;* cf. *Hindella* sp.; *Meristina* sp.; cf. *Diaphorostoma* sp.; *Leperditia* sp.; and trilobite fragments. Most of the specimens are so fragmentary that specific determination is impossible. East of these exposures there are no outcrops for 1,400 feet.

At the point a half mile east of Dickie cove limestone and calcareous shale form a low anticline pitching to the northeast. Beyond this there is another vacancy where no outcrops occur, but a quarter of a mile farther east in a bay exposures are continuous at low tide for a distance of 500 feet. They consist of limestones similar to the last outcrop and are folded into a sharp anticline whose eastern limit dips at angles of over 80 degrees. All these exposures to the west of Black point are considered to be Clemville.

To the southeast of Black point a band of sediments striking north 45 degrees east magnetic outcrops immediately adjacent to the volcanics. The beds are arenaceous limestones and shaly and calcareous sandstones cut by a weathered dyke 8 feet wide and underlain by amygdaloidal volcanics which are exposed at low tide to the south. The sediments carry a considerable fauna of Clemville corals and brachiopods. Six hundred feet south of this band is another group of sediments striking north 65 degrees east and

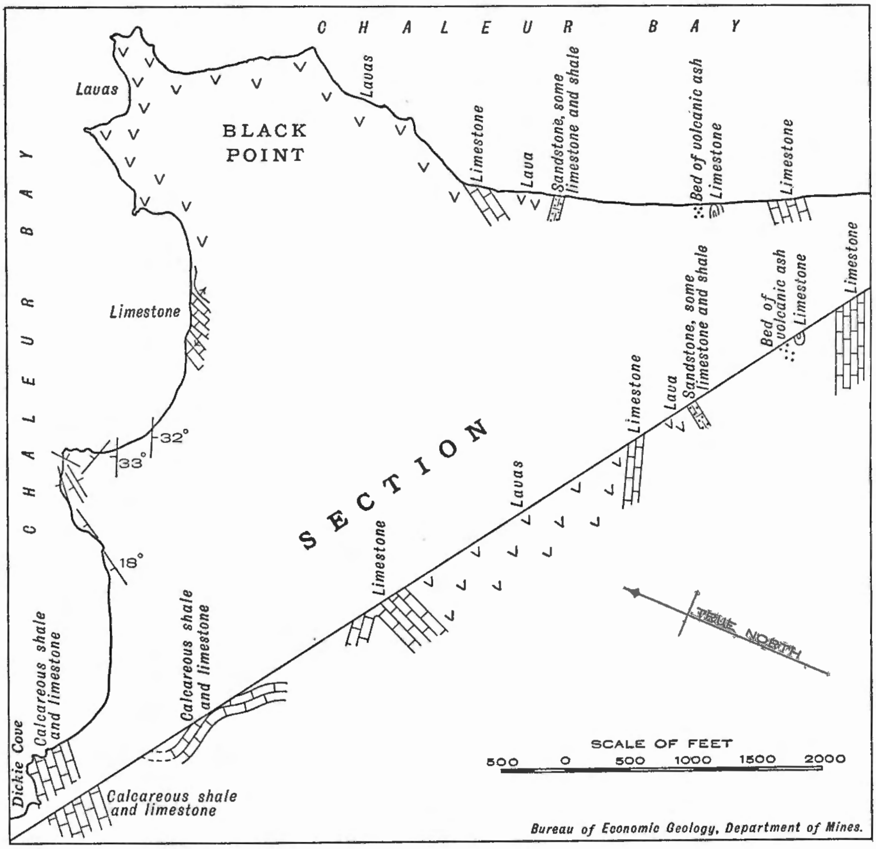


Figure 4. Geological section at Black point, New Brunswick.

dipping vertically. They are buff-weathering, argillaceous sandstones with some limestone and shale interbeds. A few fossils were found in them, and they are considered to be Clemville. South of this exposure outcrops are lacking for 1,100 feet. Here, however, a thin bed of volcanic ash is found and 100 feet farther south are thin beds of compact limestone folded into an anticline and broken by minor faulting. Another vacancy of 350 feet follows, beyond which outcrops of thin-bedded, hard limestone continue for 300 feet. These beds dip 43 degrees west and are cut by a basic dyke 15 feet wide. They yielded a few fossil fragments, but nothing diagnostic. Lithologically the beds resemble certain of those of the Matapedia river and are to be classed as of that age or as Silurian Clemville.

BLACKLANDS POINT

North of Blacklands station is a point composed of Silurian limestones. The rocks strike north 60 degrees west magnetic parallel to the shore, and dip to the southwest at angles of from 10 to 25 degrees. At least 290 feet of limestones are exposed at low tide on the point. A quarter of a mile to the northwest of Blacklands creek the same beds are exposed in a railway cut. The limestones are hard, bluish, and nodular. Coral reefs are fairly abundant. The beds also locally contain some cherty layers and masses and in places show ripple-marks. Both lithologically and faunally the rocks resemble the La Vieille limestones of other sections. One zone west of the point a short distance above high-water mark contains numerous specimens of *Stricklandinia gaspiensis*. The following fossils were collected from near the point:

Zaphrentis cf. *stokesi;* cf. *Amplexus* sp.; *Cyathophyllum* sp.; *Strombodes* cf. *mamillaris; Favosites favosus; F.* cf. *gaspiensis* Lambe; *Favosites* cf. *gothlandicus* (Fought); *Favosites* sp.; *Heliolites* cf. *subtubulatus* (McCoy); *H. interstinctus; Lyellia decipiens; Lyellia* cf. *exigua; Halysites catenulatus; Halysites catenulatus microporus* (Whitfield); *Stromatopora* sp.; *Dictyonema* sp.; crinoid stems of two species; *Orthis* sp. probably *O. flabellites; Leptaena* sp.; *Stricklandinia gaspiensis* (Billings) *Rhynchotreta* cf. *cuneata americana; Atrypa reticularis; Spirifer radiatus; Homeospira* sp.; *Meristina* sp.; *Diaphorostoma* cf. *niagarense* (Hall); *Encrinurus* n. sp.; cf. *Acidaspis* sp.

The outcrops nearest to the limestones are to the southeast, where across a bay, on a point, is exposed a red conglomerate dipping northwest and overlain by volcanics. Both conglomerate and lavas are considered to be of Lower Devonian age.

PETIT ROCHER SECTION

A Silurian section (Figure 5) begins at Limestone point a mile north of the mouth of Elmtree river and continues along the shore southward for 6 miles, past Petit Rocher, to a point south of the mouth of Nigadu river. For most of this distance the outcrops are low and parts of the section can be seen only at low tide.

At the northern end of the section the Silurian rocks lie adjacent to massive volcanic rocks which form almost continuous outcrops along the shore northward for 4 miles. The contact between the two series is apparently a fault striking northeast, along which the relative movement has been southwest on the northwest side and northeast on the southeast side.

The lowest beds of the Silurian section are dense, red, shaly rocks forming the northern tip of Limestone point. They are locally deformed and their attitude in most places is difficult to ascertain. Locally, however, they show colour banding which strikes south 40 degrees east and dips

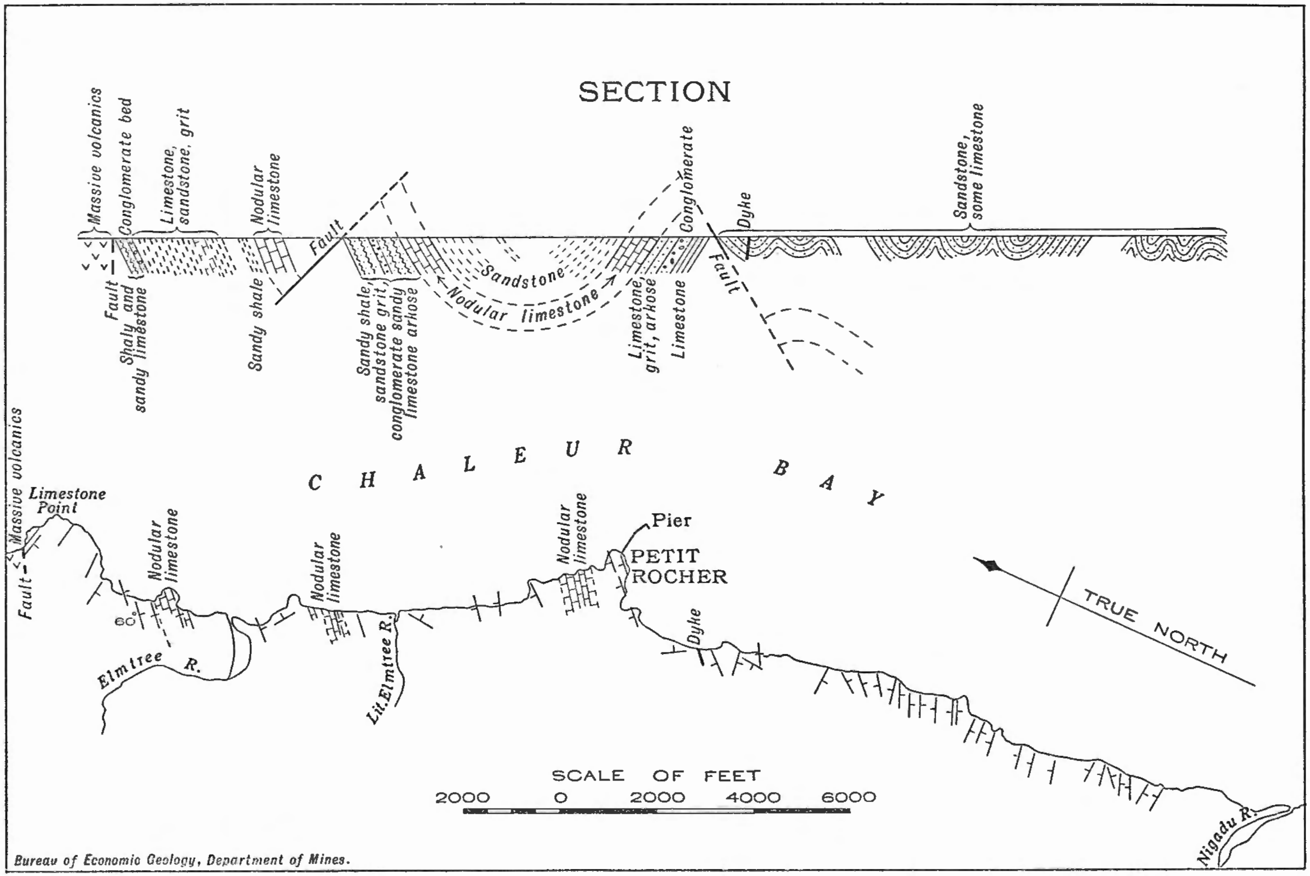


Figure 5. Geological section at Petit Rocher, New Brunswick.

steeply to the southwest. The thickness of the red rocks is about 160 feet. They are overlain by about 30 feet of greenish grey, fossiliferous, sandy limestones and shales which can be traced across to the bay west of Red point and south of the exposures of the massive volcanics. These beds strike south 45 degrees east magnetic and dip 60 degrees to the southwest. They are in turn overlain by a bed of red conglomerate, 15 feet thick, whose well-rounded pebbles are composed of quartz, dark volcanic rocks, and red chert. Above it are well-bedded, reddish grits with conglomeratic beds. Forty feet above the conglomerate zone there is another abrupt change from deep red grits to greyish green, calcareous beds. In places this change is marked by a gradational zone 2 feet wide, containing syringopora. From here to the south side of Limestone point is a thick series of limestones with sandstone and grit beds striking and dipping irregularly, the general trend, however, being northwest and the dip southwest. Locally the limestone is pink and similar limestones occur as pebbles in the conglomerate at Turgeon, to be described later as Lower Devonian. At Limestone point and immediately to the north of it the following fossils were collected.

> *Stromatopora; Zaphrentis* sp. cf. *stokesi; Cystiphyllum* sp.; *Favosites gothlandicus; Favosites* cf. *helderbergiae praecedens; Favosites* sp.; cf. *Lyopora* sp.; *Lyellia decipiens; Syringopora compacta; Syringopora* sp.; *Orthis flabellites; Leptaena* sp.; *Camarotoechia fringilla; Camarotoechia* sp.; *Spirifer* sp.; *Actinoceras;* crinoid stems.

From the same locality Young reports in addition *Halysites catenularia* and *Halysites catenularia* var. *micropora.*

South of Limestone point sandy shales are exposed at low tide. These strike north 66 degrees east magnetic and dip 70 degrees to the southeast. They carry an assemblage of Clemville fossils. Seventeen hundred feet north of the mouth of Elmtree river a zone of heavy-bedded, bluish, nodular limestone begins and outcrops for 500 feet. These beds strike north 70 degrees east magnetic, dip 80 degrees to the southeast, and contain specimens of *Stricklandinia gaspiensis*. This zone clearly represents the La Vieille and all the rocks beneath it are regarded as Clemville. The total thickness of the Clemville is estimated at 2,600 feet.

The next outcrops begin 300 feet south of the mouth of Elmtree river. They consist of sandy shales and shaly sandstones striking north 80 degrees east magnetic, dipping 60 degrees to the south, and containing a few rugose corals. They grade upward into grits, conglomerates, and sandy limestones; and a low point 1,400 feet south of the mouth of Elmtree river is composed of red arkose typical of the Clemville. To the south of this point and north of the mouth of Little Elmtree river the La Vieille limestones are repeated, striking northeast and dipping southeast. A fault in the vicinity of the mouth of Elmtree river has caused this repetition of the strata. The fault is a normal one with a throw of approximately 2,800 feet. The amount of Clemville exposed between the fault and the base of the La Vieille to the east is 1,100 feet.

The La Vieille limestone north of Little Elmtree river is overlain by red and greenish sandstones which outcrop at intervals along the shore for over 4,000 feet. For the first half of this distance the prevailing dips are to the southeast, but for the second half they are uniformly to the northwest, showing a syncline. The only fossils observed were a few rugose corals collected at a point 2,800 feet south of the mouth of Little Elmtree river. The lithological character of these beds and their position above the La Vieille suggest a correlation with the Gascons of the Port Daniel area.

Immediately below these beds, or 1,500 feet north of Petit Rocher pier, a third band of La Vieille appears, establishing definitely the synclinal structure referred to above in connexion with the Gascons. The thickness of the La Vieille here, measured from the width of the band and from the average dip, is 800 feet, though local shearing may make this estimate either too great or too small. The following fossils were collected from the La Vieille beds at this point:

Zaphrentis sp.; *Favosites* sp.; *Lyellia exigua; Lyellia* sp.; *Stricklandinia gaspiensis; Pentamerus oblongus; Atrypa reticularis; Ambonychia* sp.; *Byssonychia* sp.; *Diaphorostoma* sp.

To the south the La Vieille limestones are underlain again by Clemville beds of which a thickness of 850 feet is exposed, beginning 800 feet north of Petit Rocher pier. The upper Clemville beds are limestones and grits underlain by red grits, arkoses, and conglomerates. One limestone zone, 10 feet thick and interbedded in this red zone, contains numerous fossils. The red beds for a foot above this fossiliferous zone contain waterworn corals, evidently torn loose by wave action. At Petit Rocher pier the exposures are of coarse, red conglomerate whose boulders consist chiefly of massive volcanic rocks with quartz, red chert, and green chert in minor amounts. These rocks extend westward from the pier along the shore and are underlain by grey limestone which is exposed at low tide only.

South of Petit Rocher low exposures continue along the shore. These consist of reddish and greenish, shaly sandstones with local beds of grey limestone. The whole series is thrown into anticlines and synclines, the attitude of the beds in most places being readily recognized from the colour banding. A striking structural feature, distinct from the bedding, is a fracture cleavage which strikes in a northeast direction regardless of the direction of the bedding and stands vertically. The pitch of the folds where observed is to the east. The only fossils collected from the rocks are a few corals and brachiopods. Towards the north limit of these outcrops is a small exposure of a basic igneous rock, possibly a dyke cutting the beds. It is not know definitely whether these closely folded strata should be correlated with the adjacent Clemville or with the Gascons. In the section (Figure 5) they are correlated with the latter. This interpretation demands a fault southwest of Petit Rocher pier, cutting out the lower Clemville beds.

Along Nigadu river are exposed rocks evidently the same as those in the shore section to the north and the south of the mouth of that stream. They consist of reddish, grey, and greenish grey sandstones and sandy shales usually showing good colour banding, and, locally, crossbedding. They are for the most part much jointed and in places show a good fracture cleavage. Poor fossil remains occur locally, the best locality being along the river about 4 miles in a direct line from the coast. The fossils collected here include crinoid stems, some corals, including *Heliolites inter-*

stinctus, Zaphrentis or *Streptelasma,* and a brachiopod fragment suggesting the striæ of Coelospira. Farther up stream fissile sediments form extensive outcrops. The bedding is usually well shown, but the more characteristic structural feature is the cleavage which strikes in a northeast direction. At the falls on Nigadu river, near Nigadu lake, about 4 miles west of Free Grant, the rocks are grey, fissile shales with a few fossil remnants.

West of Ste. Rosette, on a branch of Millstream river, similar sediments locally show fossil remnants. On account of the altered character of the rocks the boundary of this Silurian belt with the Ordovician sediments to the south is difficult to define. South of Ste. Rosette a band of conglomerate on the south side of Millstream valley contains pebbles of red chert and other rocks characteristic of the Ordovician belt to the south. For lack of better evidence this conglomerate was taken to mark the southern limit of the Silurian.

BELLEDUNE SECTION

A section of Silurian rocks begins on the shore immediately north of the mouth of Henry brook and continues southeast for 3½ miles to a point south of Green Point wharf. Beds are exposed also on the lower parts of Hendry and Quitard brooks. The section is unsatisfactory for measuring thicknesses owing to the irregularity of strikes and dips and to the fact that the shore where the strata can best be seen either follows the strike of the rocks or crosses it at a low angle. The lithology of the sediments and the numerous fossils they contain suggest that they are Clemville.

The rocks exposed on either side of the mouth of Henry brook consist of sandy limestone in beds up to 15 inches thick, and locally reddish in colour. They strike from north 5 degrees east to north 26 degrees east magnetic and dip steeply to the northwest. They contain numerous corals, including: *Favosites, Halysites, Syringopora, Cladopora,* long rugose types, a stromatoporoid, bryozoa, a few brachiopods including *Leptaena rhomboidalis* and one, very characteristic of the Clemville, *Orthis flabellites.* Thin patches of Bonaventure locally overlie the Silurian beds. Sixteen hundred feet south of the mouth of Hendry brook the beds are cut by a dark brown to green dyke 20 feet wide. A second small dyke cuts arkose 700 feet farther south.

Along the shore 3,000 feet south of the mouth of Hendry brook, volcanic outcrops begin. They are dense, dark green, massive rocks, locally epidotized and cut by small quartz seams. These outcrops continue for a mile and a half. They are apparently in fault contact with the Clemville beds to the west.

From the southerly limit of these volcanics to Green Point wharf, a distance of over 1¼ miles, the rocks exposed are red sandstones, arkoses, and conglomerates, the last made up of boulders and pebbles of volcanic rocks, quartz, red chert, and green chert. No limestone pebbles could be found in any of the rock in place. At one locality the clastic beds have interbedded with them some limestone bands which lithologically resemble the Clemville and the whole series is regarded as belonging to that division. A large boulder of red conglomerate carrying water-worn rugose corals was observed in this region, but it is believed to be an erratic carried eastward from the area of red Devonian conglomerate at Turgeon.

MOULIN CREEK

Where the Gaspe highway No. 6 crosses Moulin brook, beds of Lower Devonian amygdaloidal lava, tuffs, and shales outcrop, and a quarter of a mile upstream other fossiliferous Helderberg shales are interbedded with a lava flow about 60 feet thick and showing ellipsoidal structure. There are no outcrops for the next ten chains, but above this Silurian rocks are abundant for over 1½ miles. These beds have an irregular structure with a great variety of dips and strikes. They consist of limestones, in some places nodular, and in others shaly. Fossils are locally abundant and consist of rugose corals, *Favosites, Syringopora, Halysites,* stromatoporoids, *Atrypa reticularis,* rhynchonellids, pentameroids including *Stricklandinia gaspiensis,* branching bryozoa, etc. These rocks are in turn succeeded by the altered limestones and argillites of the Matapedia group. The Silurian belt is narrow here, the steep hills to the west consisting of the Matapedia sediments.

SOUTH CHARLOT RIVER

Along the lower part of South Charlot river the rocks are volcanics, probably of Lower Devonian age. A quarter of a mile above Charlot falls Silurian sediments outcrop. They have an irregular strike and dip and consist of limestone in places nodular and carrying favosites, halysites, heliolites, and some rugose corals. The next outcrops upstream are volcanics which continue for 3 miles except for one stretch of half a mile where they are overlain by a syncline of Devonian limestone. Farther upstream Silurian strata are again encountered. This part of the river flows through a narrow valley which in places has nearly vertical walls 100 feet high and through which one can pass only at periods of low water. The rocks have an irregular strike; their dips are for the most part downstream at angles less than 30 degrees. The beds consist of limestones locally containing stromatoporoids, *Favosites* reefs, *Halysites,* cup corals, and some brachiopods, including *Coelospira* and pentameroid beaks. At one place a dyke of vesicular basalt, 7 feet wide, cuts the series, and farther upstream are numerous exposures of basic, igneous rocks associated with the sediments.

MATAPEDIA VALLEY

The Silurian series is not well exposed in Matapedia valley; the type sections are incomplete and even composite sections do not give the full sequence. Further work in adjoining regions is needed in order to determine the complete succession. As indicated by Ells (1885, page 29) outcrops of the series are restricted to the neighbourhood of lake Matapedia and a few localities between the lake and Causapscal. At lake Matapedia the beds form a shallow structural basin. The basal beds occur along the shore of the lake and, although they were given no name, the two basal formations were recognized as distinct units by Richardson as early as

1858. Higher Silurian strata, not previously recognized, were found by Crickmay in 1929 to the west of lake Matapedia in the central part of the basin. The succession, according to him, in descending order is as follows:

	Feet
St. Leon formation:	
Argillaceous sandstone and limestone conglomerate	2,000
Sayabec formation:	
Dark grey, dense limestone	300.. 500
Val Brillant formation:	
White sandstone	200

All these formations are fossiliferous and their fauna indicates that the series is equivalent to the lower part of the Chaleur Bay series. They were deposited in the same seaway, the beds at lake Matapedia being regarded as equivalents of the La Vieille, Gascons, and Bouleaux formations. The section is probably much less complete than those at Black Cape and Port Daniel, representing merely the overlapping edges of the Chaleur Bay formations on the northern margin of the seaway.

Val Brillant Formation

The Val Brillant formation is a white sandstone lying at the base of the Silurian section at lake Matapedia. It is typically exposed along the southwest shore of the lake from Val Brillant northwestward for 1¼ miles. The details of the section at Val Brillant are not well shown as, for the most part, only the massive beds outcrop. The following section is exposed along the shore 1¼ miles northwest of Val Brillant:

	Feet
Sayabec formation	
Unexposed	25
Heavy bed of white quartz sandstone	12
Thin-bedded, pale brown sandstone with rust-coloured streaks	15
Heavy bed of pale brown sandstone	9
Thin-bedded sandstone	5
Unexposed	25
Thin-bedded, pink sandstone	3

At a prominent point 2¾ miles east of Sayabec is another good exposure of the formation. The beds here are sharply upturned and in places are broken and slickensided. The following section is measured above the fault zone, along the south side of the point:

	Feet
Sayabec formation	
Covered by beach gravel	35
Alternate heavy and thin-bedded sandstone	80
Unexposed	25
Heavy-bedded sandstone	70

Two miles directly east of the south end of lake Matapedia, on the south side of the road leading from Amqui to St. Jean Baptiste de Vearney, is a low ridge of the Val Brillant formation from which rock was quarried for the church at Amqui. The beds consist of massive white quartz sandstone with fossil fragments. The formation is also exposed to the west of Val Brillant in the Notre Dame mountains where the geology is complicated by steep structures. Here the sandstone has been altered to a pink quartzite.

The lithology of the Val Brillant formation is fairly uniform. The massive sandstone beds, which alternate with thin, slaty beds, are commonly crossbedded. The size of the quartz grains varies but little, the average diameter being from 0·2 to 0·6 millimetre. They are subangular to round, clear, and well worn. Pyrite grains are sparsely distributed through the rock, being more common in the thin-bedded portions than in the massive and giving to the former a prevailing light brown colour. In the massive beds the pyrite grains are surrounded by a yellowish brown limonite stain which gives a speckled appearance to the rock. Where the sandstone has been altered by deformation to a quartzite the rock is commonly brecciated and traversed by slickensided surfaces, smoothed and crossed by scratches and grooves.

In thin section the sandstone is seen to consist almost entirely of well-rounded quartz grains with a brown iron stain coating. The interstices are filled with secondary silica, crystallized in optical continuity with the grains. Sections of the sandstone at Val Brillant show strain shadows in the quartz, but no cataclastic deformation. Sections of the same sandstone in Notre Dame mountains show a great deal of deformation, the grains of quartz being broken up into small, angular pieces. In places the rock is brecciated and the broken grains fill the fractures between blocks that have not suffered so severely.

The fossils found in the sandstone are from loose blocks in the fields on the west side of the railway track, three-quarters of a mile north of Val Brillant. Though the fossiliferous beds were not found in place the distinctive lithology leaves little doubt that the loose blocks were derived from the sandstone outcropping nearby. The fossils are preserved, for the most part, as internal and external moulds. The following forms have been identified from this locality by Crickmay:

> *Palaeocyclus* n.sp. aff. *P. rotuloides* (Hall); *Zaphrentis* sp.; *Phacops* sp.; *Orthis* n. sp. aff. *O. flabellites* (Hall); *Leptaena rhomboidalis; Brachyprion* sp.; *Pentamerus* n. sp. aff. *P. oblongus* (Sowerby); *Stricklandinia* sp. fr. *S. gaspiensis* (Billings); *Stricklandinia* sp. fr. *brevis* (Billings); *Spirifer* sp.; *Poleumita* n.sp., *P. transversalis* (Prouty); *Loxonema* sp.; *Eotomaria* sp.; *Leperditia* sp. fr. *L. alla* (Conrad).

Bailey and McInnes made a collection of fossils from loose blocks at the same locality. These were identified by H. M. Ami as follows: (Bailey and McInnes, 1889, page 14.)

> Crinoid columns; *Zaphrentis* or *Streptelasma; Orthis* (?) sp.; *Pentamerus oblongus* (Sowerby); *Murchisonia* sp.; *Oriostoma* sp.; *Lichas* sp.?

This fauna is clearly of Niagara age, but the condition of preservation of the fossils, which makes exact specific identification impossible, renders exact correlation difficult. *Palaeocyclus rotuloides* is present in the upper Clinton of New York, Pennsylvania, and Maryland. The same species occurs in the lower arenaceous part of the La Vieille formation of the Chaleur Bay series and in the Jupiter River formation of Anticosti. *Stricklandinia brevis* is found in the upper part of the Jupiter River formation. A small variety of *Stricklandinia* similar to that in the Val Brillant formation occurs in the Clemville formation of the Chaleur Bay series. The formation, then, appears to be the equivalent of the Clinton of New York state and of the lower part of the Chaleur Bay series.

The Val Brillant formation is apparently present both to the east and to the southwest of lake Matapedia. On Matane and Cap-Chat rivers

Logan describes a yellowish white quartzose sandstone which is apparently this formation; on the Matane and its tributaries, the Trout and the Tawagadik, he gives its thickness as 75 feet (1863, page 413). On the Cap-Chat the thickness is 50 feet (1863, page 411); it rests unconformably on volcanics similar to those that outcrop on the northeast side of lake Matapedia, and is succeeded by limestones apparently equivalent to the Sayabec formation. Richardson reports (1859, page 154) that many, loose, angular blocks of similar fine-grained, white sandstone occur to the west of lake Matapedia on Grand Metis river, a little below the mouth of the Musquegegish. The base of the Mount Wissick section on lake Temiscouta consists of similar white sandstones. Bailey and McInnes (1889, page 30) refer to these beds as Helderberg, but the succession and fossil lists suggest rather that the series is Silurian.

Sayabec Formation

The type exposure of the Sayabec formation is in a quarry on the shore of lake Matapedia 3 miles east of Sayabec. Here the formation may be divided into two parts, a lower of nearly unfossiliferous, sandy limestone and dolomite and an upper of dense, argillaceous limestone.

The lower part is exposed along the lake shore north of the quarry and in a low ridge running westward from the lake shore and passing through Sayabec less than one-quarter of a mile north of the railway station. It is at least 140 feet thick, the base being concealed where an interval of 35 feet of sediments is covered with beach gravel. The dolomitic beds contain a few corals, *Halysites catenulatus* and *Stromatopora* heads; otherwise they are practically barren of fossils. In another small quarry about three-quarters of a mile east of Sayabec are exposed crossbedded dolomites and finely bedded limestones of this lower division. Some of the beds are filled with crinoid columnals of small diameter.

The upper part of the Sayabec formation at the type exposure is a grey, dense, argillaceous limestone whose total thickness is computed to be 120 feet. The lower part consists of practically unfossiliferous, thin-bedded limestone. A bed about 30 feet above the lower dolomite part contains a great number of irregular, tabulate corals. Above this zone the limestone is hard and massive and fossils are fairly abundant.

The Sayabec formation is exposed in two adjacent quarries 1½ miles north of Val Brillant. The limestone here is unfossiliferous except for a bed at the top of the northern quarry, in which numerous corals are present. This horizon is probably equivalent to the similar zone in the type section, and the unfossiliferous limestones that occur below this horizon in both sections are probably also equivalent. The lower, dolomite part of the formation exposed in the type section is here missing. There is a gap, however, of 30 feet between the top of the Val Brillant formation and the limestone. Even if the lower part of the Sayabec is represented by this gap it must be considerably thinner at this locality, showing evidence of lateral variation in the formation.

The fossiliferous beds of the upper part of the type section are the highest beds exposed. The overlying St. Leon formation outcrops 3 miles to the southwest on the south side of the Lake Matapedia basin, so that it is not known just how thick the Sayabec formation is. Limestone was exposed in the excavation of a road ditch 1¼ miles west of Val Brillant; if this belongs to the Sayabec formations, as it appears to, it is the only known occurrence of the formation on the south side of Lake Matapedia basin. The St. Leon formation occurs above the limestone in this vicinity, and as the Val Brillant occurs below, the thickness of the intervening strata can be determined as 500 feet.

The following is a summary of the sequence, most of which is exposed in the type section:

	Feet
St. Leon formation	
Unexposed interval, approximately	205
Fossiliferous, grey limestone	40
Coral zone	1
Alternate thin and heavy beds of limestone, unfossiliferous	50
Grey, sandy limestone and dolomite	140
Unexposed	35
Val Brillant formation	
Total exposed section of Sayabec formation	296
Maximum thickness, approximate	500

Fossils collected by Crickmay from the type locality include: *Stromatopora* sp.; *Zaphrentis* (?) sp.; *Favosites* 2 sp.; *Syringopora* sp.; *Halysites catenulatus* (Linnaeus); *Brachyprion profundum* (Hall); *Amphistrophia* n. sp. aff. *A. striata* (Hall); *Atrypa reticularis* (Linnaeus); *Whitfieldella* sp.; *Camarotoechia* 3 sp.; *Poleumita* sp.; *Diaphorostoma* sp. fr. *D. niagarensis* (Hall); *Dalmanites* sp. fr. *D. limulurus* (Green).

In addition to the above, Logan mentions (1863, page 415) the following: *Leptaena rhomboidalis* (Wilckens); *Sieberella galeatus* (Dolman); *Crispella crispus* (Hisinger); *Eospirifer radiatus* (Sowerby).

This fauna is certainly Middle Silurian, but to which subdivision of the Chaleur Bay series it corresponds is not known.

St. Leon Formation

The typical exposure of the St. Leon formation is in the axis of the Lac au Saumon anticline at the village of St. Leon on Amqui river. Here a hill, 400 feet high, rises on the north side of the valley. The structure at this point is complicated by several small faults and only an approximate section can be given. The base of the formation is not exposed. The lowest exposed beds, consisting of grey argillaceous siltstones, in places calcareous, outcrop on the lower, south slope of the hill and dip 10 degrees northward into the hill. Overlying these beds is a limestone conglomerate whose outcrop is terminated 30 feet from its base by a fault, interrupting the sequence. North of the fault is a steep syncline of limestone conglomerate with interbeds of grey limestone forming a zone 50 feet thick. These beds are succeeded by grey and reddish, sandy and calcareous shales, extending to the peak of the hill. The section is fossiliferous throughout, but the strong secondary cleavage that cuts the rocks at an angle to the bedding makes collecting difficult. The beds near the crest of the hill contain the most fossils. To the northeast on neighbouring hills and in the bed of Amqui river grey and green argillaceous siltstones are exposed. These beds apparently overlie the section at St. Leon, being on the north limb of the Lac au Saumon anticline, and are succeeded northward by the shales of the Devonian Causapscal formation.

No complete section of the St. Leon formation is exposed in the area. At St. Leon there is apparently about 2,300 feet of sediments belonging to the formation, but since there are several small faults this figure can be regarded only as a rough estimate. On the north limb of the Albertville anticline where that structure crosses Matapedia river (Figure 9, page 104), the formation shows about 2,500 feet of thick-bedded sandstone and thin-bedded argillaceous siltstone with the base not exposed. On the south limb of the anticline the thickness is apparently greater but this is due to the presence of drag-folds which increase the width of outcrop. On the same south limb, about 3 miles northeast of Matapedia river, numerous specimens of *Monograptus* were collected in an outcrop on the northwest trending road where it crosses a small creek. The formation is exposed also on Causapscal river 2½ miles upstream from its mouth at Causapscal. The strata here are green, argillaceous siltstones. The limestone conglomerate exposed at St. Leon is apparently absent from this section and that on the Albertville anticline.

The St. Leon formation also outcrops in Lake Matapedia basin and everywhere contains fossils. The most prominent exposures are 3 miles west of Val Brillant and consist of a band of limestone conglomerate that is underlain by fine-grained, argillaceous siltstone becoming more calcareous towards the base. The lowest beds observed contain thin limestone beds and lenses, suggesting a transition to the Sayabec formation.

It is possible that the limestone conglomerate of Matapedia basin and that at St. Leon represent different stratigraphic horizons or, if the same horizon, are not continuous but in the form of lenses. The pebbles are of a dense grey limestone, quite distinct from the Sayabec limestone. They vary in size from about 1 inch to 6 inches, and are subangular to round. Their smooth outlines are commonly broken by indentations, which, in a few cases, nearly transect the pebble. The outlines of the pebbles, then, are mainly determined by solution rather than by the abrasive action of waves.

The matrix of the conglomerate is of two types, a fine-grained, argillaceous sandstone that appears as matrix and as interbeds 2 or 3 feet thick, and a limestone made up of disseminated shell fragments cemented by lime. The crossbedding of the sandstone interbeds and the comminuted shell fragments in the limestone point to shallow water deposition on a sea floor which at times was above wave base.

Both matrix and pebbles contain fossils. As the same species occur in both, they are regarded as contemporaneous. *Monograptus* occurs in the sandstone interbeds. *Stromatopora* and *Favositis* occur as pebbles and the latter is also found in the matrix.

The origin of the limestone pebbles is suggested at the type section of the St. Leon formation on Amqui river. Here thin-bedded limestone occurs near the base of the limestone conglomerate and is apparently the source of the pebbles directly above. The conglomerate, therefore, does not represent any great time break but merely an abrupt change from one type of deposition to another.

The most fossiliferous part of the St. Leon formation is the lower portion exposed in Lake Matapedia basin. Four miles southwest of Val Brillant the lowest beds of the formation are exposed in a series of road cuts and low outcrops and yielded the following fossils: *Monograptus* sp.; *Leptaena rhomboidalis* (Wilckens); *Chonetes novascoticus* (Hall); *Atrypa reticularis* (*Linnaeus*); *Cyrtia* n. sp. aff. *C. exporrecta* (Wahlenberg); *Dalmanites* sp.

From the limestone conglomerate, which is exposed 1 mile to the northeast of these outcrops and which lies about 1,000 feet stratigraphically above them, Crickmay collected the following: *Monograptus* sp.; *Heliolites interstinctus* (Linnaeus); *Favosites* fr. *F. niagarensis* (Hall); *Resserella* f. *waldronensis* (Foerste); *Sowerbyella* n. sp. aff. *S. transversalis* (Wahlenberg); *Leptaena rhomboidalis* (Wilckens); *Schuchertella* sp. fr. *S. rugosa* (Swartz); *Stropheodonta* sp.; *Wilsonia* sp. fr. *W. saffordi* (Hall); *Wilsonia* sp.; *Atrypa reticularis* (Linnaeus); *Eospirifer* fr. *E. niagarensis* (Conrad); *Crispilla* fr. *C. crispus* (Hisinger); *Encrinurus* sp.

The above species were collected from the matrix. From the pebbles were collected the following: *Stromatopora* sp.; *Favosites* fr. *F. niagarensis* (Hall); *Eospirifer* fr. *E. niagarensis* (Conrad).

The limestone conglomerate at St. Leon is unfossiliferous, but above and below it fossils are common. They include *Isorthis* 2 sp.; *Leptaena rhomboidalis* (Wilckens).

The formation is of late Middle Silurian age, probably equivalent to the middle part of the Chaleur Bay series, the Gascons and Bouleaux. In a general way its lithology is similar to that of these two formations and the evidence of the fossils points to this correlation. *Monograptus* occurs in the Gascons and also at the base of the St. Leon. *Conchidium knighti* is present near the top of the Bouleaux and this genus is present in the St. Leon formation at lake Matapedia, although the single specimen collected is too fragmentary for specific identification. The other species are in harmony with this correlation. The unfossiliferous upper part of the St. Leon may be of later date. However, the combined thickness of the Gascons and Bouleaux, 2,750 feet, is somewhat greater than that computed for the St. Leon, 2,300 feet.

The St. Leon formation is present to the west of lake Matapedia. On the Grand Metis near the mouth of its tributary, the Musquegegish, the limestones that appear to be equivalent to the Sayabec are succeeded by limestones interstratified with greenish shales. Towards the top of the section the beds become more argillaceous and arenaceous, their total thickness, according to Richardson (1859, page 154), being 2,000 feet.

Near St. Gabriel the limestone of Neigette falls, which is believed to be the equivalent of the Sayabec formation, is overlain by a series of hard, calcareous sandstones. Bailey and McInnes (1889, page 17) traced these beds westward to Bois Brûlé mountain. Near Ste. Blandine they record a limestone conglomerate filled with fossils, particularly corals. It is succeeded by calcareous and buff-weathering sandstones similar to the beds below. The lithology suggests the St. Leon formation.

LOWER DEVONIAN

Under this head are included: (1) a basal conglomerate locally of sufficient importance to be separated as a map unit; (2) the Helderberg sediments and volcanics of the Dalhousie section; (3) rocks on either side of Chaleur bay and Restigouche river equivalent to those of the Dalhousie section; (4) rocks of local areas where a paucity of outcrops and lack of sections with sufficient fossils render it difficult to determine their exact horizon; they may include strata of Oriskany and even Onondaga age; (5) the Mont Joli and Murailles formations at Percé; (6) the Causapscal formation of Matapedia valley; and (7) volcanic rocks associated with the sediments.

Basal Conglomerate

ESCUMINAC

The most striking exposures of the basal conglomerate are on either side of Escuminac river about 2 miles in a direct line north of the railway. The horizon may be followed to within a mile of Nouvelle river. The rock is a coarse conglomerate resting on Silurian beds and overlain by Helderberg sediments and volcanics. It is made up almost entirely of well-rounded limestone boulders, but contains a few composed of basic igneous rocks. Most of the limestone pebbles and boulders are derived from the Ordovician Matapedia rocks.

GLENLEVIT

Exposures of a similar conglomerate south of Restigouche river are to be seen on the Campbellton-St. Leonard highway about 4 miles south of Tide Head. The strike of the beds is northwest and the dip northeast at 45 degrees. The beds overlie Silurian limestone and are succeeded by Helderberg sediments and volcanics. Most of the boulders consist of Ordovician limestone, but a few are composed of Silurian limestone.

BLACK CAPE

Conglomerates that are correlated with these but whose age cannot be as definitely proved, occur at a number of localities along the coast. An interesting exposure is to be seen at Black Cape immediately to the east of the volcanic rocks that form the eastern end of the Silurian section. Along the shore is a band of conglomerate striking north 80 degrees east and dipping at angles of from 55 to 70 degrees to the northwest. The rock has a deep red colour. Many of the boulders consist of fossiliferous Silurian rocks of which West Point material is greatly in preponderance. The rock is cut by many calcite stringers and in places shows slickensided surfaces.

This conglomerate is overlain unconformably by Bonaventure conglomerate. The latter strikes northeast and dips to the northwest, at angles of from 15 to 30 degrees. The unconformity between the two conglomerates is distinct. Though both are red, the red of the Bonaventure is much brighter; the discordance in dip and strike is marked; and the lithology is distinct. The Bonaventure contains Silurian boulders, but not the marked abundance of those composed of West Point limestone. It also contains conglomerate boulders similar to the rock on which it rests. Calcite stringers are much more abundant in the older formation than in the Bonaventure.

The age of this conglomerate is not definitely known, other than that it is post-Silurian and pre-Pennsylvanian. It is more highly deformed than the Upper Devonian conglomerate near Escuminac and than most of the exposures of the Gaspe sandstone. It most probably represents the base of the Lower Devonian series.

NEW MILLS

Conglomerates believed to be of Lower Devonian age are exposed on the New Brunswick coast in the neighbourhood of New Mills. A belt extends along the shore northwestward from New Mills for about one mile. The rock consists of reddish conglomerate and sandstone, well bedded, and showing coarse and fine layers. The boulders are well rounded and most of them consist of volcanic rocks of many shades and textures. Large, rounded boulders surrounded by sandy material are common. The beds are more indurated than most of the Bonaventure with which they might be confused, and for the most part have low dips, being horizontal in places. At the eastern end of the exposure on the peninsula near New Mills the sediments dip off volcanic rocks at angles of from 20 to 35 degrees to the southwest, whereas near the western end of the exposure faulting has locally contorted the strata so that the dips are as high as 90 degrees.

TURGEON

West of the end of the road to the shore from Turgeon is a section showing a considerable thickness of sandstone and conglomerate (Figure 6). The lowest rocks are red arkoses, grey sandstone, and red, sandy shales locally showing ripple-marks and mud galls. Their strike is northeast and their dip 44 degrees to the northwest. Near the end of the Turgeon road a conglomerate bed was found to contain a nest of waterworn fossils, including several cup corals, some bits of favosites, and pieces of crinoid columns. Locally the sandstone contains small, irregularly shaped pieces of limestone, which in places have weathered forming holes in the rock. One small granite pebble was found. The series is cut by calcite veins and is over 900 feet thick.

Overlying these rocks is a conglomerate which is well exposed on the point 2,000 feet northwest of the end of the Turgeon road. The great majority of the boulders consist of volcanic rocks, for the most part well rounded. They are of all sizes, the largest seen having a longer diameter of 42 inches and a shorter diameter of 35 inches. Other boulders and pebbles consist of porphyry, red and green chert, quartz, red sandstone, and limestone. The last variety is the most interesting because some of the well-rounded limestone boulders contain numerous Silurian fossils, showing that they were derived from Clemville and La Vieille rocks which must have been at that time above the sea and undergoing erosion. The conglomerate also

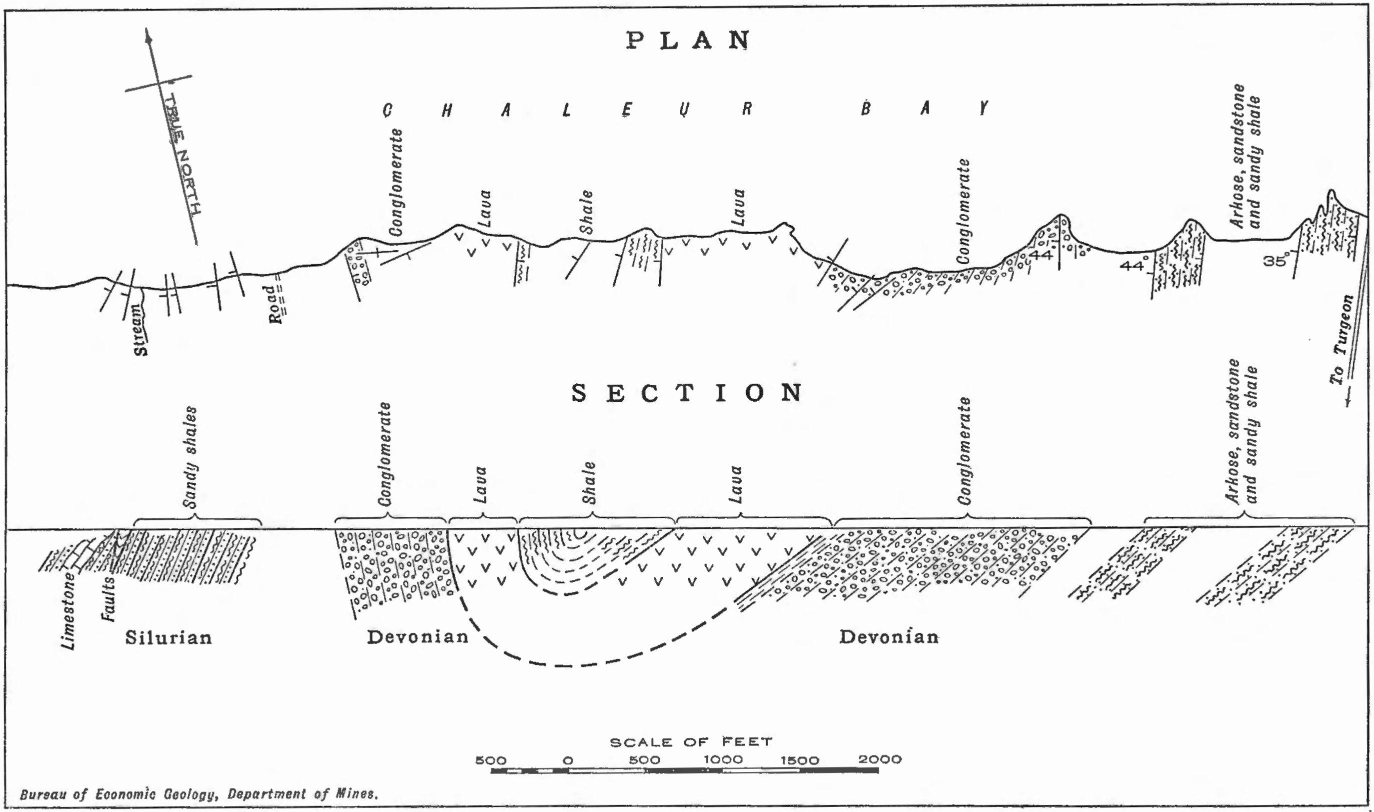


Figure 6. Geological section northwest of Turgeon, New Brunswick.

contains as pebbles, waterworn fragments of stromatoporoids, *Favosites,* and rugose corals derived from Silurian rocks. The conglomerate is considered to be the base of the Devonian.

The age of the sandstone which lies beneath the conglomerate is less certain. It may be the downward extension of the conglomerate and hence of Devonian age, or it may be of Silurian age, probably Gascons. In the Jacquet River and Culligan sections similar sandstones of the Gascons are overlaid by conglomerate which is regarded as Devonian.

The conglomerate forms a syncline. The western limb like the eastern contains boulders of fossiliferous Silurian limestone and also waterworn Silurian corals, clearly *remanié* fossils. Interbedded with the Devonian sediments is a zone of lavas, locally containing amygdules of calcite and locally porphyritic with phenocrysts up to one inch in length. Above the lavas are red and greenish mottled shales overlain unconformably by flat-lying Bonaventure conglomerate. The thickness of the Devonian beds below the zone of volcanics is over 1,000 feet; above the volcanics it is over 300 feet (Figure 6).

The next exposures to the northwest, outcropping beneath the Bonaventure, are Silurian beds belonging to the Clemville. They consist of sandstones, sandy shales, and limestones containing coelospira, bryozoa, cup corals, leperditia, etc. A fault probably separates these Silurian rocks from the adjacent Devonian conglomerate.

Dalhousie Section

The Lower Devonian series of much of the lower Restigouche and upper Chaleur Bay region is such an intimate succession of interbedded sediments and volcanic rocks that only on large scale maps can these types be separated. Furthermore, such detailed information can only be obtained in comparatively few places, such as along the coast and on certain streams where outcrops are fairly abundant. Along the roads and throughout the region as a whole the outcrops mostly consist of the harder volcanic rocks. A wrong impression, therefore, as to the relative abundance of sediments and volcanics in any given area, is apt to be obtained. In the region lying to the north and to the south of the lower Restigouche, two divisions have been recognized. The lower, which rests on the Silurian and older strata, consists chiefly of sediments with which, however, are associated minor amounts of volcanics. This is succeeded by a thick upper division consisting largely of volcanic rocks and in which sediments are for the most part to be found only locally and in comparatively thin bands.

The Dalhousie section has long been famous on account of its easy accessibility, its good exposures, and the abundance of Helderberg fossils that certain of its beds contain. It belongs to the division consisting dominantly of volcanics, but shows a higher proportion of sediments than the division as a whole. The section and its fauna have been described in a memoir by John M. Clarke (1908 b, vol. II). The following description of the section is taken partly from the manuscript of W. V. Howard who mapped this area for the Geological Survey.

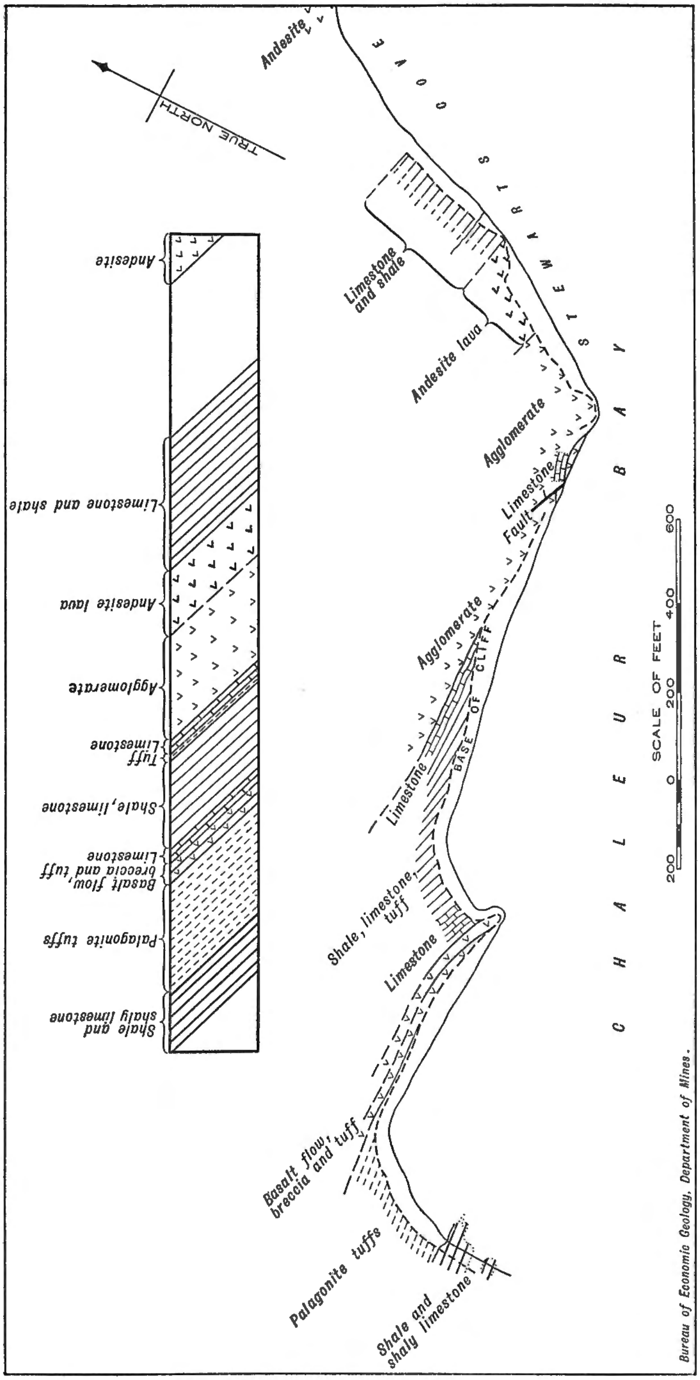


Figure 7. Geological section at Dalhousie, New Brunswick.

A few outcrops south of the mouth of Tait brook are stratigraphically below the lowest sedimentary beds of the Dalhousie section proper. About two-thirds of a mile southeast of Darlington a ridge some 60 feet in height rises abruptly from the sandy beach. This ridge, which consists of finely crystalline gabbro or dolerite, continues northwest beyond Darlington and then, turning to the west, extends along the north side of the McNish road for some 3 miles. On the Eel River road shales and tuffs underlie the gabbro as far south as the junction of this road with the McNish road. Immediately to the north of this gabbro is a dark basaltic rock carrying laths of grey feldspar 3 to 4 millimetres in length.

For over 600 yards north of this ridge there are no outcrops on the beach or along the highway to the west. In the valley west of the road, however, there are scattered outcrops of shales. The next ridge to the north is made up of sediments, tuffs, and lava flows, the commencement of Clarke's Helderberg shore section (*See* Figure 7); the succession ascends to the north. Clarke begins his section with what are known as the Lower Dalhousie beds. These rest on volcanic rocks. The volcanics are underlain, however, by other sediments which in order to retain the same numbers as those employed by Clarke will be termed Zone O.

The succession in descending order is as follows:

	Feet
Pyroxene andesite (fifth and fourth flows) (Stewart andesites)	40+
Intrusive andesite and breccia (Bon Ami andesites)	90
Pyroxene andesite (third, second, and first flows) (Stewart andesites)	85
Gap in section	250
Upper Dalhousie beds	
16. Arenaceous limestone with barren grey shales	25
15. Hard, grey limestone	2
14. Thin-bedded shale with limestone	35
13. Ash bed	1
12. Blocky, calcareous shale	2
11. Ash beds with thin limestones and shales	30
10. Thin, grey shales	10
9. Limestones and calcareous shales	75
8. Calcareous, sandy shale	20
7. Arenaceous limestone	7
Agglomerate and andesite (with bed 6)	280
Lower Dalhousie beds	
5. Hard, grey limestone	10
4. Coarse, yellowish white tuffs	12
3. Hard, grey, arenaceous shale with limestone	40
2. Grey, calcareous shales with limestone	125
1. Silicified limestone with shales	30
Basalt tuff and breccia	30
Basalt	15
Palagonite tuffs	180
Zone O. Calcareous shales	90

Zone O consists of thin-bedded, calcareous shales, sandy shales, and shaly limestones dipping 46 degrees to the north. At low tide a thickness of 90 feet is exposed. A few brachiopods, including *Leptaena rhomboidalis*, *Spirifer* sp., and several others, occur in these beds.

This zone is overlain by 180 feet of dark, greenish grey, fragmental palagonite tuffs which form a cliff about 150 feet high. The tuffs are well bedded, showing coarse and fine layers. They are soft, weathered, and crumble easily in the hand. The tuffs are overlain by a dark brown basalt flow 15 feet thick. It shows columnar jointing and at its base is amygdaloidal. It is overlain by dark, volcanic breccia and tuffs consisting of material closely resembling the underlying basalt. The breccia has a thickness of 30 feet and extends around a small point where it is succeeded by the fossiliferous Lower Dalhousie beds. These volcanics are believed to have emanated from the volcanic centre that lies behind the town of Dalhousie, and to be an early, more basic phase of the great andesite flows that were given off later.

The contact of the basal bed of the Lower Dalhousie sediments with the volcanics is irregular and as the latter shows no evidence of oxidation at the contact the sediments are believed to have been deposited directly on the irregular surface of the breccia. Zone 1 consists of limestone partly silicified and interbedded with calcareous shales. It is the only highly fossiliferous zone in the lower series. Towards the base corals are abundant; higher up there are numerous brachiopods and pelecypods. Common forms include: *Sieberella pseudogaleata; Leptaena rhomboidalis; Stropheodonta schuchertana; Rhipidomella numus; Meristella laevis.* Zone 2 consists of grey to yellowish, calcareous shale with thin beds of limestone. The few fossils it contains are all of species that are abundant in the rest of the group, such as *Spirifer concinnus, Leptaena rhomboidalis,* etc. Zone 3, which consists of arenaceous shales, also contains a few fossils of the common varieties. The yellowish white tuffs of Zone 4 are highly altered and apparently contain no fossils. They probably resulted from the deposition under water of a coarse ash. They are succeeded by an unfossiliferous, hard, grey limestone.

Above this limestone is a series of volcanic rocks, the contact between the two being very irregular. East of the point where the volcanics are first encountered the shore follows the contact fairly closely for over 300 feet. In front of the steep exposures of the volcanics small outcrops of sediments project through the sand. These conform in strike and dip to zones 1 to 5 (strikes north 62 degrees west, magnetic dip 48 degrees northeast). The largest outcrop is Zone 6, Clarke's "inclusion" of limestone. This consists of arenaceous limestone, 12 feet thick, containing corals and brachiopods including *Leptaena* and *Atrypa,* and also fragments of bryozoa. Its beds dip to the north under the cliff of volcanic rocks overlying Zone 5. On the seaward side they are protected by an underlying mass of hard, dense, greenish grey andesite, traversed by a number of small, irregular veins of calcite and chlorite (Figure 7). On the southwest side of this mass there has been a slight offsetting.

It is probable that the sediments of Zone 6 and the underlying lava represent interbedded horizons that formerly continued eastward, but which, except for these remnants, have been removed by erosion. If this interpretation is correct it is necessary to assume that after a deposition of bed 6 there was a period of erosion during which the bed was locally removed. Its remnants were later buried by the fragmental, volcanic material that forms the next succeeding zone.

The volcanics that overlie Zones 5 and 6 form a cliff some 100 feet high extending for 1,000 feet along the shore. Their thickness is about 280 feet. The lower 170 feet consist of dark green agglomerate made up of bombs of irregular shapes and sizes, some of them over 2 feet long. Small veins and patches of calcite occur scattered through the breccia

Overlying this fragmental portion is a dense, amygdaloidal, andesitic lava. The amygdules consist of calcite and the rock is cut by numerous calcite veins. The ridge formed by these volcanics crosses the highway one-half mile to the west of the shore, but a short distance beyond disappears beneath the valley south of Dalhousie mountain. This is taken to mean that the vent from which they came was not Dalhousie mountain but was a volcano situated probably somewhere to the east.

Above this flow lie the Upper Dalhousie beds. The lowest of these, Zone 7, is a coarse-grained, arenaceous limestone in which corals are abundant. The limestone rests directly on the lava and the uneven contact is probably due to the unevenness of the upper surface of the flow rather than to any erosion interval. The corals in this lower zone include: *Amplexus shumardi, Favosites helderbergiae, Favosites hemisphericus*, etc.; brachiopods and a few pelecypods also occur. *Leptaena rhomboidalis, Spirifer concinnus*, and *Atrypa reticularis* are abundant, together with *Rhipidomella, Schizophoria multistriata*, etc.

Zone 8 consists of soft, calcareous shales exposed at the mouth of Wellington brook, and very rich in *Leptaena rhomboidalis*. Besides this species and the others mentioned from Zone 7 it contains *Strophonella punctulifera* and *Spirifer perlamellosus*. Clarke also mentions fragments of *Proetus* sp. and the sponge *Hindia* from this zone.

The limestones and calcareous shales of Zone 9 are rich in corals, pelecypods, and brachiopods. Of the corals, *Favosites* and *Amplexus* are the most common. Of the brachiopods, *Spirifer concinnus, Spirifer perlamellosus, Atrypa reticularis, Stropheodonta patersoni, Strophonella punctulifera, Leptaena rhomboidalis*, and *Rhipidomella numus* are the most abundant, but many others are also present including *Rensselaeria stewarti*. Pelecypods include *Carydium gregarium, C. elongatum*, and *Sphenotus ellsi*.

The thinly bedded, soft shales of Zone 10 contain fewer corals and brachiopods, but a larger number of pelecypods. This last group reach their maximum development in Zone 11 which is composed of tuffaceous material interstratified with thin limestones and shales. The lamellibranch fauna includes several species of *Pterinea*, as well as *Mytilarca dalhousie, Modiomorpha impar, Carydium gregarium, C. elongatum, Macrodus matthewi, M.* (?) *baileyi, Sphenotus ellsi*, and *Palaeoneilo follis*. Gasteropods include *Coelidium strebloceras* and *Melissosoa compacta*. The more numerous brachiopods are *Rensselaeria stewarti, Spirifer concinnus*, and *Atrypa reticularis*, and the abundant corals are *Amplexus shumardi* and *Favosites*.

In the calcareous shales of Zone 12 Clarke found several species of *Kloedonia* with *Coelidium strebloceras*, and in the thin ash bed of Zone 13 he found *Rensselaeria stewarti*. In the former zone there are also a large number of imprints of algæ. The thin-bedded shales of Zone 14 were found to contain *Coelidium strebloceras, Sphenotus ellsi, Cypricardella norumbigae, Spirifer concinnus*, and *Rensselaeria stewarti*.

Above Zone 14 the section disappears except for a few bands of harder rock which project above the beach at lower water. These consist of two varieties of limestone which are probably interbedded with softer shales not exposed. The lower limestone beds, Zone 15, are composed of fragments of shells, largely brachiopods, together with a few fragments of quartz.

and glassy fragments of volcanic ash. Zone 16 consists of arenaceous limestone with large *Favosites,* numerous *Spirifer concinnus,* and a few pelecypods.

A vacancy of some 250 feet extends to the end of Stewarts cove where flows of pyroxene andesites begin. From here to Bon Ami point there are three flows and north of that point there are two others of similar character. The lowest extends along the shore for over 250 feet and is marked by parallel lines of amygdules from 6 to 12 inches apart. Both this flow and the one that overlies it consist of dark grey, dense rock in which red flakes of iddingsite can be seen in hand specimen. The third flow is different in that it contains many small, black amygdules of chlorite and limonite. Few of these reach a diameter of more than 4 millimetres, but because of their abundance the rock weathers readily. Along this part of the shore the cliff is indented with deep clefts and on some of the points patches of this flow can be seen. In the pierced rock, which forms an island at high tide, the contact between the amygdaloidal flow and the lower, harder, second flow is well marked just at the top of the opening. Fractures filled with chalcedony and agate traverse both these flows.

Immediately north of Bon Ami point outcrops of two flows are to be seen at low tide. The lower consists of a grey, fine-grained rock in which grey feldspar crystals and flakes of iddingsite are visible. The upper is similar, but has more iddingsite and has been stained red by iron oxide. The ridge formed of these andesites extends in a westerly direction to the road about half-way between Dalhousie and Darlington and thence to a point about 2,000 yards west of the road where it joins the south side of Dalhousie mountain.

At point Bon Ami the andesites are intruded by dykes, the earliest of which is the andesite that forms the point itself. It is a dark grey, dense rock weathering brownish. Subsequent to its intrusion, movement took place giving rise to two sets of joints, one striking north 70 degrees west and dipping southwest and the other striking north 35 degrees west and dipping northeast. Along many of these joints and in drusy cavities throughout the rock chalcedony was deposited. The veins for the most part are short and narrow, but some have a width of over one inch and may be traced for over 50 feet. They are banded and are stained reddish or violet. Subsequent to the deposition of the chalcedony there was further movement causing slickensiding. This was followed by the intrusion of a dark grey, dense, andesite similar to the Bon Ami rock. The next event was the intrusion of a red, volcanic breccia. The fragments that comprise the greater part of the rock vary in size; some are angular masses 6 to 8 inches across. They consist of fragments of the dyke rocks mentioned above, magenta scoriaceous lava with irregular chloritic amygdules, and dense, reddish amygdaloidal rock with small chloritic grains and a host of minute calcite amygdules. The matrix is glass. Evidently, subsequent to the extrusion of the andesite flows that overlie the Upper Dalhousie beds, local fracturing took place along the contact between the third and fourth flows. This was followed by the intrusion of an andesite sill, a breccia dyke, and several other andesite dykes. Further faulting followed the injections.

Between Bon Ami and Inch Arran, the point on which the lighthouse is situated, there is a gap of 500 yards in the shore section, which may be underlaid by sedimentary strata. Inch Arran is formed of a flow of red andesite, and andesitic rocks continue westward with local breaks to point La Nim. They are concealed at several places by overlying patches of the Gaspe sandstone series. East of Dalhousie volcanic tuffs are associated with the flows.

Between the eastern end of Dalhousie and a point about a mile west of the town the few outcrops along the shore consist of a dense black rock in which there are a few phenocrysts of feldspar 2 to 3 millimetres in length. Similar rocks outcrop at various points in the town, along the railway and the Campbellton road to within a quarter of a mile of the railway crossing, and also form the main mass of Dalhousie mountain to the south. This mountain, which consists of pyroxene andesite, is the truncated core of a volcano and represents the last phase of volcanic activity in this area. The islands that lie along a line 500 yards north of the shore are composed of similar rock.

To summarize: the basaltic tuffs and flows below Zone 1, including possibly the associated palagonite tuffs and the Stewart andesites above Zone 16, were deposited as a result of eruptions of a volcano that occupied the site of the present Dalhousie mountain. The tuffs and flows between the Lower and the Upper Dalhousie beds, the Inch Arran andesites, and the intrusive andesites probably came from the east or northeast.

The range and distribution of the fauna of the Dalhousie beds are summarized in the following table taken from Howard, which is in turn based largely on that of Clarke (1908 b). The numbers refer to the zones of the Dalhousie series. In the last four columns are indicated the forms present in the Helderberg beds of New York, the Saint Albans of eastern Gaspe, the Chapman sandstone of Maine, and the Coblentzian of Europe, respectively.

Range and Distribution of the Dalhousie Fauna

—	1	2	3	6	7	8	9	10	11	12	13	14	16	He	SA	Ch	Co
Spirorbis sp.							X				X						
Pterygotus sp.									X								
Phacops logani Hall v. *gaspensis Clarke*									X					(X)			
Dalmanites micrurus Green									X					X			
Bronteus barrandii Hall v. *major* Clarke								X						(X)	X		
Proetus sp.						X	X										
Beyrichia kloedeni McCoy cf. v. *acadica* Jones										X				(X)			
Pachydomella nov.											X						
Kloedenia marginalis Ulrich and Bassler										X							
K. manliusensis (Weller)										X							
K. retifera Ulrich and Bassler										X							
K. sussexensis (Weller)										X							
K. punctillosa Ulrich and Bassler										X							
Kloedenella pennsylvanica (Jones)											X						
K. halli (Jones)											X						
Orthoceras cf. *longicameratum* Hall									X					X			
Kionoceras cf. *rhysum* Clarke									X						X		
Holopea enjalrani Clarke										X							

Range and Distribution of the Dalhousie Fauna—Continued

—	1	2	3	6	7	8	9	10	11	12	13	14	16	He	SA	Ch	Co
H. enjalrani v. *corrugata* Clarke										X							
H. cf. *antiqua* Vanuxem v. *pervetusta* Conrad											X			X			
Coelidium strebloceras Clarke									X	O	O	O					
C. tenue Clarke									X							X	
Melissosoa compacta (Hall)	O								X			O		X			
Platyceras sp.								X									
Euomphalus disjunctus Hall									X					X			
Pterinopecten denysi Clarke							X										(X)
P. cf. *proteus* Clarke and *wulfi* Frech?								X									(X)
Pterinea intercostata Clarke	O						X										(X)
P. cf. *pseudolaevis* Oehlert							X				X						(X)
P. fasciculata Goldfuss v. *occidentalis* Clarke	O								X								(X)
P. (*Pteritonella*?) *incurvata* Clarke							O		X							(X)	
P. brisa v. *vexillum* Clarke						X		X								(X)	
Pteritonella passer									X							(X)	
P. hirundo Clarke									X								
Mytilarca dalhousie Clarke							X	X	X					(X)			
Modiomorpha impar Clarke							X	X	X								
Goniophora curvata Clarke											X						
G. tethys (Billings)								O							X		
Sphenotus ellsi Clarke							X		X	X	X	O	O				
Carydium gregarium Beushausen							X	X	X								X
C. elongatum Clarke	O						X	X	X								(X)
Cypricardella norumbegae Clarke							X		X		X	O					
Macrodus matthewi Clarke								X	X								
M. ?baileyi Clarke									X								
Janeia sp.?							X		X								(X)
(*Pectunculus* ?) *plutonicus* nov						X											
Palaeoneilo (*Nuculites*) *follis* Clarke									X	X	X	O					
Nuculana (*Ditichia*) *securis* Clarke									X								(X)
Conocardium incarceratum Clarke									X					(X)			(X)
Rensselaeria stewarti Clarke							O	O	X		O	O				(X)	(X)
Sieberella pseudogaleata Hall	X							O	O					X			
Camarotoechia								X						(X)			
Uncinulus nobilis Hall								O									
Spirifer concinnus Hall	X	X	O	O	O	X	X	X	O	O	O	O	O	X	X		(X)
S. coralliensis (Ulrich?)						O								X			
S. perlamellosus Hall						X	X							(X)			
Cyrtina chalazia Clarke							X							(X)			
Meristella princeps Hall	X								X					X			
M. laevis Hall	O													X	X		
Nucleospira concentrica Hall							X							X			
Trematospira perforata Hall v. *atlantica* Clarke							X							(X)			
Rhyncospira globosa Hall	O													X	X		
Atrypa reticularis Linné		O			O	O	X	X	X					X	X		
Stropheodonta varistriata Conrad						X	X	O						X	X		
S. patersoni Hall prot. *bonamica* Clarke	O					X	X								(X)		(X)
S. (*Brachyprion*) *major* Clarke	X					X	X		O								
S. (*B.*) *schuchertana* Clarke	X					X	X										
Leptostrophia becki Hall	O				O	X	X		X					X			
Strophonella punctulifera Conrad	X	O			O	X	X	O						X	X		
Leptaena rhomboidalis Wilckens	X	O	O	O	O	X	X	O	O					X	X		
Leptaenisca concava Hall	X													X			
Orthothetes (*Schuchertella*) *radiatus* Hall									X					X			
Schizophoria multistriata Hall	X				O	O	X	O	O					X			
Rhipidomella hybridoides Clarke	O	X	O			O	O	O									
R. numus Clarke	O						X	O									
Craniella agaricina Hall and Clarke							X							X			
Crania								X						(X)			
Pholidops ovatus Hall						X	X	X						X			
Orbiculoidea sp.									X								

Range and Distribution of the Dalhousie Fauna—Concluded

—	1	2	3	6	7	8	9	10	11	12	13	14	16	He	SA	Ch	Co
Fenestella crebipora Hall	O			O		O	O			O	O			×			
Alveolites squamosus Billings							O										
Favosites hemisphericus M.-E. and H.	×			O	O		O	×	O			O	×				
F. helderbergiae Hall	×			O	O		O	×	O			O	×	×			
Aulopora tubaeformis Goldfus						O											
Synaptophyllum simcoense Billings									O								
Halysites catenularis Lamarck								×					×				
Zaphrentis (*Amplexus*) *shumardi* M.-E. and H.	×			O	O	O	O	×	O	O	O	O	×		×		
Heliophyllum sp. ?					O												
Cyathophyllum radiculum Rominger ?						O								×			
Streptelasma calciculum Hall	O																
Stromatopora antiqua Nicholson and Murie	O																
Dictyonema splendens Billings								×							×		
Hindia fibrosa Roemer (sp.)						×	×							×	×		

NOTE: Species identified by Clarke, ×.
Closely allied species, (×)
New occurrences determined by Howard, O.

From the close affinities of this fauna with that of the Appalachian Gulf region, especially that of New York, Clarke concludes that deposition in these two regions was contemporaneous and that there was an unimpeded basin passage between the two. With the fauna of the Saint Albans beds at the eastern end of Gaspe peninsula there are fewer identities. The Saint Albans fauna, however, shows quite as much agreement with that of New York as does the Dalhousie. Apparently different elements of the Helderberg fauna became sequestered in the embayments of this old coast.

OTHER RESTIGOUCHE AND UPPER CHALEUR BAY SECTIONS

MCNISH ROAD

South and west of the Dalhousie section proper, outcrops of volcanics and sediments may be traced along the McNish road. West of Darlington the first outcrops to be encountered are a continuation of the coarsely granular gabbro which on the shore forms the first point north of the mouth of Eel river and continues northwestward in a ridge. On the southwestern slope of the ridge shales are exposed; the ridge itself turns towards the west and crosses the strike of the formations of which it is composed. Most of these rocks are shales and tuffs, for the most part deeply weathered. The southern slope of the ridge is covered by a fine talus, consisting largely of angular fragments of shale.

One hundred and fifty yards west of the branch road to the south, near the summit of the ridge, a fine-grained, light grey oligoclase andesite underlies a thick series of calcareous shales. A similar rock is exposed on the side of the road about 450 yards farther west. The road, near the point where it turns north, passes over reddish shales, but at the top of the ridge is exposed a dark, dense basalt which may be the basalt flow that overlies the palagonite tuffs in the shore section.

From this bend in the road towards the north there are few outcrops and the ridge disappears beneath the plain immediately west of the road. Three-quarters of a mile northeast there is a ridge continuous with the south side of Dalhousie mountain. This consists of dark, greenish grey, hornblende-bearing andesite resembling in appearance the andesites of Dalhousie mountain.

Three hundred yards south of the railway crossing is a ridge of light grey, dacitic rock in which white feldspar is abundant and which extends eastward for over a thousand yards. Immediately overlying this are grey, calcareous shales and close to the railway is an outcrop of grey andesite with grains of iddingsite. North of the railway there are no outcrops, but from the red colour of the soil it is inferred that the underlying rock is Bonaventure formation.

EEL RIVER

The numerous branches of Eel river drain a belt of country most of which is underlain directly by Lower Devonian sediments and volcanics. The dips throughout much of this belt are low and in places, as along the Balmoral road 3 miles west of Balmoral church, the sediments lie horizontally on the crest of the major anticline which lies immediately southeast of the lower Restigouche syncline.

The rocks are an interbedded series of volcanics and shaly limestones. A typical exposure occurs on the Eel River road about half a mile southwest of where it crosses Miller brook. Clarke described this exposure as follows: "Outcrop 220 feet long; its sediments are all normally and steeply tilted to the north as on the shore and are crossed by five distinct beds of contemporaneous lavas, tuffs, and ashes. The contacts of the sedimentaries with these thin ejections are absolutely unaltered; indeed here, as in the shore section, there are ash beds in which the fossils lie unaffected. Evidently the thin, volcanic masses carried too little heat to effect any change in the sediments lying in cool waters, only the heavier outpours seen on the shore section radiating enough heat to produce any contact changes" (1910, page 127).

JACQUET RIVER

Jacquet river and some of its tributaries such as Bighole brook, Mill brook, and McNair brook, show many exposures of Devonian volcanic rocks and sediments. On the upper part of Bighole, and also on McNair and Mill brooks, volcanic rocks are exposed for long distances. On the lower part of Bighole and on Jacquet river itself, below Sunnyside, volcanics and sediments are exposed in about equal amounts. The sediments consist of shales and shaly limestones and are here and there highly fossiliferous. The igneous rocks are for the most part interbedded with the sediments, their contacts with the latter being parallel to the bedding planes of the strata. Some of the igneous rocks are dense, amygdaloidal and ellipsoidal, and clearly represent surface flows; others are coarse grained and may be sills. A few outcrops of grey gabbro appear to be intrusive, and at several places along the river reddish acid porphyry dykes cut the strata. A mile and a half above the railway bridge the river is bordered by high outcrops of reddish and yellowish volcanic tuffs and breccias. Half a mile farther upstream on the east bank greenish ash beds are associated with massive volcanic rocks. On Bighole brook, about 2 miles above its junction with Jacquet river, tuffs and breccias are also associated with shales.

LOUIZON BROOK

Louizon brook lies between Jacquet river and Nash creek. Its headwaters drain the country south of Lorne Settlement, a region composed largely of Devonian volcanic rocks—apparently the same belt that is exposed on the upper waters of Bighole brook to the south. Below Lorne Settlement there are few outcrops for a couple of miles, what there are consisting of tuffs and massive volcanics, in places amygdaloidal. Towards the east and west road, which crosses the stream 2 miles south of the main coast highway, outcrops become numerous. Two chains above the bridge is a bank 40 feet high in which fossiliferous shales dipping at a low angle to the northeast are overlain by a volcanic flow. The contact is perfectly conformable with the bedding of the sediments. The lava shows ellipsoidal and amygdaloidal structures, the amygdules consisting of white calcite. In places calcite masses up to 5 inches across are present. Thirty chains below the bridge, a zone of shales 4 feet thick and dipping 60 degrees to the north lies between two volcanic flows. The upper surface of the lower flow is amygdaloidal and the lower part of the upper flow is both amygdaloidal and ellipsoidal, the pillows resting directly on the shales.

NASH CREEK

Along the various branches of Nash creek are numerous exposures of interbedded Devonian sediments and volcanics. They are locally cut by dykes and small masses of acid intrusive rocks. On the lower part of the river a belt of Ordovician rocks three-quarters of a mile wide is exposed; from them the Devonian sediments dip off on either side. Near the eastern contact are fossiliferous Devonian sediments containing the following forms, which were identified by E. M. Kindle: *Cyathophyllum* (?) sp.; *Amplexus* cf. *shumardi; Favosites helderbergiae; Leptaena rhomboidalis; Stropheodonta punctulifera* (?); *Rhipidomella hybridoides* (?); *Gypidula* cf. *pseudogaleata; Spirifer* cf. *concinnus; Cyrtina chalazia* Clarke cf. *Cyrtina pyramidalis; Holopea sp.; Euomphalus disjunctus; Orthis* cf. *rudis.*

BELLEDUNE RIVER

Good exposures are to be seen along the lower part of Belledune river, particularly between the coast highway and the railway. The rocks consist of limestones, shales, grits, and conglomerate. The beds are locally broken by faults and have dips ranging from a few degrees to over 70 degrees. Some are fossiliferous. In limestone on the west bank of the river immediately above the highway bridge, numerous specimens of *Leptocoelia flabellites* were collected and some small corals of the *Streptelasma* type. In one conglomerate bed a coiled gasteropod was found and certain of the shales and sandy beds have corals and brachiopods, poorly preserved. At several places dense, dark, volcanic rocks are associated with the sediments.

In the long railway cut immediately to the west of the river a considerable thickness of dark grits, locally conglomerate, are exposed. The conglomerate zones contain many volcanic pebbles, some rounded quartzite pebbles, feldspar fragments, and a few granite pebbles. A small Devonian fauna was collected from certain beds near the eastern end of the section. It includes two cephalopods, one an *Orthoceras;* and small brachiopods, one an *Eatonia.*

Outcrops along the river above the railway bridge consist of limestone, chert, argillite, reddish grits, conglomerate, greywacke, quartzite, and volcanics. Towards the headwaters of the river the outcrops consist of dense, dark, massive volcanics.

Farther east, to the south of Hodgins, there is an area underlain by argillites and conglomerate. No fossils were found in any of these beds, but the similarity of their lithology to types in the Devonian succession on the Belledune makes it probable that these rocks are of the same age. Another area underlain by similar sediments lies south of the railway between Turgeon and Belledune stations.

NORTHERN BELT

A belt of Helderberg sediments and associated volcanic rocks swings around the volcanic zone at Campbellton and crosses Restigouche river 3 miles west of Tide Head. It extends eastward with a fairly uniform width to Nouvelle river. Good exposures are to be seen along the highways on either side of the Restigouche, on the various branches of Little river, the headwaters of river du Loup and Harrison brook, the northward flowing tributaries of Escuminac river, and the west side of Nouvelle river. The rocks consist of shales and limestones, commonly fossiliferous, with local sandstones and conglomerates and also interbedded volcanic rocks. They are overlain to the south by a thick mass of volcanics with which are associated minor amounts of sediments. East of Nouvelle river the proportion of volcanics decreases and the belt takes a swing to the south, disappearing under Bonaventure sediments and Pleistocene material.

The belt reappears north of Carleton where it may be seen on the headwaters of Martien brook and still better along Green river and its tributary McKeen brook. It here consists of shales and limestones with which are associated dark andesites and tuffaceous beds. No good section is, however, available. Fossils are present at a number of places. In the flume between the mill and the junction of the main branches of Green river, range III, Maria township, the following were collected: *Fenestella* sp.; *Monotrypella* sp.; *Leptostrophia magnifica* Hall and Clarke; *Spirifer concinnus; Spirifer perlamellosus; Spirifer* sp.; *Strophonella* sp.; *Trematospira perforata* Hall var. *atlantica* (?) Clarke; *Pholidops* cf. *ovata* Hall; *Aviculopecten* sp.; *Aviculopecten flammiger* Clarke; *Carydium* cf. *gregarium* Beushausen; *Coelidium strebloceras* Clarke; *Cypricardinia* cf. *distincta* Billings; *Edomontia* n. sp.; *Sphenotus* cf. *ellsi* Clarke.

On the west branch of Green river where it is crossed by the road to Lac Sans Facon were found: crinoid stems, *Meristella* sp.; *Spirifer* sp.; *Orthothetes* sp.; *Leptocardia* sp.

From the left bank of Green river about 300 yards below the junction of the two main branches, the following were found: crinoid stems; *Trematospira* (?) *(Trematella)? corticora* Hall; *Fenestella* sp.; *Camarotoechia* sp.; *Camarotoechia* cf. *altiplicata* (Hall); *Leptostrophia blainvillei* Billings; *Orthothetes becraftensis* Clarke cf. *Stropheodonta patersoni* Hall; *Spirifer cyclopterus* Hall; *Carydium* sp.; *Cypricardinium lamellosa* Hall; *Cypricardinia distincta* Billings (?); *Cryptonella* cf. *fausta* Clarke; *Mytilarca dalhousie* Clarke; *Mytilarca* sp.; *Modiamorpha* cf. *odiata* Clarke; *Nuculites* sp.; *Pterinea radialis* Clarke; *Schizodus appressus* (?); *Sphenotus truncatas* (Conrad); *Melissosoa campacta.*

These forms indicate a close relationship with the Helderbergian.

PERCÉ

Aside from the basal conglomerate beds near Black Cape, there are no outcrops of Lower Devonian strata along the Gaspe coast of Chaleur bay and proceeding eastward none appears until Percé is reached. Here the Devonian rocks have been divided by C. H. Kindle into two formations, the Mont Joli and the Murailles limestone.

The first work on the Devonian beds at the eastern end of Gaspe was done by Logan who, under the general term "Gaspe series," recognized two divisions, the "Gaspe Limestone" and an overlying "Gaspe Sandstone." The former, which he believed to be Upper Silurian, he divided into eight divisions, the type section being at the Forillon between Cape Rosier cove and cape Gaspe. Clarke later showed that all these are Devonian and grouped Logan's divisions into three formations. The lowest two, Nos. 1 and 2, he called the "St. Albans beds." These are of Helderberg age. Divisions 3 to 6 he called the "Bon Ami beds." These consist of magnesian limestones carrying few fossils, mostly diminutive forms, but quite distinctly of Helderberg age also. The upper formation, Logan's divisions 7 and 8, is the "Grand Grève limestone." This contains a fauna of some one hundred and fifty-five species which, taken as a whole, are eminently characteristic of the Helderberg-Oriskany with a considerable representation suggestive of incipient stages of the Onondaga fauna of the New York standard.

Mont Joli Formation

The Mont Joli formation is of Helderberg age and is probably equivalent to the Mount Albans beds. It consists of grey, calcareous sandstones and shales. It is typically exposed at mount Joli which is composed for the most part of alternate beds of sandstone and shale, the more compact layers averaging 12 to 18 inches in thickness. The lower, calcareous beds here rest with faulted contact against Upper Ordovician beds which have been thrust up over the vertical Devonian strata. The formation is exposed from the fault to the North Beach of Percé and shows there a thickness of some 500 feet. Another exposure of the formation occurs along the shore from the mouth of the Grande Coupe southeastward for about 400 feet before its strike carries it beneath the sea.

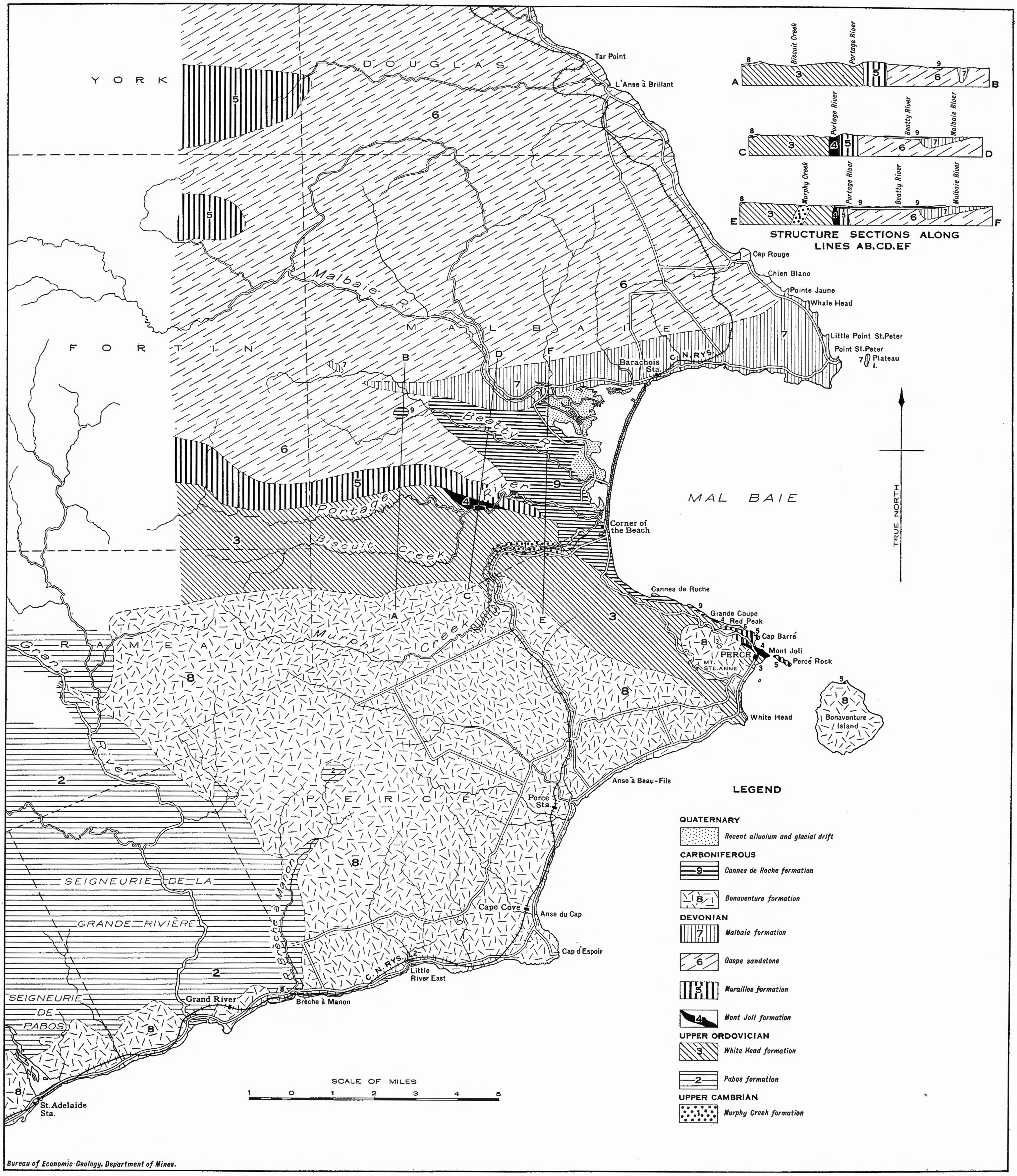


Figure 8. The geology of Percé, by C. H. Kindle.

A third section is exposed along Portage river a half mile below Biscuit creek, where the beds contain an abundance of corals and stromatoporoids. The section here is as follows:

	Feet
Top not exposed.	
Shale and sandstone, predominantly shale with thin sandstone layers containing fossils like those on the north face of mount Joli	200
Sandstone	2
Brown shale, weathering easily	30
Shale, containing corals; the upper 2 feet of the shale are full of small, elongate ones	10
Shaly sandstone, containing *Favosites*, *Stromatopora*, and small corals	15
Shale, containing *Zaphrentis cingulosa* (?)	2
Shaly sandstone	10
Base not exposed.	

Where seen the base is overthrust by Upper Ordovician strata. The contact with the overlying Murailles limestone is not seen, but the Mont Joli probably grades up into the Murailles just as the St. Albans beds are reported to grade up into the Bon Ami beds near cape Gaspe. At the head of Portage river, however, the Murailles limestone has at its base a bed of conglomerates 2½ feet thick. This may mean that the Mont Joli formation was never deposited there or else that the land was uplifted between the periods of deposition of the Mont Joli and the Murailles limestone. In this same locality sandstone beds near the base of the Murailles contain plant fragments similar to those of the Gaspe sandstone.

The following fossils were collected by C. H. Kindle from the Mont Joli beds: at mount Joli—*Zaphrentis cingulosa; Pleurodictyum* n. sp.; *Favosites* sp.; *Dalmanella perelegans; Phacops* sp.; *Ceratocephala tuberculata; ostracods;* at the mouth of Grande Coupe—*Zaphrentis cingulosa; Favosites* cf. *helderbergiae; ostracods;* on Portage river—*Zaphrentis cingulosa; Favosites* cf. *helderbergia;* Phacops.

Murailles Limestone

The Murailles limestone includes all the beds between the Helderbergian formation below and the Gaspe sandstone above. Its upper and more fossiliferous part corresponds to the Grand Grève of Clarke. The formation includes Clarke's Cape Barré beds and his Percé beds, since in the region west from the coast it is impossible to recognize Clarke's divisions, the outcrops consisting for the most part of limestones which are lacking in fossils. In the Portage River region, however, some fossils were found in the first stream draining the south side of the Murailles limestone ridge west of Pass creek. These are identical with those collected from the top of Red peak near Percé. In the same stream large gasteropods of the genus *Naticopsis,* obviously of Devonian age, occur. Farther up the same stream a slab covered with a great variety of bryozoa and ostracods, and numerous boulders of a white sandstone resembling that below Red Peak, were seen. A few fossils were obtained in Pass creek, in the cut the Portage river makes through the limestone, and in Four Hour brook at the head of the river. A *Phacops* and a pelecypod were found in the limestone near the Gaspe sandstone in Anse à Brillant brook. Except for these localities fossils were found in the Murailles limestone only in the vicinity of Percé along the Murailles, in Percé brook, and at the northern end of Bonaventure island. Those found at

Percé are very similar to those from the Grand Grève limestone on the north side of Gaspe bay. As is the case there, the greater number of fossils were obtained from the upper part of the limestone near the Gaspe sandstone, the Cape Barré beds being almost lacking in them.

The thickness of the vertical Murailles limestones north of Portage river is about 2,500 feet. The thickness estimated to be present in the cliffs of the Murailles at Percé is 400 to 500 feet. The thickness in Percé rock is half that.

The following fossil collections were made by C. H. Kindle from the Murailles formation:

Percé Rock: *Spirifer murchisoni; Spirifer arenosus; Meristella lata; Leptocoelia flabellites; Orbiculoidea montis; Phacops logani; Dalmanites bairdi; Dalmanites perceensis.*

L'Anse à Brillant River: *Cypricardinia distincta* Billings; *Phacops logani.*

Pacing Creek: *Spirifer arenosus; Spirifer plicatus.*

Stream West of Pass Creek: *Fenestella; Phacops; Dalmanites perceensis* (pygidium over 10 cm. long); *Naticopsis*; bryozoa; ostracoda.

Near Portage River Waterfall: *Dalmanites perceensis; Fenestella; Leptaena rhomboidalis; Meristella lata.*

Causapscal Formation

Under this head are included the lower Devonian rocks of the Matapedia Valley region. The type section is on Causapscal river some 8 miles above its mouth, where a series of shales and argillaceous limestones occupy the axis of the Albertville anticline. The crest and north limb of the fold are well exposed in a series of bluffs on both sides of the river. The shales are grey, laminated, and everywhere show a strong secondary cleavage. In the upper part of the section limestone occurs in beds 1 to 2 feet thick, with shale interbeds commonly 1 to 12 inches thick.

The Causapscal formation has a thickness of at least 2,200 feet and it outcrops more widely than any other formation in the northern part of Matapedia valley. On Matapedia river it is well exposed immediately south of Causapscal. North of Causapscal it is exposed on both flanks of the Albertville and Lac au Saumon anticlines. Between Lac au Saumon and lake Matapedia it is the only outcropping formation.

Except in streams tributary to Matapedia river, the Causapscal formation is poorly exposed. The shaly portions are only locally seen and the limestones form low, inconspicuous outcrops. In such exposures there is commonly a strong, secondary cleavage which has destroyed all signs of stratification. Fossils are exceedingly rare and most commonly found on the buff-coloured surfaces of the weathered limestone.

At no place was the base of the formation observed. On Matapedia river near mile-post 49 the shales overlie beds of the St. Leon formation with apparent conformity of dip, but there are at least 200 feet of strata unexposed near the contact. Farther north, on the north limb of the Albertville anticline, the contact is also hidden, but the dips of the two formations are about the same. It would appear, therefore, that the two are essentially conformable, even though there is a considerable hiatus between their periods of deposition, the St. Leon being Middle Silurian and the Causapscal, as will be shown later, Oriskany in age.

The Causapscal formation is overlain conformably by the Heppel sandstone. The contact is exposed a mile south of the village of Causapscal on a road that leads up to the plateau summit. Here the Causapscal shales are calcareous and sparsely fossiliferous. They are overlain by an arenaceous shale 50 feet thick which is in turn succeeded by a massive sandstone 200 feet thick. The sandstone is overlain by a dark grey, fissile shale 150 feet thick whose outcrop is terminated by a fault that brings a coarse, arkosic sandstone into juxtaposition with it. The boundary between the Causapscal and Heppel formations is placed at the contact between the argillaceous limestone and the arenaceous shales, that is, the top of the Causapscal formation is placed where sand first becomes an appreciable constituent. The change is fairly abrupt, only 50 feet of transitional beds intervening between the type limestone and the coarse sandstone, typical of the Heppel formation.

On the north limb of the Albertville anticline the relations are somewhat different. Northward from near the base of the Causapscal formation about 3,000 feet of shales and argillaceous limestones are exposed. Higher in the section the limestones contain fine bands and lenses of sand an eighth of an inch to an inch thick. These beds are best exposed on Causapscal river below the falls. It is probable that the sandy beds belong to the Heppel formation and that there is more or less of a complete gradation from the Causapscal into the Heppel.

The Causapscal formation presents little variation throughout its belt of outcrop. North of the Lac au Saumon anticline it appears to be more calcareous than at Causapscal and dense limestones make up many of the hills in this direction. On the south limb of the Albertville anticline on Causapscal river there is a 2-foot bed of limestone conglomerate, but it appears to be a discontinuous lens as it is not known at any other locality.

As already mentioned fossils are rare in the formation. Most of the few specimens collected are deformed and fragmentary. They are most readily found in river exposures where bedding planes are stripped clean, or on the weathered surfaces of outcrops. The rock will rarely split easily along the bedding, so it is nearly impossible to obtain fresh specimens by breaking it.

The following fossils were collected by Crickmay about 1,500 feet above the base, the lower part of the formation being unfossiliferous:

Eodevonaria hudsonicus Clarke
Coelospira dichotoma Hall
Leptocoelia sp. aff. *L. acutiplicata* (Conrad)
Spirifer sp. cf. *S. modestus* Hall

Near the top of the formation, south of Causapscal, the following were collected.

Leptaena rhomboidalis (Wilckens)
Amphistrophia continens Clarke
Coelospira dichotoma Hall
Rensselearia sp.
Spirifer sp. cf. *S. vanuxemi* Hall
Spirifer sp.

This fauna certainly indicates a lower Devonian age for the formation. Of the species found in the Causapscal the following are known in the Oriskany of New York.

Coelospira dichotoma
Eodevonaria hudsonicus

In the Grand Grève of the eastern Gaspe occur:

Amphistrophia continens
Spirifer modestus nitidus
Coelospira concava

VOLCANIC ROCKS

Under this head are included rocks that occur as flows and tuffs associated with the Lower Devonian sediments; in addition, similar rocks locally have intrusive relationships occurring as pipes, dykes, and sills in the Lower Devonian and older strata. The rock types are largely of intermediate composition. Local areas of acid eruptives occur, however, and basic varieties are also represented. The rocks, in addition to their differences in composition, show considerable variation in texture depending on their mode of crystallization. Reference will be made to only a few of the more important varieties and for convenience these will be described under local names. These volcanics have been studied in detail by W. V. Howard and part of the following descriptions are from his work.

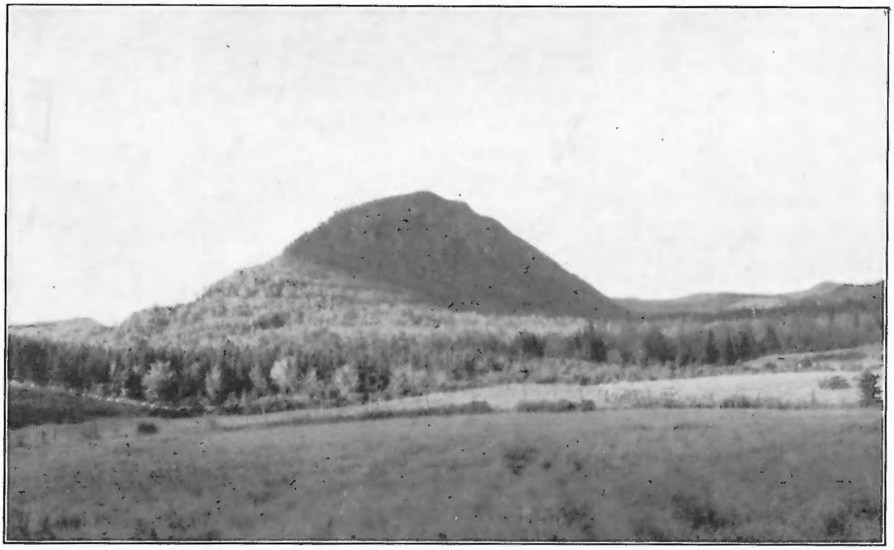
Intermediate and Basic Types

DALHOUSIE MOUNTAIN ANDESITES

These rocks compose Dalhousie mountain, which is a volcanic neck, and the islands offshore at Dalhousie. They are chiefly dense, dark varieties in which the only minerals visible to the naked eye are plagioclase feldspar in small laths less than 2 millimetres long, and iddingsite which occurs as rounded grains up to 3 or 4 millimetres in diameter surrounded by an aureole of iron stain due to the migration of iron to the surrounding rock. Some varieties are coarse in grain; others are so fine that no constituent can be determined megascopically. These are considered to be mere textural variations, since on microscopic examination all show the same mineralogical composition.

In thin section the rocks are seen to be porphyritic, containing rounded and resorbed phenocrysts of augite and hypersthene, together with andesine and irregular grains of black iron ore in a groundmass composed chiefly of andesine feldspar. In the groundmass are smaller grains of augite and bastite after hypersthene in a felted aggregate of feldspar grains. Some varieties show flow structure. In many there is a small amount of an isotropic base, and since much of the feldspar in the groundmass is in the form of irregular interstitial grains there seems to have been originally a glassy base which has since become partly devitrified.

Besides the bastite, other secondary minerals are present. Iddingsite formed originally from hypersthene has become altered to a colourless serpentine with a development of iron oxides along the border. Much of



73513

A. Sugarloaf mountain, Campbellton, a Lower Devonian volcanic neck.

B. Contact of two lava flows on shore a mile northwest of Dickie, N.B.

the hematite or limonite leached from the iddingsite was deposited in strain fractures, in places filling cracks in andesine phenocrysts. Calcite has also been introduced into similar fractures. The chief characteristic of the typical flow of this series is the occurrence of phenocrysts of iddingsite in a groundmass of colourless augite, andesine, and black iron oxide. The andesites which overlie the Upper Dalhousie beds to the northeast of Stewart cove are of this type. There are here five flows, three along the cove west of Bon Ami point and two north of the point. The middle flow contains a great number of small, spherical amygdules composed of green chlorite and brown iron oxide, probably limonite, with some carbonate. Similar flows occur on the northwest slope of Dalhousie mountain.

On the north side of Chaleur bay a similar group of flows and tuffs associated with Lower Devonian sediments extends with local breaks as far east as the western edge of Maria township. The flows are massive rocks, commonly amygdaloidal. In thin section they are found to contain smaller amounts of iddingsite and larger amounts of hypersthene than the rocks at Dalhousie. Also, the augite within the groundmass is more granular and only locally is it present in the large masses with interpenetrating laths of andesine so typical of the flows at Stewart cove. It is hardly likely that all these pyroxene andesites had their origin in the volcano that occupied the site of the present Dalhousie mountain. Several vents may have given rise to flows of similar composition.

INCH ARRAN ANDESITES AND LATITES

These include the volcanic flows, inclusions in the flows, and the associated tuffs and agglomerates that extend from Inch Arran point to Dalhousie and on westward for some 3 miles. These rocks vary considerably in colour and texture, but all are biotite-augite andesites or latites. They are typically grey and consist of phenocrysts of orthoclase, microperthite, oligoclase, biotite, augite, and black iron oxide in a groundmass of small laths of feldspar and iron oxides, and locally some interstitial glass. Included in the flows are fragments of similar rocks.

Another type that occurs as inclusions in the flows is a reddish, finely crystalline monzonite in which black needles of ferromagnesian minerals are abundant. Under the microscope the rock is seen to be highly altered. Much of the feldspar appears to have been originally orthoclase, whereas the most abundant ferromagnesian mineral, whose outline suggests that of biotite, is completely altered to iron oxides. Other grains bordered by iron oxides are composed of augite. Apatite is present as an accessory constituent, and secondary kaolin carbonates and limonite are abundant.

Along cracks and in cavities in these flows and tuffs iron has been deposited as hematite. Many vugs are lined with hematite crystals associated with calcite and a fibrous zeolite that was identified as phillipsite and is commonly stained red by iron oxides.

MAPLE GREEN ANDESITES

In the vicinity of Maple Green, to the west of Dalhousie Junction, is a series of pyroxene andesite flows which resemble closely rocks from what appears to be a volcanic neck underlying the Bonaventure beds about half a mile south of Maple Green. The andesites continue for about half a mile westward. The rock from the supposed volcanic neck is coarsely granular, containing tabular grains of feldspar and hypersthene with a maximum diameter of 8 and 2 millimetres respectively. In thin section phenocrysts of augite are also seen to be present. The groundmass is composed of glass. In the flows, which are amygdaloidal, the phenocrysts are much smaller and the glassy groundmass has been partly devitrified.

SUGARLOAF DACITES

Sugarloaf mountain is believed to be a volcanic neck. It consists of massive, porphyritic rock and in the region surrounding it are flows of similar rock and considerable thicknesses of volcanic tuffs. The latter are particularly well exposed along the highway and the railway west of Campbellton.

The massive volcanics consist of dark grey, porphyritic rocks having phenocrysts of oligoclase or andesine with some hornblende and quartz in a groundmass of feldspar and quartz. The presence of hypersthene is in places suggested by aggregates of serpentine having outlines typical of that mineral. Orthoclase occurs in minor amounts both as phenocrysts and in the groundmass. Black iron oxide and apatite occur as accessory minerals.

The associated tuffs are light grey and composed of irregular fragments of quartz, orthoclase, oligoclase, andesine, and black iron ore in a fine-grained, almost glassy, base. Some are rhyolitic rather than dacitic in composition.

GAUVIN ANDESITE

The rocks that predominate in Maria mountain consist of latite in the southern part and oligoclase andesite in the northeastern part, particularly along Maria brook. The latter consists of reddish to greenish grey, porphyritic rocks with interbedded amygdaloidal and tuffaceous rocks. On weathering the rock becomes brown, takes on an earthy lustre, and a fine network of short needles of feldspar up to 5 millimetres in length becomes apparent.

Under the microscope the rock is found to consist of phenocrysts of oligoclase andesine in a groundmass composed essentially of a host of microlites of feldspar in black glass. The rocks are in places cut by irregular, banded veinlets of chalcedony, brown chlorite, and calcite; and locally there are a few amygdules of the same material. Black iron oxide is usually present. There are also a few phenocrysts of chloritized augite.

MARIA LATITE

The southwestern part of Maria mountain in ranges II and III, Maria township, consists of latite in the form of a volcanic neck and associated flows. In hand specimen the rocks are pinkish and fine in grain, containing no recognizable minerals with the exception of small patches of limonite.

Microscopically these latites are found to consist of partly resorbed phenocrysts of quartz and orthoclase in a groundmass of small, irregular grains of quartz and orthoclase, minute laths of plagioclase, small grains of black iron oxide, and interstitial glass. Some sections contain neither phenocrysts nor identifiable minerals in the groundmass and there are gradations between these extremes.

NOUVELLE DACITES

North of Chaleur bay and east of Nouvelle river are outcrops of a finely crystalline rock characterized by a brownish colour and rusty, limonitic pits. The rock is a fine-grained dacite which in thin section is seen to contain biotite in some specimens and hornblende in others. For the most part the ferromagnesian minerals are almost completely resorbed, leaving only shadow crystals filled with chlorite, quartz, and brownish iron oxides. There are in some specimens phenocrysts of plagioclase and, less commonly, some of quartz and orthoclase.

West of Nouvelle is a dark grey, volcanic rock with laths of feldspar visible to the naked eye, and on Glen brook is another purplish in colour with square phenocrysts up to 3 millimetres in width. In thin section both of these are found to consist of phenocrysts of orthoclase, plagioclase, and quartz, all partly resorbed, with a few grains of black iron oxide in a groundmass of the same materials and a pale amber glass. The grey volcanic is traversed by veins of quartz and calcite, whereas the purplish one is traversed by calcite veins and contains inclusions of other volcanic rocks.

A pipe-like mass of pinkish dacite cuts Ordovician sediments on the Samuels branch of Stewart river. It consists of laths of kaolinized plagioclase and much irregular interstitial quartz with a chloritized ferromagnesian mineral and threads of black iron oxide partly altered to hematite. Dykes of similar rocks were found near the mouth of Samuels brook and on Eperlan brook north of Carleton.

ESCUMINAC DOLERITES

Under this head are included rocks intrusive into the Ordovician, Silurian, and Lower Devonian strata and believed to be related to the lava flows associated with the Lower Devonian sediments. They vary in colour from dark grey to dark brownish grey and in texture from fine-grained with no recognizable constituents to porphyritic with feldspar phenocrysts up to 5 millimetres in diameter. In the Dalhousie region they form a zone near the base of the lowest Dalhousie sediments. North of Chaleur bay, dykes of similar rock cutting Ordovician beds were found along Eperlan brook, Stewart river, Mann brook, on numerous branches of Nouvelle river, and other places. They vary from types consisting mainly of oligoclase-andesine and secondary chlorite to augite dolerites. The following serve as examples.

North of Carleton a dyke cutting Ordovician sediments extends from the east to the west branch of Eperlan brook, about a mile above the fork. This rock contains small laths of andesine with minutes grains of apatite, irregular shreds of black iron oxide, and large amounts of chlorite. Occasionally one may find feldspathic phenocrysts which appear to be rather more basic than the feldspar in the groundmass. Orthoclase is present in stumpy laths with square cross-sections. Calcite has been introduced.

On two small tributaries west of Nouvelle river a dyke of similar rock contains granules of augite in addition to the feldspar laths, shreds and grains of iron oxide, and patches of chlorite so typical of these rocks.

A mile north of Gauvin post office, Maria township, a dyke of augite-poor dolerite was found cutting Lower Devonian sediments. In the vicinity of Shannonville, N.B., several dykes of highly weathered, grey dolerites cut across the bedding of Lower Devonian sediments. In thin section these intrusive rocks are seen to be composed mainly of oligoclase with a small amount of micrographically intergrown quartz and feldspar. Apatite and black iron oxide are present and also secondary quartz.

These dyke rocks range from types free of augite to varieties in which augite is plentiful. Some of the latter closely resembles some of the Dalhousie Mountain andesites.

CHEMICAL COMPOSITION OF TYPE ROCKS

Chemical analyses of some of the most important types of the Lower Devonian volcanics were made by W. V. Howard. The following table summarizes the results (Howard, 1926).

—	I	II	III	IV	V	VI
	Sugarloaf dacite	Dalhousie Mountain andesite	Bon Ami andesite	Hypersthene andesite	Inch Arran andesite	Stewart andesite
SiO_2	62·99	56·74	54·87	50·72	48·33	47·15
Al_2O_3	18·03	18·41	19·64	21·25	19·48	28·62
Fe_2O_3	2·02	4·30	1·18	3·20	2·87	3·34
FeO	1·52	2·04	2·93	3·32	2·14	3·46
MgO	1·00	1·33	3·15	3·84	4·98	3·48
CaO	3·25	6·02	7·32	7·08	8·04	7·49
Na_2O	5·82	5·58	5·47	5·22	5·04	3·64
K_2O	1·05	1·13	1·47	2·56	2·72	0·70
H_2O	2·07	2·05	1·78	1·32	3·80	0·67
TiO_2	0·71	1·02	1·76	1·63	1·16	1·32
P_2O_5	0·29	tr.	tr	pres.	....	pres.
MnO	0·09	0·12	0·16	tr	0·05	0·12
CO_2	1·00	1·25	0·70	0·10	1·05	0·29
	99·84	99·99	100·43	100·29	99·66	100·28

Acid Types

In the region of the lower part of Benjamin river and to the west in the area drained by New Mills river are numerous exposures of acid, eruptive rocks. Some of these are light in colour, almost white; others are distinctly reddish. All are dense or fine grained and in some of them small phenocrysts of feldspar can be distinguished with the naked eye. The feldspar is commonly reddish orthoclase. Some of the rocks are distinctly banded, showing flow structure. In thin section these are seen to consist of phenocrysts of orthoclase and quartz in a glassy matrix.

Most of these rocks have the composition of rhyolite. Some are almost certainly flows. On the shore about a mile northwest of the mouth of Dickie creek reddish rhyolite is associated with reddish, tuffaceous beds of similar composition, and with darker, amygdaloidal lavas. The flow structure seen in many places suggests extrusive origin. On the other hand, some of these acid, eruptive rocks may have an intrusive origin. They border a region on Benjamin river which, as will be shown later, is underlain by Devonian granite. It is possible, therefore, that some of these dense, rhyolitic rocks are border phases of intrusive masses which, under only a shallow cover, cooled quickly.

INTRUSIVE ROCKS

As has already been mentioned, dyke rocks of intermediate and basic composition occur fairly abundantly cutting the pre-Devonian rocks, particularly in the region north of Chaleur bay. These are regarded as the dyke equivalents of the great volcanic flows of Lower Devonian time, which are so conspicuous a feature along both sides of the lower Restigouche. South of Chaleur bay there are in addition acid intrusives. They include finer grained, acidic dykes, locally porphyritic, and syenite and granite dykes and stocks. The largest mass is a stock on Nipisiguit river immediately south of Bathurst. This has a length of 10 miles and a maximum width of about 4½ miles. Other stock-like masses of granite occur on Benjamin river, on the northeast side of Antinori lake, and to the south of Val d'Amour near Campbellton.

These small stocks are regarded as the upper parts of an underlying batholith of considerable size. Granite batholiths are a conspicuous feature of central New Brunswick. They form a nearly continuous zone extending from the southwest corner of the province through to Nipisiguit bay. North of Nipisiguit river only small masses are met. It is highly probable, however, that at depth these are united with the larger mass. The dykes and the finer grained granite and granite-porphyry masses such as those that compose Squaw Cap, Slate mountain, and other elevations southwest of Tide Head, are also regarded as having their origin in this large, underlying acidic intrusive.

Granite

NIPISIGUIT RIVER

The granite mass south of Bathurst is well exposed along Nipisiguit, Little, and Middle rivers. It may most readily be seen at Rough Waters and at Pabineau falls on the Nipisiguit. At the former locality the fresh, massive granite exposed at the river passes up into weathered material overlain by the flat-lying Pennsylvanian sandstones.

The rock is slightly pink to brick-red in colour due to the presence of large, orthoclase crystals. The texture varies from coarsely granular to semi-porphyritic. Feldspar crystals, in places an inch long, lie in a matrix of a rather even-grained mass of pale pink feldspar and glassy quartz with numerous small flakes of biotite. Cutting this general type are dykes of pale pink, fine-grained aplite.

Under the microscope the granite is seen to be a normal acid variety consisting of orthoclase, albite, quartz, and biotite with accessory iron ore and apatite and a little secondary chlorite. In the aplitic variety muscovite takes the place of the biotite.

On Little river are exposed some granitic types somewhat different from the regional reddish variety. One phase is a pale, greyish white, fine-grained, porphyritic granite with a speckled appearance due to flakes of biotite. Under the microscope the rock is seen to consist of larger crystals of quartz, plagioclase, and orthoclase with slender plates of biotite in a finely granular groundmass of quartz and feldspar.

The granite of the Nipisiguit intrudes Ordovician strata which it has altered into hornfels types. It is overlain by undisturbed Pennsylvanian sediments.

ANTINORI LAKE

Outcrops of granite begin on the northeast side of Antinori lake, which lies about 10 miles south of Jacquet River, about $\frac{3}{4}$ mile from the end of the portage coast, and continue to the south end of the lake. The rock is massive and weathers dark. On the freshly broken surface it is light flesh-coloured to pink. In thin section it resembles the Nipisiguit granite, consisting of orthoclase, quartz, albite, and biotite. The rocks it intrudes are dense, dark sediments altered to hornstones containing an abundance of reddish brown biotite and, locally, pyrite.

BENJAMIN RIVER

On the south branch of Benjamin river, beginning about 4 miles from the coast, is an area of intrusive rocks traversing Lower Devonian volcanics and sediments. The intrusives consist of a grey gabbro and a pink granite. Their southern limit on the river was not determined.

The first outcrops consist of a light grey gabbro which in thin section is seen to consist of an acid labradorite, large augite crystals, accessory iron oxide, and secondary chlorite as an alteration product of the augite. Farther upstream is a reddish granite consisting of reddish orthoclase, albite, quartz, and biotite. The gabbro appears to be a border phase of the granite, though this relationship was not established.

BALMORAL ROAD

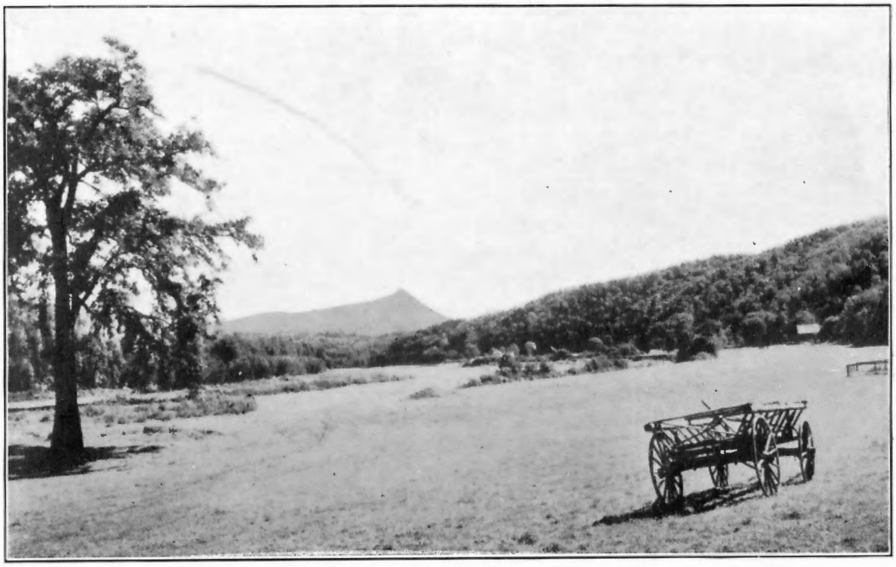
South of Val d'Amour, along the old part of the Balmoral road, are outcrops of a fine-grained, reddish granite cutting Lower Devonian sediments. Other scattered outcrops occur in this general region between Val d'Amour and Popelogan lake.

LORNE SETTLEMENT

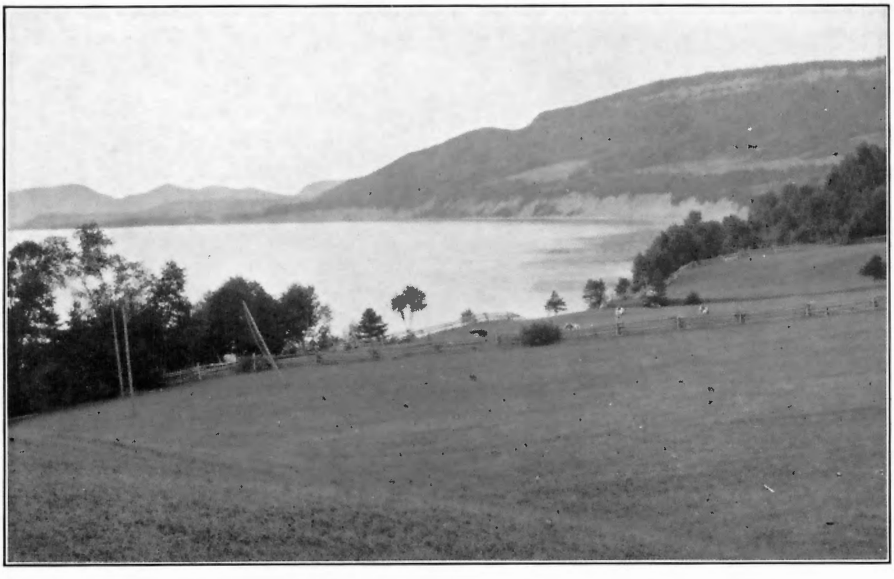
In the neighbourhood of Lorne settlement are several dykes of reddish, fine-grained syenite. They traverse fossiliferous Lower Devonian sediments. A thin section of a specimen from one of these dykes shows orthoclase, minor amounts of albite, hornblende, secondary epidote, chlorite, and carbonate and accessory apatite and iron oxides.

SLATE MOUNTAIN

Slate mountain, Squaw Cap mountain, and a number of other prominent hills in the region southwest of Tide Head consist of fine-grained, acid,



A. Looking down Restigouche valley, above the mouth of Upsalquitch river. Squaw Cap mountain in the distance, composed of Devonian intrusive rock.



B. Upper Devonian fish beds near Maguasha, overlain by Bonaventure conglomerate.

intrusive rocks of the composition of granite. Some are so dense that individual crystals cannot be distinguished with the naked eye, but with a hand lens the granitic texture of most is apparent. Some varieties are porphyritic, showing small phenocrysts of feldspar in a dense matrix. The rocks vary in colour from grey to reddish. In places these are intruded along the bedding planes of the sediments, as for example near Flatlands where a rhyolitic rock shows sill relationships with the Helderberg beds.

Dyke Rocks

Numerous acid dykes cut the Ordovician, Silurian, and Lower Devonian strata, particularly in the region of Upsalquitch river. They are commonly dense grey to reddish rocks in which phenocrysts of feldspar are usually abundant, but their border phases in many cases consist of very dense rock of lighter colour in which no phenocrysts are visible. The sections of these rocks that were studied proved to be altered; outlines of the feldspar phenocrysts are easily discernible, but these have been altered largely to carbonate and sericite. These dyke rocks undoubtedly had their origin in the same magma that produced the larger, intrusive masses.

A dyke rock of somewhat different character is exposed in a railway cut at Campbellton where it intrudes volcanic tuffs of Lower Devonian age. The rock is reddish, of medium grain, and contains numerous flakes of biotite. A similar rock is exposed on the shore at Shaw cove near Dalhousie Junction. Here it forms two sill-like intrusions in sandstone-conglomerate strata believed to belong to the Gaspe sandstone series. At the contact with the sandstone the intrusive shows a dense, chilled border.

Age of the Acid Intrusives

The granites of the interior of New Brunswick and the central part of Gaspe peninsula are of Devonian age. They intrude Lower Devonian strata and were locally unroofed and incised before the deposition of the Pennsylvanian formations. In Maine and southwestern New Brunswick the Perry formation, whose Upper Devonian age is established from its plant remains, rests unconformably on granite, and granite boulders are abundantly present in its conglomeratic beds.

In central Gaspe, Lower Devonian fossiliferous sediments are folded, faulted, and brecciated, are cut by numerous syenite, porphyry, and granite dykes, and are mineralized with sphalerite-galena-bearing veins undoubtedly derived from the granitic intrusive masses. The strata of the Middle Devonian Gaspe sandstone series are folded, but nowhere were they seen by the writer to be intruded by granite or syenite, nor were mineral veins found anywhere in this series. It would appear that there was deformation accompanied by intrusion at the close of the Lower Devonian and that in later Devonian time there was renewed deformation The two sills of red, biotitic granite, which occur at Shaw cove near Dalhousie Junction, New Brunswick, are the only evidence seen by the writer that this later movement was accompanied by igneous activity.

MIDDLE DEVONIAN

Gaspe Sandstones

GENERAL

The Gaspe sandstones as defined by Logan consist of a series of clastic sediments lying above the Gaspe limestones. The type section (Logan, 1863, pages 394-396) is on Gaspe bay where Logan gives a thickness of 7,036 feet to the series. The rocks consist of grey, arenaceous shales, grey sandstones, drab sandstones locally inclining to red and green, drab conglomerates, and red sandstones. Argillaceous iron ore occurs in some of the beds, one band having a thickness of 3 inches. Towards the base of the series there is a small seam of coal with carbonaceous shale, measuring altogether about 3 inches in thickness. The contact between the series and the underlying Gaspe limestone is exposed at Little Gaspe, where the two series are practically conformable, the difference in dip being at most only a few degrees. The abrupt change in lithology is, however, striking.

The Gaspe sandstone contains numerous plant remains. The chief representative is *Psilophyton.* Several horizons in which it occurs have been described by Dawson as old soils in which the plants were apparently rooted. Among the plants described by Dawson may be mentioned: *Prototaxites logani, P. crassum, P. tenue, Stigmaria areolata, S. minutissima, Didymophyllum uniforme, Calamites inornatus, Annularia laxa, Lepidodendron gaspianum, Leptophleum rhombicum, Lepidophloios antiquus, Psilophyton princeps, P. robustium, P. elegans, Arthrostigma gracile, Cyclostigma, Cordaites angustifolius.* This flora represents the *Psilophyton-Arthrostigma* flora which preceded the *Archaeopteris* flora. It occurs in the Chapman sandstone of Maine and apparently died out shortly after the close of the Hamilton, after which the Archaeopteris flora flourished until the end of the Devonian. Remains of fish are also found in the series. In the type section at Gaspe bay fragments and spines of *Cephalaspis, Machaeracanthus,* and others have been found near the middle of the series.

The Gaspe sandstone covers wide areas in the interior of Gaspe. In the region of the zinc-lead field of the central part of the peninsula the formation rests on a thick series of volcanic rocks which in turn rest on Lower Devonian sediments of the Gaspe limestone series. Psilophyton remains are locally abundant, just as in the coast section.

Marine invertebrate fossils have been found in the series at a number of localities. Clarke (1908 b) lists forty-eight species collected by himself and others. Of these, seven are found also in the Grand Grève limestone (upper member of Gaspe limestones); one is Helderbergian, eight occur in the Oriskany of New York, thirteen in the Hamilton of New York, and ten others are close allies or possible affinities of species found in the Hamilton of New York. In 1921 the writer collected seventeen species on Mississippi brook and on York river above the mouth of that tributary, eight of which are not given in the list of Clarke. Concerning this fauna (Alcock, 1926 C, page 43) E. M. Kindle reported: "This fauna contains certain elements of the early Devonian fauna represented by *Leptocoelia flabellites* which elsewhere occurs in the Oriskany sandstone, but associated with the older

Devonian forms are such Middle Devonian species as *Microdon (Cypricardella) gregarius, Nuculites triquetrus,* and other representatives of Hamilton time. The fauna is, therefore, considered to represent Middle Devonian time, although including survivals of the early Devonian fauna."

Fossils have also been collected by I. W. Jones (Jones, 1930) in the Berry Mountain map-area of central Gaspe. The Gaspe sandstones are here divided into three divisions. The lower consists of greenish to brownish, fairly hard, medium to coarse-grained sandstones grading up into measures of finer texture and consisting of brown to buff, rather soft, thin-bedded, fine-grained sandstones and argillaceous sandstones. Reporting on fossils from this division collected by Jones at seven places, Kindle states that they represent a transition from Lower to Middle Devonian. Deposition of this division apparently took place under conditions that alternately admitted and excluded marine faunas. The middle division consists of chocolate—or reddish—brown shales grading up into deep red, fine-grained sandstones and arenaceous shales. These red rocks show crossbedding, lenticular structures, ripple-marks, mud-cracks, worm-borings, and a few rain-prints. The upper division consists predominantly of hard, grey, massive, crossbedded, coarse-grained sandstones with local, fine-grained, brown sandstones and chocolate-brown shales. The only fossils found in this division are some poorly preserved, carbonized plant remains.

The abrupt change from the Gaspe limestones to the Gaspe sandstones is regarded as a structural break of some importance. The abundance of grains of volcanic rock in the lower beds of the Gaspe sandstone at many places is evidence that the underlying Lower Devonian volcanics were undergoing erosion while the sandstone was being deposited. In the zinc-lead field of central Gaspe, as stated previously, the Lower Devonian sediments have been deformed much more than the Gaspe sandstones. The former are folded, faulted, brecciated, intruded by dykes of syenite and porphyry and mineralized by veins of quartz and carbonate carrying sphalerite, galena, and chalcopyrite. The Gaspe sandstones, on the other hand, though folded gently, were nowhere in this region observed to be cut by dykes or mineral veins. It is to be concluded, therefore, that deformational movements took place at the close of the Lower Devonian period and that the base of the Gaspe sandstone marks the beginning of the Middle Devonian deposition.

The series is believed to have been deposited largely under continental conditions. The beds containing marine fossils are limited to a few horizons near the base of the series. Plant remains of types that are known to be land forms, on the other hand, occur practically throughout the series. In sandstone, *Nematophyton* trunks have been found normal to the bedding planes, apparently just as they grew. The character of the sediments also favours the interpretation of deposition under continental conditions. Their clastic character, their thickness combined with wide areal extent, and the reddish colour of parts of the formation, all point to terrestrial deposition. It is probable that uplift of the old land of Acadia rejuvenated the streams, with the result that large quantities of coarse, clastic material were supplied and deposited as deltas and along flood-plains.

LOCAL

In Chaleur Bay region the Gaspe sandstone series occurs in two areas. The first is along the lower part of Restigouche river, where it forms a belt along the north or Gaspe side, and a narrower, more patchy zone on the New Brunswick side. The second area is in the region of Cascapedia and New Richmond between Grand Cascapedia and Little Cascapedia rivers.

Restigouche Area. In Restigouche area the Gaspe sandstone rocks rest on Lower Devonian volcanics. The actual base of the series, showing the sandstone in contact with the volcanics, can be seen on the shore west of Campbellton; and at numerous places on the Gaspe side the basal beds can be seen in close proximity to the underlying lavas. Good outcrops of the series extend almost continuously along the north shore of the lower Restigouche from the mouth of Glen brook to point à la Garde. Other outcrops occur west of Cross Point pier as far as point Bourdeau, and on the opposite side of the river at Campbellton.

The series consists of sandstone and conglomerate, grey, buff, or greenish in colour. Between Mission point and Campbellton it includes black shales also. The pebbles of the conglomerate are usually less than 5 inches in diameter, are well rounded, and consist of quartz, basic volcanics, acid volcanics, red chert, and limestone. On Battery point low outcrops of the series overlain by Pleistocene stratified gravels contain numerous, well-rounded pebbles of limestone of the Matapedia series, some of which are traversed by calcite stringers of pre-Gaspe sandstone age. The veins end abruptly at the edge of the pebbles, showing that they were formed in the rock from which the pebbles came. The beds commonly show lenticular structure with lenses of sandstone in conglomerate and of conglomerate in sandstone. Locally the series is cut by numerous, small, calcite stringers some of which cut across pebbles. At point à la Garde a vug of white agate was found in the conglomerate. East of Mango brook the series is sheared and shows numerous slickensided surfaces.

Plant remains occur in the series in this region. A mile west of point à la Garde the shore section shows numerous fragments of Psilophyton, and a quarry near point Bourdeau shows a few others. On the shore about 2 miles west of Cross point specimens of Nematophyton (Dawson and Penhallow, 1888; Alcock, 1929) were collected. These were giant algal plants, of which numerous specimens were collected by Logan and Dawson in the Gaspe sandstone series of Gaspe bay and by Robert Bell in the interior of the peninsula. Dawson also collected in the Restigouche region and states that the plants found in these beds are different from those found in the measures at Escuminac bay, which will be described later as Upper Devonian, the former belonging to a much lower horizon and being identical with those in the lower part of the Gaspe sandstones in the type section.

On the south side of the Restigouche, about half a mile west of Campbellton, argillaceous beds have yielded a considerable fish fauna (Whiteaves, 1881; Traquair, 1890; Woodward, 1892; Eastman, 1907) and a few invertebrate fossils. The varieties of fish include:

Cephalaspis campbelltonensis Whiteaves
" *jexi* Traquair
Acanthoessus semistriatus Woodward

Climatius latispinosus Whiteaves
" *gracilis* "
Phylctaeniaspis acadicus "
Protodus jixi Woodward
Doliodus problematicus "
Cheirocanthus costellatus Traquair
Gyracanthus incurvis "

The invertebrates include two small species of gasteropoda, entomostraca, fragments of a large pterygotus, and a spirorbis. The last two species occur also in the Gaspe sandstone of the type section.

The beds of the Gaspe sandstone series in the lower Restigouche region dip at angles varying from zero to 90 degrees and in places are even overturned. Their general structure is that of a syncline resting on the volcanic rocks which form a broad belt on either side of the river. Hence the main dips are southward on the north side of the river and northward on the south side. On the Gaspe coast between the mouths of Glen and Mango brooks the beds are vertical with local reversed dips to the north. In the region of point à la Garde and Battery point there is a subsidiary anticlinal fold along the axis of the main syncline. This brings the underlying volcanic rocks to the surface along the road that branches off from the main highway to point à la Garde. The anticlinal structure can also be traced in the dips of the sandstone and conglomerate beds around the point.

On the New Brunswick side, three-quarters of a mile west of Dalhousie Junction, beds of buff sandstone outcrop in low cliffs along the coast. They dip to the north at about 60 degrees. These beds overlie Lower Devonian volcanics and shales and locally are overlain in turn by flat-lying Bonaventure strata. West of Dalhousie there are other outcrops of sandstone and conglomerate along the shore. These strike northeast and dip 40 degrees northwest. The conglomerate consists largely of volcanic boulders derived from the underlying volcanic rocks. In this locality the series is intruded by a red, medium-grained rock carrying large flakes of biotite. The intrusive takes the form of two sills intruded along the bedding planes of the conglomeratic sandstone.

The thickness of the series in this region is difficult to estimate. Between the mouth of Escuminac river and the Nouvelle the belt of country underlain by the Gaspe sandstone has a width of approximately one mile. Much of this belt has no outcrops, however, so that the attitude of the underlying beds is not known. An outcrop on the north border of this zone, near the contact with the underlying volcanics, occurs near the railway crossing on the main highway, 3½ miles east of Escuminac river. The dips here are about 45 degrees to the south. Rocks towards the middle of the belt and apparently higher up in the series outcrop along the shore west of the mouth of Glen brook. The dips here are almost vertical. In outcrops on the southeast border of the belt, at the mouth of Dumville brook at Pirate cove, the dips range from 45 to 90 degrees. If across this belt the series is not repeated by folding or faulting, there must be a thickness of from three-quarters to a mile of sediments. It is possible, however, that as at point à la Garde there may be a subsidiary roll in this covered area which would greatly reduce the figure.

The upper part of the Gaspe sandstone series as here described is Division A of the Escuminac section of Kindle (Kindle, 1930). It consists of angular pebble conglomerates interbedded with chocolate, green, and grey, argillaceous and sandy shales. The lower beds are characterized by an ostracode fauna and numerous plant fragments, the latter closely associated with a bed of coal 2¼ inches thick. In his description of the Escuminac Bay beds Kindle uses the term Gaspe sandstone to include all the strata described here under the terms Middle Devonian and Upper Devonian.

Cascapedia Area. Between the Cascapedia and Little Cascapedia rivers is an area underlain by a sandstone series that is correlated by the writer with the Gaspe sandstone. Outcrops occur along the railway east of Cascapedia station, on the east side of the road ascending the east side of Cascapedia river, on the north side of Harriman lake, and at other localities in this region. The beds consist of buff sandstone and conglomerate with dips ranging from horizontal up to 70 degrees. The series is quite different from the deep red beds of the Bonaventure series, which outcrop at numerous places to the south and which lie horizontally. To the north of the belt are high hills of Ordovician conglomerate. The conglomerate of the Gaspe series is distinguished from this older conglomerate by its fresher appearance and by the fact that it contains boulders of the Ordovician conglomerate. The latter at a number of places was found to contain marine fossils, whereas the Gaspe sandstone locally contains plant remains, as for example on the railway about 2 miles east of Cascapedia station.

Mal Baie. The Gaspe sandstone series in its type section along Gaspe bay is thrown into a number of rolls. South of the Tar Point anticline there is a wide area in which the dips are low and to the south. In the region of Beatty river the axis of the succeeding syncline is reached, to the south of which the beds rise steeply with northerly dips. This southern limb is, near the coast, concealed by the overlying Cannes de Roche formation. The distance across the strike of the Gaspe sandstone on this south limb of the Beatty River syncline, from the overlying Malbaie conglomerate on Beatty river to the Murailles limestone upon which the Gaspe sandstone here rests, is approximately 7,000 feet. The average dip of the beds on this limb is 75 degrees, and there are apparently no dislocations in this section. The thickness is, therefore, calculated to be 8,500 feet, an estimate greater than that given by Logan.

Marine fossils were found at a number of places in the Gaspe sandstone of the Percé-Malbaie region. Along the shore below Red peak, at Percé, the base of the Gaspe sandstone, the only part of it outcropping in the immediate vicinity of Percé, contains fossils. Other fossil localities include Portage river just west of the Cannes de Roche beds, the little fork of Malbaie river 2½ miles directly north of the bridge, and Sprune gulch about 2,200 feet stratigraphically above the Murailles limestones.

Malbaie Formation

The Malbaie formation extends from point Jaune on the south side of Gaspe bay round point St. Peter and along the north side of Mal baie to Beatty river. It is conformable with the Gaspe sandstone and forms the upper part of the continuous succession of Devonian deposits in this area. Its lithology is sufficiently distinct to make it a distinct formation. These beds were placed by Logan in the Bonaventure series, by Ells in the Gaspe sandstone series, and later by J. M. Clarke and Winifred Goldring in the Bonaventure.

The base of the formation is arbitrarily placed below the lowest of the thick limestone pebble conglomerates which outcrop along the south shore of Gaspe bay westward from point St. Peter. Below the lowest of these conglomerates, in the cove immediately west of point Jaune, there is a fault mentioned by Logan as marking the top of his Gaspe sandstone. Six thick beds of limestone pebble conglomerate, separated by sandstone strata and dipping 15 degrees east, make five points of land and an island on this part of the coast. These are Jaune point, Whale head, Hurley Burley, Little St. Peter point, St. Peter point, and Plateau island. The thickness of the formation along this part of the shore is 3,000 feet.

Somewhat similar coves and points of land are formed on the north shore of Mal baie as far west as Belle Anse where a monclinal fold causes the strata to the west to assume a nearly horizontal attitude. The junction or hinge between the horizontal beds and the inclined beds to the east is plainly exposed immediately west of the harbour of Belle Anse.

These conglomeratic beds of the Malbaie formation are exposed for over a mile along Malbaie river, and about 2 miles above the bridge they interfinger at their base with beds of the underlying Gaspe sandstone. The dip of the beds here is about 20 degrees to the east. This Malbaie conglomerate is also exposed three-quarters of a mile up the north branch of Beatty river, tightly folded in the axis of a syncline of Devonian rocks. The river here crosses to the north of the synclinal axis and about a mile farther upstream it recrosses to the south side. At this place only the Gaspe sandstone is seen in the bed of the stream. A high hill to the west on the synclinal axis marks the western limit of the Malbaie conglomerate, its termination being apparently due to the pitching up of the axis of the syncline in that direction.

The Malbaie conglomerate between point Jaune and Whale head has yielded plant fragments similar in appearance to those in the Gaspe sandstone below. Its age is, therefore, probably Middle Devonian.

Heppel Formation

Resting above the Lower Devonian Causapscal formation in Matapedia Valley region is a series of coarse sandstones which are here designated the Heppel formation. They are typically exposed in the neighbourhood of Heppel station and extend from a mile south of Causapscal to within a mile of Ste. Florence. The discontinuity of exposures and the complications of structure prevent the making of any estimate of the thickness of the formation in this area. The rock is dominantly a coarse, feldspathic sandstone of a grey or light brown colour, but a mile south of Heppel the brown sandstones are overlain by red shales and sandstones. The best exposures of this locality are in a quarry 30 chains east of the main highway on a small creek tributary to the Matapedia. The sandstones bear current ripples and large, polygonal mud-cracks. The red beds are about 120 feet thick and are overlain by pale greenish grey sandstones.

As already mentioned, the Heppel formation is underlain by the Causapscal formation, from which it is separated by a fairly sharp boundary. The top of the Heppel is not known. The belt of outcrop of the sandstone is terminated at the south by a fault that brings the Ordovician phyllites of the Matapedia series into apparent superposition. To the east the formation covers wide areas.

The Heppel formation is represented on Ells' map as occurring on Causapscal river 10 miles above its mouth. The basal contact was placed by him at the falls where a calcareous sandstone overlies an arenaceous limestone designated as " Silurian." It seems probable that the arenaceous limestones really belong with the sandstones in the Heppel formation and that the actual contact with the Causapscal formation beneath is a mile downstream from the falls. On Causapscal river the Causapscal formation is about 3,000 feet thick, which is the normal thickness as verified elsewhere. To include in it the arenaceous limestones that occur north as far as the falls would give it a thickness of 6,500 feet. The sandstones above the falls are more abundantly fossiliferous than the arenaceous limestones below, but the limestones contain many of the same species. Moreover, beneath the typical exposures of the Heppel formation, in the limestone of the Causapscal formation, fossils are exceedingly rare and those that are present are not found in the beds below Causapscal falls. The latter beds, then, are more closely allied to the fossiliferous sandstones above Causapscal falls which are considered to be equivalent to some part of the sandstone at Heppel.

This correlation carries with it certain implications, one of which is a marked lateral change in the Heppel formation. South of Causapscal, argillaceous strata are confined to two zones, red shales which occur high in the section and grey arenaceous shales at the base, the latter only about 50 feet thick. On Causapscal river, on the other hand, the lower 3,500 feet of the Heppel is argillaceous and calcareous with only a minor amount of sand. This lateral gradation from coarse to fine, from clastic to calcareous, sediments suggests that the source of material was from a land mass to the south.

The fossiliferous sandstone above Causapscal falls grades upward into an arenaceous shale and this into finely laminated, grey shales. In the typical exposures of the formation no such shales are present. There is, then, a lateral gradation in the upper part of the formation and in the same direction as that in the lower part. The fossiliferous sandstone at the falls is merely a tongue of the thick sandstone at Heppel, the rest of the formation having been replaced by argillaceous and calcareous sediments.

The Heppel formation outcrops west of Causapscal river, crossing Matapedia river between mile-post 52 and Lac au Saumon. Only the lower part of the formation is known in this direction and consequently it is shown on the old map as " Silurian " (Causapscal formation). The outcrop belt of the Heppel extends less than 3 miles west of Matapedia river to a point where the eastward plunge of the structures brings the Causapscal formation to the surface in the axis of the syncline (Figure 9).

The stratigraphic position of the Heppel formation above Lower Devonian beds and its characteristic lithology correlate it with the Gaspe sandstone. The formation is locally fossiliferous and its fauna strengthens this correlation. A mile and a quarter south of Heppel, where the highway is crossed by a creek, a small collection of fossils, including a spirifer and plant remains, was made by the writer; and about 6 miles east of Causapscal, where the private road of the International Company crosses Fourmile brook, another collection including corals, bryozoa, brachiopods, pelecypods, and plant remains was made. Both of these collections were examined by E. M. Kindle who pronounced them to be of Middle Devonian age and who correlated the beds in which they were found with the Gaspe sandstone.

At the falls on Causapscal river the following fossils were collected by G. W. Crickmay:

Zaphrentis sp.
Dalmanella sp.
Dalmanella lucia Billings
Rhypidomella sp.
Rhypidomella logani Clarke
Stropheodonta sp.
Leptostrophia sp. cf. *L. magnifica* Hall
Leptostrophia blainvillei (Billings)
Schuchertella becraftensis (Clarke)
Schuchertella sp.
Eodevonaria sp. cf. *E. billingsi* Clarke
Chonetes sp. cf. *C. hemispherica* Hall
Beachia sp. cf. *B. suessana* (Hall)
Rensselearia sp. cf. *R. ovoides* (Eaton)
Camarotoechia n. sp. aff. *C. oriskania* Rowe
Spirifer gaspensis Billings
Spirifer sp. aff. *S. plicatus* (Weller)
Meristella sp. aff. *M. lata* Hall
Modiomorpha sp.
Pterinea sp.
Platyceras sp.
Dalmanites sp.

This fauna is allied to that of the Grand Grève limestone of the eastern extremity of Gaspe, but two species, *Leptostrophia blainvillei* and *Spirifer gaspensis,* are confined to the Gaspe sandstone. At the eastern end of Gaspe there is a marked break between the Grand Grève limestone and the Gaspe sandstone, but on Causapscal river there is almost a complete gradation from the Causapscal to the Heppel. The latter may, therefore, include beds that are not present at Gaspe bay; and this may account for the considerable number of Grand Grève species present at Causapscal falls, but foreign to the Gaspe sandstone of the type area.

UPPER DEVONIAN

General Statement

A series of clastic sediments on the north side of Scauminac bay overlies the Middle Devonian sandstones. Their fossil content, consisting of plant remains and a considerable fish fauna, is evidence of their Upper Devonian age. The section extends from Pirate cove to a point three-quarters of a mile east of Maguasha pier where the upper beds of the series are overlain by standstones and conglomerates of the Bonaventure formation, the two being separated by an erosional break. In this distance outcrops are almost continuous, long stretches of steep cliffs affording an excellent view of the section.

The line drawn between the beds considered to be Middle Devonian and those regarded as Upper Devonian is somewhat arbitrary. It is taken between Divisions A and B of Kindle's Escuminac Bay section (Kindle, 1930). Division A, as already mentioned, is lithologically like the typical Gaspe sandstone, and its plant remains and ostracod fauna show clearly that it belongs to the same series that outcrops on Gaspe bay and at Campbellton. Above Division A there is an abrupt change in lithology. The actual contact between A and B is not exposed, so it is not possible to say whether or not there is a structural break. The B beds where seen first have a dip of 50 degrees to the southeast, but eastward their dip, and that of the conformably overlying beds, flattens out. The A beds have dips as high as 90 degrees and it is possible that if an actual contact could be exposed it might prove to be an unconformity. The change in lithology is so distinct that more than one worker in the field has mapped the B beds as Bonaventure.

The succession, according to Kindle, is as follows:

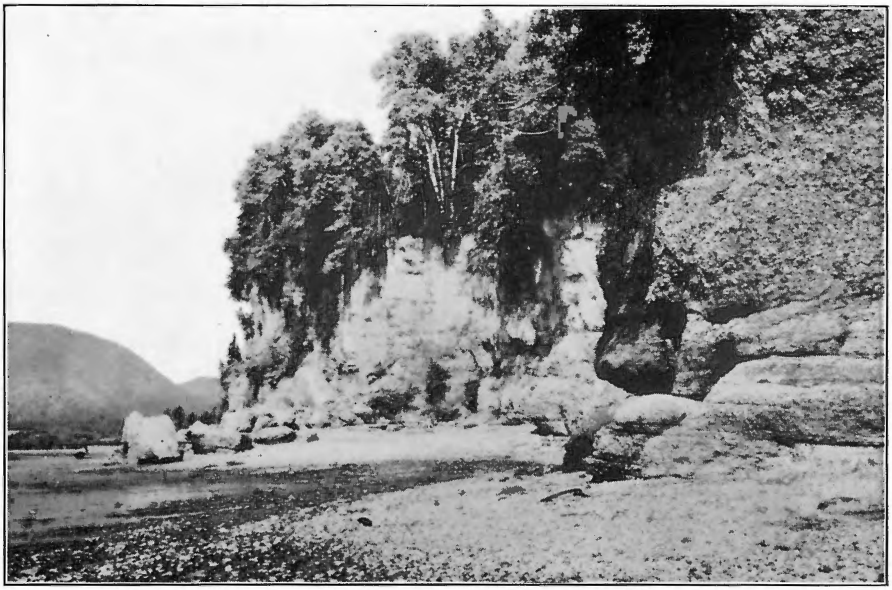
	Feet
B. Coarse, angular-pebble conglomerate with salmon-coloured matrix..........	210
C. Coffee-coloured shale (dull red, wet) with occasional green bands. Upper part with a conglomerate 0 feet to 40 feet. (C1) Lower part of formation partly concealed. Barren of fossils: (both sides of mouth of Englishman creek)..	450
D. Coarse, rounded-pebble and boulder conglomerate in grey matrix. Barren of fossils. (Fleurant conglomerate; type locality Fleurant point; also seen at Mushroom rock and southeast of Englishman creek ⅓ mile)...............	45
E. Grey, argillaceous shales and sandy shale interbedded with shaly and thin-bedded sandstone terminating in a 16-foot member (E1) of reddish beds. Fossil fish and fine plant fossils (Escuminac beds, Maguasha bay)..........	370

The whole series forms a broad syncline pitching north. At Maguasha the east limb of the syncline folds down, forming an anticline with a limb on either side of Maguasha pier.

Pirate Cove Formation

The strata mapped under the name Pirate Cove include Divisions B and C of Kindle. The basal beds consist of conglomerate well exposed on the point a quarter of a mile east of the mouth of Dumville brook. This conglomerate is succeeded by reddish, sandy shales overlain in turn by a conglomerate. To the west of the mouth of Englishman brook an abrupt downfold in the beds brings this band from its position high up in the cliffs to a position down near their base. The beds disappear under the Fleurant conglomerate about a mile west of Fleurant point.

A good exposure of the Pirate Cove beds occurs at Escuminac or Browns point, southwest of the mouth of Dumville brook. The rocks here strike northeast and dip about 5 degrees to the southeast. Above the rubble of the shore the lower beds are seen to consist of some 20 feet of soft, reddish, sandy shales, well bedded in thin layers. They show round, greenish grey spots where the red colour has been reduced by some organic



A. Upper Devonian Pirate Cove beds, Escuminac point.

B. Tilted Bonaventure rocks near Black Cape.

material. Streaks of similar colour occur along the beds in some places, and cut across them in others. The rocks show crossbedding on a coarse scale. Above these soft shales is a zone of salmon-coloured conglomerate about 15 feet thick. It is more indurated than the underlying beds and gives vertical cliffs. It contains lenses of reddish sandstone which show ripple-marks and sun-cracks. Overlying this is about 35 feet of coarse conglomerate, containing ill-sorted, angular, and subangular pebbles and boulders. Some of the latter have a length of a foot, but the majority are from 1 to 4 inches in diameter. Many consist of hard, Ordovician limestone of the Matapedia series. Others are of Silurian sandstone of the Clemville division; pink, fossiliferous, Silurian pebbles, apparently derived from the West Point formation; and pieces of stromatoporoid reefs from the La Vieille. A few pebbles of calcite and a few of igneous rocks are also present, but the Ordovician and Silurian ones predominate.

Fleurant Formation

The Fleurant formation consists of conglomerate with a thickness of about 45 feet succeeding conformably the Pirate Cove beds. It forms vertical cliffs along the shore west of the flowerpot near the mouth of Smiley brook; between here and Englishman brook one can observe the conglomerate at the top of the cliff, overlying the Pirate Cove beds. It is also exposed on the tip of Fleurant point. Two miles farther east, a short distance to the west of Maguasha pier, northwesterly dipping beds of the same formation underlie Scaumenac shales.

The conglomerate is grey and made up of fairly well-rounded pebbles and boulders. It also has some sandstone lenses, commonly only a few inches thick. The pebbles and boulders consist of volcanic rocks, both acid and basic, evidently derived from the Lower Devonian lava flows and tuffs, the Ordovician limestone, Silurian fossiliferous limestone, coral fragments, quartz, red granite, and porphyry. The largest boulder seen is 18 inches long. Many of the Ordovician limestone boulders are traversed by calcite stringers evidently formed before the boulders.

The rock where worked by the waves is hard and strong, the waves evidently having eroded any weathered material; above wave-action the face disintegrates readily, and beds at the top of the cliffs east of the mouth of Englishman brook have been mistaken for Pleistocene deposits. The flowerpot near the mouth of Smiley brook shows the firmly cemented rock below and the weathered friable portion above the limits of wave-action. The exposure west of Maguasha pier, where westerly dipping beds of conglomerate are overlain by the Escuminac fish beds, resembles the friable conglomerate in the cliff referred to above.

Clarke (1923, pages 30-31, 161-162; Schuchert, 1927, pages 126-132) has argued for a glacial origin of the Fleurant conglomerate, claiming to have found glacially striated boulders in it. The boulders, however, are uniformly rounded and it would seem more probable that they were transported and deposited by torrential streams rather than by ice.

Escuminac Formation

The Escuminac formation consists of grey, thin-bedded sandstones, shaly sandstones, and sandy shales. Shale interbeds between layers of sandstone commonly show ripple-marks. A characteristic feature is the presence of numerous concretions, some of which have a diameter of 3 feet. They are uniformly flat, their diameter in the plane of the bedding being much greater than their thickness. Pyrite cubes are common in the beds.

The upper 16 feet of these beds are reddish, and overlying them with the same dip and strike are strata of the deep red Bonaventure series. Between the two formations, however, is a decided erosional break well exposed in the shore section 55 chains east of Maguasha pier. There is here an abrupt change from reddish, sandy Escuminac beds to a conglomerate that contains large sandstone fragments derived from the Escuminac. Plainly, the Escuminac beds had suffered uplift and erosion before the deposition of the Bonaventure began.

The red colour of the Upper Escuminac beds is due to ferric oxide in the sediments, resulting probably from the oxidation of ferrous iron in the greenish shales. It is probable that this oxidation took place after the deposition of the series, when the upper beds were exposed to weathering and prior to the deposition of the Bonaventure strata. That the red colour of these upper Escuminac beds is not a stain derived from the overlying Bonaventure is to be concluded from the fact that in other places where the red Bonaventure series rests on older rocks the latter are not commonly stained to any great degree.

The Escuminac beds have yielded many fine specimens of Upper Devonian fish which have been described by a number of workers, including Whiteaves (1888), Traquair (1890), Eastman (1907), and Hussakof (1912). Many of the best specimens have been collected from the concretions in the series. The described types include:

Botreolepis canadensis Whiteaves
" *traquairi* Bryant
Cephalaspis laticeps Traquair
Euphanerops longaevus Woodward
Acanthoessus concinnus Whiteaves
" *affinis* Whiteaves
Eusthenopteron foordi Whiteaves
Cheirolepis canadensis Whiteaves
Diplacanthus horridus Woodward
Scauminacia curta Whiteaves
Coccosteus canadensis Woodward
Holoptychius quebecensis Whiteaves

Botriolepis is the most abundant type. *Eurthenopteron foordi* often reaches a length of 2 to 3 feet and occurs in the shale layers. Almost complete examples of *Scauminacia curta* have been found in the concretions.

Associated with the fish remains are excellent examples of Devonian ferns which have been described by Sir William Dawson (1872; 1882). Dawson states that four species of fossil ferns occur, all Upper Devonian types, of which one is peculiar to this locality, and the others are found in the Upper Devonian of the Perry formation in Maine, or in the Catskill group of New York. He lists:

Archaeopteris gaspiensis Dawson
" *jacksoni* Dawson
Cyclopteris obtusa Lesquereux
" *(Platyphyllum) brownii* Dawson
Caulopteris (?)
Knorria
Lepidostrobus
Sternbergia

CARBONIFEROUS

The Carboniferous rocks of the region will be described under four divisions: the Bonaventure formation, the Cannes de Roche beds, the Bathurst formation, and the Clifton beds of eastern New Brunswick. The Bonaventure formation takes its name from Bonaventure island, near Percé, which is composed entirely of these beds except in the lower part of the cliffs at its northern tip where underlying Devonian limestone outcrops. It consists dominantly of coarse, clastic, deep red rocks whose age, owing to a lack of fossils, has long been a subject of dispute. It has been placed by some writers in the late Devonian, by others in the Carboniferous. The Cannes de Roche beds are probably of the same age as the Bonaventure, but deposited in a different basin. They have supplied plant remains of late Mississippian or early Pennsylvanian age. The Bathurst formation, which consists of shales, sandstones, and conglomerates, dominantly reddish in colour, may also be part of the Bonaventure. It grades up into the plant-bearing strata of the Clifton formation.

Bonaventure Formation

Distribution. The Bonaventure rocks occur characteristically as a border formation along the north shore of Chaleur bay, the neighbouring parts of Restigouche river and the gulf of St. Lawrence, and on the south side of Chaleur bay, forming Heron island and patches along the coast between Dalhousie Junction and Bathurst. Their most northerly exposure is in the region around Percé where they form Bonaventure island and the capping of mount Ste. Anne. West and south of Percé a larger area of Bonaventure rocks, comprising over 100 square miles, stretches almost to Grand river. The coast in this section has long stretches of vertical cliffs formed of flat-lying red rocks, and except for narrow breaks at the mouth of Grand river and at Brèche à Manon exposures continue to near Chandler. West of Port Daniel the series begins again and continues for 40 miles to Black Cape. In some places the outcrops along the shore are low, but at others, as at St. Godfroi, vertical cliffs over 100 feet high border the shore. The greatest width of this belt is along Bonaventure river where outcrops occur for over 5 miles in a direct line from the coast. Bonaventure rocks underlie much of the farming belt between New Richmond and Carleton. Even where no outcrops are to be found, the presence of the formation below the overburden is commonly betrayed by the deep red colour of the soil. These rocks cap Maguasha peninsula and extend down to the shore at Maguasha point, giving rise to steep cliffs.

On the New Brunswick side the most westerly exposure of the Bonaventure is on the Dundee road about 6 miles east of Campbellton. Patches also occur in the region drained by Eel river west and south of Dalhousie. The shore at Charlo is bordered by cliffs of these rocks and fragmentary patches occur along the shore in the region of Nash creek, Jacquet River, and Belledune. The most southerly exposure is a small area along Millstream river, about 2 miles from the coast.

Lithology. The Bonaventure formation is marked by three features which are widely characteristic—a coarse, clastic lithology, a deep red colour, and an undisturbed structure—though exceptions to all three are to be noted. The chief rock types are coarse sandstones and conglomerates with red shale and shaly sandstones abundantly developed. These varieties occur in all combinations, nearly every section showing the exceedingly variable nature of the sediments. The conglomerates as a rule do not show well-defined bedding but the sandstone and shale interbeds almost everywhere plainly indicate the attitude of the rocks. Crossbedding is locally well shown. The conglomerates contain pebbles and boulders of all sizes, some reaching a diameter of a foot and a half. They are for the most part fairly well rounded, though subangular and even angular ones locally occur. They consist of all the varieties of rock occurring in the surrounding region and include: volcanics in great variety and abundance; sediments including limestone, shale, argillite, quartzite, sandstone, and conglomerate; intrusive rocks in minor amounts; and quartz. The matrix is usually a coarse, deep red sandstone. Both conglomerates and sandstones in places contain calcite in the form of white specks and grains and some beds are traversed by stringers and veins of calcite.

The colour of the formation is characteristically deep red, but locally this gives place to a pale salmon. In places the finer grained, red beds show circular areas of a light green colour. These are due to small grains of carbonaceous matter around which the ferric oxide has been reduced to a ferrous condition, forming a greenish spherical mass. These markings are particularly abundant in the sandstones of Heron island and in certain beds at Maguasha and Scauminac points. In places some of the shale beds are green throughout.

The Bonaventure formation here and there contains limestone. One important locality is near the road on the west side of Cascapedia river, about 4 miles north of the place where highway No. 6 crosses the river. A small mill has been used here to grind the limestone for fertilizer and some of the rock has been burnt for lime. The limestone forms a ridge that can be traced in a northwest direction for over a mile to the point where it crosses the railway. The rocks have a low dip to the southwest. The limestone is massive, greyish to reddish in colour, contains no fossils, and has a thickness of from 18 to 20 feet. It is locally conglomeratic and at its base grades into red conglomerate. That there is a thickness of at least 100 feet of conglomerate below the limestone can be shown by descending from the outcrop near the road directly to the river where flat-lying beds of red conglomerate outcrop at the water's edge. The lime rock is also overlain by red conglomerate, the adjacent hills to the southwest consisting of the

A. Downfaulted Bonaventure beds (left), resting against Ordovician limestones, (right), shore southwest of Percé.

B. The Chaleur Bay coast near Grande Anse, N.B., showing cliffs of flat-lying beds of Clifton formation.

normal red conglomerate. A chemical analysis of a sample of the limestone gave the following:

	Per cent
SiO_2	10·42
FeO	0·47
Al_2O_3	0·51
$CaCO_3$	83·48
$MgCO_3$	5·40
	100·28

Similar, reddish, crystalline limestones occur interbedded in sandstones about 3 miles east of Chandler. Another limestone locality occurs near Little River East, Percé township, where exposures can be seen between the highway and railway just west of the crossing.

Massive limestones occur also in the Bonaventure formation on the New Brunswick side of Chaleur bay. Along the shore southeast of Belledune, beds of massive, dolomitic limestone are associated with the sandstones and conglomerates. In places the limestone forms the base of the series and can be seen resting unconformably on the upturned edges of the older rocks.

Succession and Thickness. The great amount of lateral variation within the series makes the details of any particular succession of little significance. Horizon markers that might be used to compare different sections are absent. Only an approximate idea can, therefore, be gained of the thickness of the series. Certain minimum figures can, however, be obtained. The section between Maguasha wharf and Maguasha point shows over 370 feet of conglomerate, sandstone, and shale. In the region immediately to the north, some hills 600 feet high are composed of this series, so it is probable that at least another 200 feet can be added to the shore section. The eastern cliffs of Bonaventure island display a thickness of about 400 feet of sandstones and conglomerates and behind the village of Percé, mount Ste. Anne contains 800 feet of similar rocks. On the New Brunswick side the greatest thicknesses occur in the region around Dalhousie. Since the difference in altitude of the nearly horizontal beds of different exposures is about 600 feet, the minimum thickness in this region must be that amount.

Structure. The Bonaventure formation nearly everywhere lies flat. There are, however, some exceptions. Exposures of deep red, tilted, sandstones and conglomerates believed to belong to this formation occur at intervals west of Cascapedia bay between St. Omer and St. Jules de Maria. Half a mile north of St. Omer station, along the road that ascends the east side of Stewart river, red conglomerates and sandstones locally dip southeast at 40 degrees. Along the railway near the watertower at Carleton West similar beds dip at angles up to 90 degrees. East of this the dips become less, until at Carleton the formation is once more flat. Northeast of Carleton other exposures of tilted beds occur. Three miles west of Cascapedia river, in a field on the west side of the road that ascends the valley of Manderson brook, about a mile northwest of the railway crossing, an anticlinal fold occurs in Bonaventure rocks. Dips on one limb are as high as 90 degrees. The lithology of the tilted beds is identical with that of adjacent, flat-lying, red beds of typical Bonaventure.

Other localities also show disturbed Bonaventure rocks. East of Black Cape the formation has a marked seaward dip. At Cannes de Roche, rocks whose correlation with the Bonaventure will be discussed later have dips as high as 90 degrees.

In addition to the disturbances mentioned above, the formation is locally faulted. One of the most striking faults is exposed on the shore about half a mile west of Percé, where down-dropped, horizontal, Bonaventure beds abut against highly tilted Ordovician limestones (Plate XI A).

Relationship to Other Formations. Wherever the Bonaventure formation is in contact with other formations the relations are those of either an unconformity or a fault. The base of the formation is exposed at numerous places: on the north tip of Bonaventure island where it rests on Devonian limestone; on the shore near Brèche-à-Manon where it rests on vertical beds of Upper Ordovician limestone; at Black Cape where it rests on tilted, red conglomerate of supposed Lower Devonian age; and on the shore southeast of Maguasha pier where it rests unconformably on Upper Devonian, sandy shales.

On the New Brunswick side the base of the formation can be traced for considerable distances along the shore east of Jacquet river, where it covers tilted Silurian strata. The base is not a uniform plane but has depressions suggesting old stream valleys which were first filled by clastic materials. The coast section on either side of Belledune also has patches of flat-lying rock resting unconformably on folded and eroded older formations.

The age of the formation will be discussed later in connexion with the Cannes de Roche beds.

Associated Igneous Rocks. Igneous rocks are known to be associated with Bonaventure strata in at least two localities. On the shore about 4 miles southwest of Percé a dyke of dense, dark basalt cuts the horizontally lying beds of red Bonaventure conglomerate which here form steep cliffs. The dyke is nearly vertical and varies in width from 2 to 7 feet. It has been broken, by horizontal movement within the Bonaventure strata, into four parts. The Bonaventure beds are sheared along the horizontal fault planes and one section of the broken dyke shows dragging and a little brecciation at its base. The dyke is locally amygdaloidal and is cut by many, small, calcite veins.

Igneous rocks apparently conformable with the bedding planes of the Bonaventure strata are to be observed about a quarter of a mile east of Grand River pier and in the cliff facing the water east of Brèche à Manon. At the former locality actual contacts are not exposed, but on either side of the igneous outcrop flat Bonaventure beds are exposed. The rock is an olivine basalt, dark green to black, very massive, but showing both horizontal and vertical joints. It is locally amygdaloidal and in places the upper portion appears to be tuffaceous, so that it is probably of volcanic origin.

At Brèche à Manon a similar dark green to black basalt occurs interbedded with the Bonaventure strata near the summit of the shore cliff. The rock is locally amygdaloidal and above the more massive part is a tuffaceous portion which is highly amygdaloidal. The rock in hand specimens shows numerous, scattered, red spots which in thin section are seen to be iddingsite replacing olivine. The rock is believed to be an interbedded flow of Bonaventure age.

Origin. There is evidence that in Bonaventure times there was a depression corresponding in a general way to that occupied at the present time by the upper part of Chaleur bay. The Bonaventure sediments are confined to the immediate belt along the shore of the bay and to a few side valleys which apparently existed at the time Bonaventure deposition commenced. Near Jacquet River there is evidence that while the beds were accumulating cliffs bordered the depression much as they do today and locally occupied the same site as some of the present cliffs. East of the mouth of Armstrong brook some of these old cliffs are re-exposed in shallow sea-caves. Flat-lying Bonaventure strata abut against cliffs of tilted Silurian sediments and can be traced up to a point where they form a horizontal capping over the older rocks. Evidently in Bonaventure days a depression corresponding somewhat to the present Chaleur bay was filled with coarse, clastic material. The deep red colour so characteristic of the formation suggests that the material accumulated under conditions favouring thorough oxidation, that is subaerial deposition in probably an arid climate. Some of the better sorted beds suggest sedimentation in standing water. The interbedded limestones are probably of freshwater origin.

Cannes de Roche Formation

The Cannes de Roche formation is exposed along the coast northwest of Percé and in the region drained by the lower parts of Beatty and Portage rivers. It consists of three members, a lower red conglomerate, a middle division of red and green shales and shaly sandstones very much like those on Heron island, and an upper division of buff sandstones and conglomerates carrying plant remains. These beds can be traced along the south side of Mal baie from Corner of the Beach to within an eighth of a mile of the Grande Coupe, except for an interval a mile east of Cannes de Roche where a thrust fault has overturned them and brought Ordovician beds over them. In Beatty river, Portage river, and Murphy creek the beds are nearly horizontal. The flat-lying beds near the pier at Cannes de Roche bend up near the stream to form the steeply tilted beds that line the shore as far as Corner of the Beach. The thickness of the lower conglomerate is here 40 feet, that of the middle sandstones and shales about 80 feet, and that of the upper sandstone and conglomerate at least 80 feet. The basal conglomerate half-way between Corner of the Beach and Cannes de Roche is made up of large boulders, most of which are Murailles limestone and Gaspe sandstone, some as much as 2 feet in length. They evidently came from a nearby source.

On the eastern side of a cove a mile east of Cannes de Roche the base of the cliff shows the upper, plant-bearing part of the Cannes de Roche formation overturned with a dip of 60 degrees to the south. The middle part of the cliff is composed of Ordovician strata which are thrust over these beds. At the top of the cliff and continuing towards the east is the lower part of the Cannes de Roche formation. Its beds dip 35 degrees to the north, and its base is a limestone conglomerate that lies on the Ordovician strata on which it was originally deposited.

The upper strata of the Cannes de Roche formation are also exposed in Murphy creek and the lower parts of Portage and Beatty rivers. The middle and upper beds are seen farther upstream in the latter two rivers. In Beatty river the upper, plant-bearing beds extend for about 2 miles up the river, the middle strata for $\frac{3}{4}$ mile, and the basal conglomerates for another $1\frac{1}{4}$ miles to the branching of the river. An outlier occurs three-quarters of a mile up the south branch. From it large blocks have slid down over the underlying Gaspe sandstone to the stream-bed below.

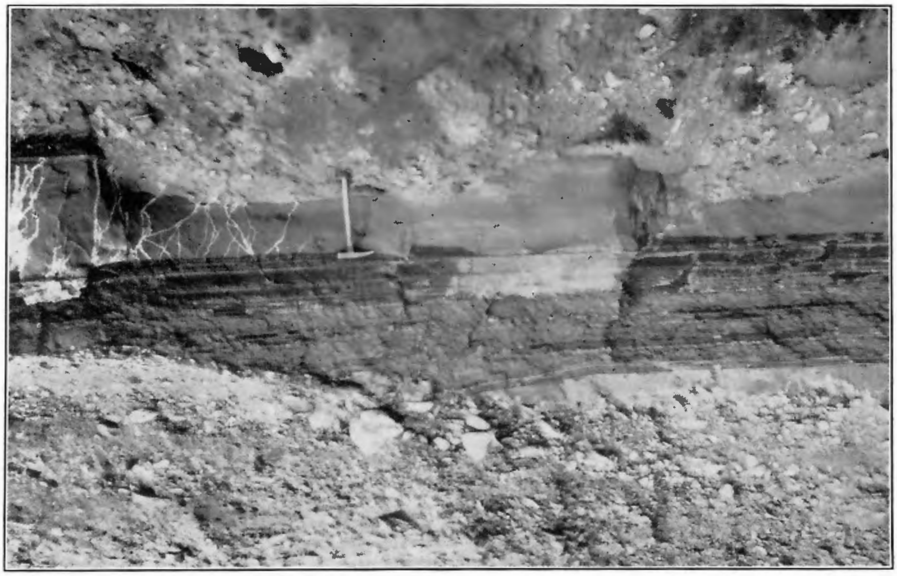
Casts of *Calamites* were collected by C. H. Kindle from the overturned beds east of Cannes de Roche and impressions of *Calamites* were obtained near Corner of the Beach and on Murphy creek. Carbonized tree trunks were seen along Beatty and Portage rivers, and between Corner of the Beach and Cannes de Roche. The material collected was examined by W. A. Bell who reported that it consisted of pith casts of *Calamites* and one small fragment of a species of *Adiantites*. The writer made a collection from the coast section in 1931, which was also examined by Bell. It, too, consisted of pith casts of *Calamites* as well as fragments of a pteridospermous plant in too poor a condition for identification. Bell concluded that a late Mississippian or a Pennsylvanian age is indicated, more probably Pennsylvanian.

It is probable that the Cannes de Roche formation is of the same age as the Bonaventure. It has the same general type of lithology and the same relation to the older formations. It was, moreover, nowhere found either above or below the Bonaventure. The most probable explanation of this is that it was formed in a separate basin. On this theory, at the time of the deposition of the Bonaventure and the Cannes de Roche beds, the thrust block formed of Murailles limestone and Gaspe sandstone and now exposed in Red peak of the Murailles must have extended much farther to the west, separating the deposition basins of these two formations. The coarse boulders of the conglomerate exposed between Corner of the Beach and Cannes de Roche would have been brought down from this Devonian ridge. This separation into two basins would account for the presence in one of plant remains and not in the other. It is here considered that the ages of the Bonaventure and the Cannes de Roche are approximately the same and that they are probably early Pennsylvanian.

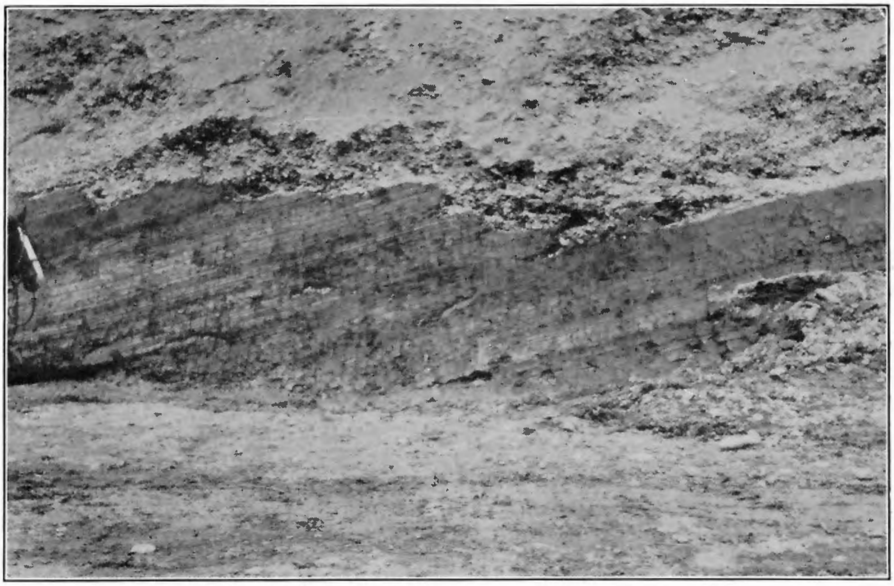
Bathurst Formation

The Bathurst formation outcrops along Nipisiguit river and on Redpine brook, a tributary of that stream, as far east as the railway. A few outcrops occur along Little Bass river. The base of the formation is well exposed at Rough Waters on the Nipisiguit where it rests on Devonian granite. On the east bank of Tetagouche river about a mile above the railway bridge two small patches of the formation overlie Tetagouche slates.

The beds range from shales to fine conglomerates. Except for a few, thin, nearly black, shaly beds, they have a pronounced reddish colour. Sandstones and shale predominate, but thin lenses of conglomerate occur at various horizons, holding pebbles, most of which are quartz and only



A. Stratified gravels overlying laminated clays and sands, Tide Head, N.B.



B. Stratified gravels overlying unconformably deformed and eroded varved clays, Highway No. 6, 3½ miles east of Matapedia.

locally exceed 2 inches in diameter. Bedding planes are well marked and crossbedding is commonly shown. Many of the sandstones contain much calcite in the form of reddish grains and plate-like masses enclosing grains of sand. The beds lie horizontally or with dips of less than 10 degrees, and with no sign of faulting. On Redpine brook a thickness of 125 feet is exposed.

The beds of the Bathurst formation were correlated by both Logan (1863, page 451) and Ells (1881, page 7) with the Bonaventure formation. They present some differences, however, from the typical Bonaventure which outcrops to the north and west. The Bonaventure on the whole is more conglomeratic and the beds as a rule are a more brilliant red than most of the Bathurst. The Bathurst beds are succeeded apparently conformably by the grey beds of the Clifton formation whose abundant plant remains show it to be Pennsylvanian. To regard the Bathurst and the Clifton as belonging to the same series appears to be the most probable interpretation.

Clifton Formation

Beds of the Clifton formation underlie the region from Janeville east to Miscou. They are best exposed in the cliffs between Clifton and Grande Anse. The rocks have low dips and form broad, gentle rolls.

At Clifton and Stonehaven the cliffs are about 120 feet high. The lower beds in these cliffs are dominantly red and consist of shales, sandstones, and fine conglomerates apparently belonging to the Bathurst formation. These are succeeded by the grey sandstone of the Clifton. The lower, reddish portion, however, contains some grey sandstone and the Upper Clifton portion some reddish shales, so the whole succession is regarded as one series. The lower zone contains no plant remains. Eighteen feet above the base of the grey zone is a coal seam 6 inches thick and some 132 feet stratigraphically above this is a second seam 8 inches thick. Immediately below the first coal bed the grey sandstones contain numerous, well-preserved plant remains. Outcrops continue down the coast to Shippigan. Towards Shippigan the grey beds are gradually succeeded by purple sandstones, shales, and conglomerates. The estimated total thickness of the formation is about 700 feet.

The fossil plants occurring in the beds at Stonehaven and Clifton show that the rocks are of Upper Westphalian age, and equivalent to the Morien and Pictou series of Nova Scotia. They include the following species, according to Sir William Dawson (Bailey, 1902, pages 27-28). Dawson's list has been revised by W. A. Bell.

Calamites cisti? Brongniart
Asterophyllites grandis? (Sternberg)
Annularia sphenophylloides (Zenker)
Sphenophyllum emargination Brongniart
Neuropteris rarinervis Bunbury
Sphenophyllum cuneifolium (Sternberg)
Odontopteris sp.
Mariopteris nervosa (Brongniart)
Sphenopteris obtusiloba? Brongniart
Mariopteris muricata (Schlotheim)
Alethopteris serli (Brongniart)

TRIASSIC (?)

Reference has been made to a basic dyke that cuts the Bonaventure strata on the coast 4 miles southwest of Percé. It is possible that this dyke is of Triassic age, for the Triassic in the Bay of Fundy region and New England was a period of volcanism and basic intrusion. It is more probable, however, that the dyke is related to the volcanic rocks which are believed to be contemporaneous with the Bonaventure. The rock is a basalt resembling lithologically these volcanics.

QUATERNARY

The Quaternary deposits consist of those laid down during the Pleistocene and Recent periods. The Pleistocene deposits consist of morainal material or drift, gravel hills and ridges formed as kames, and scattered erratics. The Recent deposits include clay and sand laid down during the Champlain submergence when the region was depressed below its present level.

Moraines, Kames, Etc.

Over most of the region the mantle of glacial drift is light. On the plateau surface bedrock is commonly to be found at or near the surface. Most of the drift consists of boulders and few sections of boulder clay are exposed. Locally, however, there are areas that have the characteristics of terminal moraine topography. At Maria East, west of Cascapedia river, is an area of rolling country in which lie a number of lakes and ponds and in which the drainage is disorganized.

The thicker sections of glacial material exposed consist of stratified gravels evidently deposited as kames by glacial streams. In the region south of Tide Head good sections of bedded and coarsely crossbedded gravels, some 80 to 100 feet in thickness, are exposed along the highway, the railway, and Christopher brook. On the north side of the Restigouche, Battery point consists of stratified gravels about 100 feet thick, and important gravel pits used to supply railway ballast and road material occur near pointe à la Garde. At Nouvelle a low hill of gravel lies just north of the railway, and about one mile west of Carleton a deposit of stratified gravel and boulders overlies conglomerate beds that outcrop along the railway. At the mouth of Cascapedia river a good section of a kame is exposed at the east end of the covered bridge, and along the shore near New Richmond are similar deposits.

On the south side of Chaleur bay a deposit of gravel, which Chalmers has called the Restigouche kame, stretches along the coast from Eel River valley to Nash creek, a distance of some 12 miles. Its height at the western end is 150 to 175 feet and at the eastern end 50 to 75 feet. It follows the shore fairly closely except at Charlo and Eel rivers where it recedes into the second concession. Near New Mills station the railway crosses it. It is overlain in places by post-glacial clay and sand. Evidently in late Pleistocene times when the ice that occupied this region was melting the area was depressed and glacial streams poured their detritus into the basin.

Bedding and cleavage in Ordovician rocks, Cascapedia valley, Que.

Matapedia valley also shows numerous deposits of stratified gravels. Hills and ridges of gravel and sand are particularly striking features between Amqui and the south end of lake Matapedia, with Matapedia river winding through them. In fact both lake Matapedia and lac au Saumon owe their existence to gravel ridges that serve as dams. The deposits continue southward as far as Causapscal and farther south a few occur on the east side of the valley near Ste. Florence. They are also present in some of the tributary valleys such as that of Amqui river and in Matalik valley near Albertville. They are confined to the bottom of the valleys. In some places they are in the shape of conical hills; in others they are in the form of ridges that do not as a rule have any particular orientation. In places, as at Amqui, the hills extend continuously across the valley floor. The deposits were evidently laid down in late Pleistocene times, possibly as crevasse fillings, when the glacier that occupied the valley was disappearing.

Laminated Clays and Sands

Varved clays and sands are exposed at several places in the region. Three and a half miles east of Matapedia on the north side of highway No. 6, immediately to the west of a bridge over a small stream, is an exposure, part of which is figured in Plate XII B. The photograph was taken when the section was freshly exposed at the time of the widening of the highway. Some 12 feet of clay is shown with the base still concealed. The clay is overlain by 30 feet of coarsely stratified gravel, the contact between the two being very sharply defined. The clay beds have dips up to 20 degrees and at one place an anticline is well shown. The top of the clay is clearly an erosion surface, having no relation to the bedding planes. There is no evidence of weathering of the clay beds, however, at their contact with the overlying gravel, to suggest any considerable break in time between the times of deposition of the two materials. Other exposures of similar banded clays can be seen a mile south of Matapedia along the highway that follows the south side of Restigouche river.

On the shore near Oak Bay mills, about a quarter of a mile southeast of the mouth of Busteed brook, are other exposures of laminated clays. About 5 feet of distincly banded clays are exposed and the beds are thrown into sharp folds. The clay is overlain by horizontally lying, undisturbed sand and gravel.

A section of sand, clay, and gravel south of Tide Head shows similar relationships. The exposure is in a sand pit immediately to the east of highway No. 17, about 300 feet south of the railway crossing at Tide Head (Plate XII A). The section exposed is as follows:

Coarse, stratified gravel with boulders up to 1 foot across

(Erosional unconformity)

	Feet
Sand	2
Sandy clay (varved)	2
Sand, 2 thick beds	5
Clay	

The gravel rests on an eroded surface of the sand and sandy clay and at one place the beds of the latter are contorted into sharp anticlines and synclines.

Still another exposure of this character was observed on the east bank of Jacquet river about 1½ miles south of highway No. 11. Here about 10 feet of well-bedded clays is overlain by coarse gravels. The contact between the two is sharp and its irregular character indicates an erosional break.

These exposures suggest two things: (1) the presence of a glacial lake at some stage in the glacial history of the region; and (2) two periods of ice movement. Varved clays are characteristic of deposition in glacial, fresh-water lakes. Evidently through some such cause as a dam, either of ice or of glacial debris, a lake existed at some stage of the Pleistocene in this region. The deformation of the varved beds and their eroded surface is evidence of another ice advance over the region after the clays were laid down. In two places at least the beds have dips that are too steep to have been original. Landslides or unequal loading might have produced the deformation, but the local topography is not such as to make this explanation probable. An ice advance appears to be the most satisfactory explanation.

Post-Glacial Clay and Sand

Marine clay is present at a number of localities around Chaleur bay. In the Jacquet River shore section about 600 feet east of the eastern belt of volcanics a layer of clay about 80 feet above the shore contains numerous shells. The following specimens were collected here: *Macoma calcava, Mya arenaria, Saxicava rugosa, Neptunea despecta* var. *tornata, Balanus hameri.*

The clay varies greatly in thickness and in most places contains layers of sand. In some localities it grades up into the Saxicava sand; in others the latter rests on an uneven surface of the former as if the clay had been eroded to some extent. The deposits of clay and sand are confined chiefly to the coast and lower parts of the valleys. Partial, imperfectly exposed sections have a thickness of at least 100 feet. Just how much thicker these deposits are is not definitely known.

The clays and sands in the region around Bathurst have been studied by C. H. Paisley (Paisley, 1875, pages 41-43; Young, 1910, pages 57-59). These in places rest on boulder clay. They have yielded a variety of shells which were determined by Sir William Dawson. A section measured at a railway cut just north of the crossing of Tetagouche river shows the following succession.

	Feet
1. Soil	1– 2
2. Coarse gravel	6– 8
3. Sand with an occasional layer of reddish clay	10–12
4. Yellowish clay	¾
5. Reddish sand	1¼
6. Reddish yellow clay with threads of sand	1⅔
7. Greenish sand with an occasional valve of *Mya* and innumerable shell fragments	1⅔
8. Coarse sand and reddish clay intermingled, in some places without evident stratification; occasional, small, angular rock fragments, very fossiliferous	0-2
9. Reddish, sandy clay, fossiliferous	2½
10. Interstratified red and blue clays; an occasional *Mya* and *Natica*	6

From bed 8 were collected the following forms: *Saxicava rugosa, Mya arenaria, M. truncata, Leda pernula, L. glacialis, Nucula tenuis (expansa), Aphrodite groenlandica, Macoma calcarea, M. groenlandica, Cryptoden gouldii* (?), *Natica clausa (affinis), Buccinum undatum, Balanus crenatus, B. hameri, Mytilus edulis.*

From bed No. 9 were collected: *Mya arenaria, M. truncata, Nucula tenuis, Balanus crenatus, B. hameri, Mya* (Young).

The precise locality from which the following forms were collected is not stated, but it is presumably the same as the foregoing: *Euryechinus drobachiensis, Nucula expansa, Leda minuta, L. limatula, Bela turricula, Trophon scalariforme, Buccinum cyaneum, B. groenlandicum, B. tenue, Fusus tornatus,* two species of *Spirorbis.*

Plants: *Zostera marina, Phizomata* cf. *Equisetum* and fragments of grasses.

CHAPTER IV

STRUCTURAL GEOLOGY

Chaleur Bay region lies in a zone of folded rocks, a zone that extends southwestward through the Eastern Townships of Quebec and on into Vermont and New Hampshire where it is referred to as the Northern Appalachians. This is in turn only part of a still greater Appalachian belt extending in a northeast direction for 2,000 miles from central Alabama to Newfoundland. This whole belt shows the result of horizontal compression acting along northwest-southeast lines. It is thrown into folds whose axes trend northeast. Certain parts of the belt are marked by close folding, thrust faulting, and the development of cleavage. All this deformation did not take place, however, at the same time. In the southern Appalachians the main period of folding, the Appalachian revolution, was at the close of the Palæozoic. The northern Apalachians were little affected by this; their main deformation took place in two earlier periods of orogeny, one at the close of the Ordovician, known as the Taconic revolution, and one in the Devonian, known as the Acadian or Shickshockian. There is, in addition, evidence of a still earlier deformation which probably took place in the Cambrian.

The northern border of the folded belt in Canada is a zone of faulting that passes northeastward from lake Champlain to Quebec city and from there along St. Lawrence river swinging south of Mingan islands and Anticosti. Northwest of this zone undisturbed remnants of overlapping Palæozoic sediments rest on the Precambrian granites and gneisses. Between Quebec city and Murray Bay on the north side of St. Lawrence river the fault zone can readily be traced by following the line between the tilted and the horizontally lying rocks. Where information is available from detailed studies such as those made at Quebec city (Raymond, 1913, page 33) and at mount Serpentine (Alcock, 1926 b, page 140), the faults of this zone are known to be overthrusts from the southeast.

Structurally the rocks of Chaleur Bay region can be divided into four main assemblages according to the number of revolutions by which they have been affected. These include: (*a*) the metamorphic rocks of the Macquereau group; (*b*) the Upper Cambrian and Ordovician rocks deformed by the Taconic orogeny; (*c*) the Silurian and Devonian rocks affected by the Shickshockian revolution; and (*d*) the comparatively little disturbed Carboniferous rocks.

MACQUEREAU ROCKS

As has already been mentioned, the Macquereau rocks are largely quartzitic sediments that have been sheared, rendered schistose, and altered to a much greater degree than any of the younger formations. That this deformation took place in pre-Middle Ordovician times is shown by the fact that the basal conglomerate of the Mictaw formation on North Port Daniel river consists of boulders lithologically identical with rocks of the Macquereau. In addition the Macquereau sediments are intruded by amphibolite and peridotite and these in turn by grey granite, but none of these intrusives cuts the adjacent Middle Ordovician and Silurian formations. The series was, therefore, folded, intruded, and metamorphosed in pre-Trenton times and eroded to form the basal beds of the Middle Ordovician Mictaw. Whether this revolution took place in the Cambrian or whether it was Precambrian is not definitely known. No structures were worked out for the Macquereau beds. In most places they strike in a general east and west direction and dip steeply to the north or south.

UPPER CAMBRIAN AND ORDOVICIAN ROCKS

The area over which Upper Cambrian beds are exposed is very limited, the only outcrops being some discontinuous ones that extend for about one mile along Murphy creek. The rocks are thin-bedded, dark limestones and shales which dip at an angle of 65 degrees. These rocks are quite fresh as compared with the Macquereau sediments. Lithologically and structurally they are quite similar to the rocks of the Ordovician formations.

The Ordovician rocks present a complex in which a scarcity of fossils and a lack of good sections leave our knowledge of the events of this period far from complete. Two divisions can be recognized, however, on a basis of fossil remains, sediments with a Normanskill graptolitic fauna and a younger series of Richmond age. The former include the Mictaw beds on Middle Port Daniel river and the Tetagouche series on the New Brunswick side of Chaleur bay, west of Bathurst. The latter forms a broad belt north of Chaleur bay and a considerable area in the region of Matapedia, Upsalquitch, and Restigouche rivers.

These Ordovician rocks, like the Upper Cambrian of Murphy creek, are quite different from the metamorphosed sediments of the Macquereau series. They were nowhere found to be cut by peridotite, amphibolite, or the grey granite of the Port Daniel region. They are, however, cut by dark dykes and sills of basic and intermediate composition, by porphyry dykes and sills, granite and syenite dykes, and by numerous quartz and calcite veins. Some of the basic intrusions may be of Silurian age, but the majority of them and all the acid intrusives, as well as the veins, are Devonian.

Bedding planes are usually well preserved in the Ordovician sediments, but in many places a slaty cleavage is the dominant structure and in some places the only structure that can be recognized. Here and there in Matapedia valley the strata, whose bedding planes can be readily distinguished by colour banding crossing the cleavage, are thrown into a series of such minute folds that only the larger can be shown on even a large scale map. Here the cleavage with its regular northeast strike is the dominant structure.

Some of the Ordovician rocks are limestones and argillites; others are quartzites and conglomerates. The character of the cleavage varies considerably with the rock type. From some of the argillaceous rocks real slates have developed; other more quartzitic types merely break up into hackly fragments. In the limestones the cleavage planes are usually spaced an inch or so apart. A common type consists of thin-bedded limestones with shaly interbeds; in these the argillaceous partings have developed a strong, slaty cleavage, whereas the limestones are not fractured. In other places interbedded quartzose and shale rocks show a similar structure, a well-developed, slaty cleavage crossing the shale beds but not the hard, quartzitic layers. Some of the argillaceous rocks of Matapedia valley are transformed into phyllites with a silky lustre due to the development of considerable secondary mica.

The strike of the cleavage has a fairly constant northeast direction. The dips of the cleavage planes are everywhere steep, varying from about 75 degrees northwest or southeast to vertical. The cleavage planes have the normal relation, parallel to the axial planes of the folds. Locally, however, as in some of the beds on Tetagouche river, a different relationship was seen. Here the dominant structure of the sediments is a strong fracture cleavage the planes of which are normal to the axial planes of the minor folds. This suggests two periods of deformation, one in which the beds were thrown into folds, and a second, resulting from a pressure at right angles to that of the first, producing the fracture cleavage.

The greater degree of deformation the Ordovician rocks exhibit over that shown by the succeeding Silurian and Devonian strata is the main evidence of the Taconic orogeny. In nearly all their exposures a difference can be observed between the two sets of rocks, by structural features alone. A convenient locality where Ordovician and Lower Devonian beds can be compared is point Joli at Percé. Here a fault brings strata of these two ages into juxtaposition. The Devonian rocks consist of hard limestone with shaly interbeds, standing on edge and cut by calcite veins. The fossils present are brachiopods, corals, trilobites, and trails. To the south of the fault are the Ordovician strata consisting of limestone, shale, and black, calcareous argillites. They are broken, sheared, dragged, and cut by numerous veins and in every way appear to have suffered a greater degree of deformation than the Devonian beds.

On Bonaventure river the contrast between the Silurian and Ordovician rocks is equally striking. Outcrops along the river for about half a mile above the mouth of the First West branch consist of reddish sandstone and conglomerate with limestone layers. The beds are locally fossiliferous, are fresh, and little deformed having uniformly low dips, for the most part less than 25 degrees. The contrast between these Silurian sediments and the first outcrops of the Ordovician strata, off which they dip, is very marked. The underlying Ordovician rocks are exposed about half a mile above Kirby camp and consist of slates, argillites, shales, and limy shales dragged and sheared. They locally show a good slaty cleavage and are cut by numerous veins and stringers of quartz and calcite. No fossils were found in them. These characteristics are so uniform throughout the region that unfossiliferous beds that are broken, cleaved, and traversed by numerous veins are mapped as Ordovician in absence of more reliable age criteria.

Besides the greater deformation suffered by the Ordovician rocks than by the Silurian and Devonian there is other evidence of a period of late Ordovician orogeny followed by erosion before the deposition of the Silurian sediments. Along North Port Daniel river the Middle Ordovician Mictaw beds rest unconformably on the metamorphosed Macquereau rocks. Between Macquereau point and Gascons the basal Silurian beds rest directly on the Macquereau: a short distance farther west the Silurian rest on the Mictaw beds and in neither case is the contact a fault plane. This relationship means one of two things—either in post-Mictaw times there was folding followed by erosion and upon the bevelled edges of the Macquereau and Mictaw beds the Silurian strata were deposited, or else during the deposition of the Mictaw a high elevation of Macquereau projected above the area of deposition. The latter possibility takes for granted also that no Upper Ordovician beds were deposited in this region. Owing to the lack of good sections with horizon markers it is difficult to ascertain the thickness of the Mictaw formation. It appears, however, to be too thick to render probable this second possibility.

The Silurian conglomerates offer still another proof of Taconic folding. A common feature of the Silurian conglomerates of the Petit Rocher and other sections of northern New Brunswick is the presence of small pebbles of red argillite. Beds of this argillite occur in the Tetagouche series of Middle Ordovician age and undoubtedly were the source of the red pebbles. Clearly, the Ordovician rocks were uplifted and undergoing erosion when the lowest Silurian beds were being laid down.

The Lower Devonian conglomerates north of Escuminac and near Glenlivet in New Brunswick are made up largely of Ordovician limestone boulders. This suggests that in Lower Devonian time a high region composed of Ordovician rocks was close at hand. It offers no proof, however, of an Ordovician orogeny for, as will be shown, there is evidence that in late Silurian times there was uplift and erosion and the Ordovician sediments might have been uncovered then.

Search was made along many streams for that most conclusive of all proofs of Taconic folding, an outcrop in which fossiliferous Silurian beds rest directly with an angular unconformity on rocks whose fossil content or lithology leaves no reasonable doubt as to their Upper Ordovician age. Though on a number of streams, such as the various branches of Escuminac and Little rivers, it proved easy owing to an abrupt change of lithology to locate closely a contact of the two formations, nowhere was the actual contact found.

The unconformity between the Silurian and the underlying Ordovician is also shown in the basin of lake Matapedia. It was here recognized first by Logan (1863, page 414) whose conclusions were later confirmed by both Ells (1885, page 29) and Low (1885, page 19). Low-dipping, Silurian rocks are bounded on the north by highly deformed slates of the Quebec groups (Cambrian and Ordovician), on the northeast by Shickshock mountains composed of similar slates and, in addition, arkosic quartzites and volcanics, and on the south by Notre Dame mountains made up of deformed strata of Silurian and Devonian age. The Silurian rocks of the basin are essentially unmetamorphosed, secondary cleavage, which is so marked in the Silurian and Devonian rocks of Notre Dame mountains to the south, being entirely absent. The beds have low dips and overlap the highly tilted strata on the north side of the lake and the arkose-volcanic formation that overlies these slates. Though the base of the Silurian is nowhere exposed, the unconformable relations can best be explained by deformation and erosion of the Ordovician rocks prior to the deposition of the Silurian beds.

A theory to explain these relationships without postulating Ordovician folding was advanced by Clark (1921, page 149). He suggested that there is here a thrust fault with the younger, more competent beds, the Silurian, thrust over the older, less competent shales. This theory fails to take into account the thick series of competent, arkosic quartzites and volcanics that overlie the shales and upon which the Silurian beds rest unconformably. It is difficult to conceive how any system of overthrusting can explain these relations. Moreover, the complete lack of cleavage in the Silurian rocks and their only slightly altered character render it improbable that they form a thrust plate. There can be no doubt that the complex structures of the Quebec group are pre-Silurian.

SILURIAN AND DEVONIAN ROCKS

The Silurian and Devonian sediments are on the whole much fresher than the Ordovician. Over wide areas their dips are low, but locally they form sharp folds with vertical dips. Here and there, as in the Silurian beds at the south end of the Petit-Rocher section, there is a good fracture cleavage developed across the closely folded beds, and in the upper part of Matapedia valley there is a fracture cleavage in some of the Silurian and Devonian strata. In places, also, as along Nigadu river, Silurian sediments are sheared into phyllitic rocks. Near some granitic intrusive masses, as for example at Lorne settlement, the Devonian rocks are altered to slaty rocks. These more pronounced secondary structures are, however, the exception rather than the rule.

Though there is no evidence that the Silurian rocks are more deformed than those of the Lower Devonian there is conclusive evidence of a considerable period of erosion separating the deposition of these two groups. This evidence may be summarized as follows:

The Silurian rocks at the type section of Port Daniel are made up of the following formations, beginning with the oldest—Clemville, La Vielle, Gascons, Bouleaux, West Point, Indian Point. The Silurian rocks which underlie the Helderberg sediments and volcanics in the region of the lower Restigouche contain only the lowest member, the Clemville. This means that the other members were not deposited here or else that they were eroded before the deposition of the overlying Lower Devonian rocks. Considering the thickness of the whole series, over 5,000 feet at Port Daniel and over 7,000 feet at Black Cape, and the comparatively short distance that separates these areas from the Restigouche region, only 25 to 50 miles, it would seem that an erosion interval offers the most probable explanation.

The geological map of the lower Restigouche brings out a relationship that supports this conclusion. Along the north side of the Restigouche the width of the Silurian band between the belts of Ordovician to the north and Lower Devonian to the south is variable; and in the region of the Kempt road, which ascends the valley of Little river, the Silurian pinches out altogether, Helderberg shales here resting directly on Ordovician limestones.

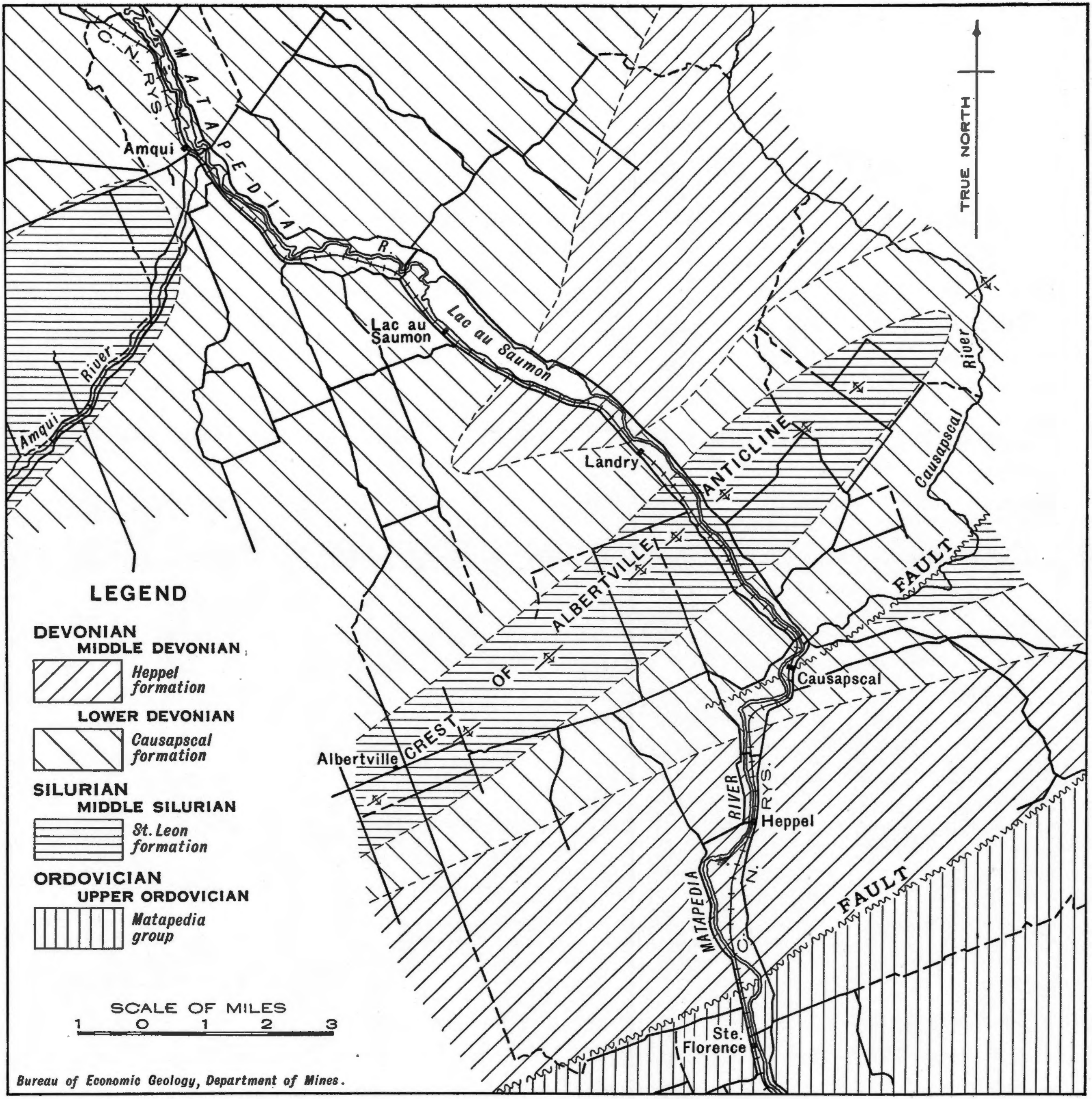


Figure 9. Geology and structure of a portion of the Matapedia valley.

This clearly means that in late Silurian time, after the region had been uplifted, there was here a river valley along which the strata were eroded down to the Ordovician complex. With the subsequent incoming of the Helderberg sea sedimentation took place on the Ordovician rocks of the valley bottom and on the Silurian rocks on either flank.

Farther east similar relationships are shown. Between Black Cape and Port Daniel a broad belt of country is underlain by Silurian rocks which are flanked to the north by Ordovician sediments. From Cascapedia river westward a narrow Silurian belt of varying width lies between the belts of Lower Devonian and Ordovician strata. Between Maria and St. Omer the Silurian belt disappears except for a few small patches.

Other evidence of late Silurian uplift is the presence in the Devonian conglomerates of limestone pebbles and boulders carrying Silurian fossils. These basal Helderberg conglomerates have already been described.

The Devonian sediments appear on the whole to be nearly conformable with the underlying Silurian beds. From this it is inferred that the uplift in late Silurian times was in the nature of an upwarp, perhaps differential in nature but involving only gentle folding. The erosion that followed this elevation was considerable, enough to remove locally all the Silurian sediments.

Though the Taconic deformation was evidently more intense than the later Shickshockian, the main structural features of the region naturally date from the latter. Broad, open folds are characteristic of the Silurian and Devonian rocks in contrast with the small, irregular folds exhibited by the Ordovician strata. Probably the most striking structure of the region is the syncline of the lower Restigouche. This syncline pitches to the east and involves all the formations from the Ordovician to and including the Gaspe sandstone. The syncline is somewhat asymmetrical, the dips on the north limb being steeper as a rule than those on the south. On the Gaspe side, in the vicinity of Escuminac, some beds of Gaspe sandstone are even slightly overturned to the south. South of this syncline, in the region from Dalhousie to Bathurst, the structure is a series of anticlines and synclines disturbed to a considerable degree by faulting. Only in local areas, such as certain shore sections where outcrops are almost continuous, can the structure be worked out in detail.

In Matapedia valley, between Causapscal and Amqui, there are two main anticlines, which may be referred to as the Lac Au Saumon and the Albertville. Both strike northeast and to the northwest of each is a shallow syncline.

The Albertville anticline has been traced northeastward to Causapscal river. Its axis is exposed in the Matapedia valley near mile-post 50. The crest is occupied by the St. Leon formation for 4 miles east of Matapedia river and by the overlying Causapscal formation on Causapscal river. The anticline pitches to the northeast. For 6 miles west of Albertville this plunge appears to flatten out and no lower beds are brought to the surface. The second anticline, that crossing the Matapedia at the head of lac au Saumon, has a similar northeastward pitch. The axial portion of the fold is exposed in a railway cut three-quarters of a mile north of lac au Saumon, where the northeast plunge is 5 degrees.

The anticlines are asymmetrical, the north flanks being the steeper, and the south flanks dipping gently for long distances. For 2 miles along Causapscal river, beds of the Heppel formation on the south limb of the Lac au Saumon anticline dip at angles less than 5 degrees, whereas to the south the north limb of the Albertville anticline dips as steeply as 70 degrees. These anticlines have small, local drag-folds on their flanks.

Faults resulting from the Devonian orogeny are numerous throughout the entire region. In nearly all the sections where detailed relationships have been worked out, faults are present. In Matapedia valley immediately north of Ste. Florence a northeastward trending fault separates presumably Ordovician phyllites from the Heppel sandstone. It is probable that this is a thrust rather than a normal fault, though the exposures near the contact are too few to afford definite evidence.

Another fault, which may also be a thrust, occurs at Causapscal. North of the village the south limb of the Albertville anticline shows dips of from 5 to 20 degrees; at the village, south of the fault, the dips abruptly increase to 70 degrees or more. The fault extends in a northeasterly direction and 3 miles up Causapscal river brings the St. Leon formation to the surface.

As has already been mentioned, the Silurian and Devonian rocks locally show a good secondary cleavage. In most places at least this is merely a fracture cleavage, not the true slaty cleavage exhibited by the Ordovician rocks in so many places. In the Silurian shore section, both north and south of the mouth of Nigadu river, reddish, sandy shales are thrown into close folds. The cleavage planes are closely spaced, stand vertical, and strike northeast parallel to the axial planes of the folds. The cleavage is not due to the development of platy minerals but is clearly of the fracture type.

In Matapedia valley a fracture cleavage is present in the Silurian and Devonian strata, particularly in the argillaceous zones. In the Causapscal formation the fracture planes are commonly widely spaced, 6 inches or more apart, and the rock shows no tendency to split into thinner sheets. The upper argillaceous beds of the Heppel formation on Causapscal river show a nearly vertical cleavage, with cleavage planes so closely spaced that it resembles a slaty cleavage.

CARBONIFEROUS ROCKS

The Carboniferous rocks are characterized by two features, first, a fresh unaltered character, and second, a prevailing flat attitude or very low dips. The Bonaventure beds are locally disturbed and at one place are cut by a basic dyke which in turn is faulted. The Clifton formation east of Bathurst is thrown into broad, gentle rolls with nowhere any sign of intense deformation. Evidently the great Appalachian revolution of late Palæozoic time, so pronounced throughout the southern Appalachian region, produced only insignificant results in this northern belt.

SUMMARY OF STRUCTURAL HISTORY

The earliest event of which there is record in the history of the region is the deposition of the Macquereau sediments. When this took place it is impossible to say, other than that it happened some time prior to the

Upper Cambrian. The character of the sediments suggests that the material was derived from a granitic terrain that was undergoing erosion, probably the Precambrian rocks to the north. A certain amount of volcanic activity accompanied the deposition of the sediments.

These rocks were deformed, possibly in Cambrian times, and the deformation was accompanied by intrusions. The earliest of these were basic, consisting of dunite and hornblendic rocks, and the later were grey muscovite granite and granite-gneiss. The present metamorphosed character of the Macquereau sediments dates from this period of deformation.

The period of deformation was followed by erosion; later, in Upper Cambrian time, a seaway apparently occupied this region, extending from Newfoundland through the Gaspe-St. Lawrence region to Vermont and southward along the present site of the Appalachians. Along St. Lawrence river deposits then formed are known now only in the form of pebbles in Ordovician limestone—conglomerate. At the close of the Cambrian, uplift again took place and subsequent erosion removed most of these sediments, the only place in the Chaleur Bay region where any remnant is known to exist today being on Murphy creek near Percé.

In Middle Ordovician time the region was again depressed beneath the sea and sediments again accumulated. Remnants of these strata are known in two areas of Chaleur Bay region, at Port Daniel in Gaspe and in the vicinity of Bathurst in northern New Brunswick. In the latter region volcanism took place on a large scale in this period.

In Upper Ordovician time southern Gaspe and northern New Brunswick were submerged and a thick series of limestones and shales laid down. These, at the eastern end of Gaspe, are described under the terms Pabos and Whitehead formations, and at the western end of Chaleur bay as the Matapedia group.

At the close of the Ordovician the region was elevated and the rocks folded in the Taconic revolution. This was followed by a period of erosion and not until the Middle Silurian was the region again depressed beneath the sea. The erosion following the Taconic folding was extensive; in places Silurian rocks rest on much older rocks as, for example, at Port Daniel where they rest on Macquereau sediments and at lake Matapedia where they rest on highly altered early Palæozoic sediments and volcanics. Volcanism took place several times during the deposition of the Silurian sediments.

After the deposition of the Middle Silurian Chaleur Bay series the region was again uplifted and suffered erosion. This elevation was, however, in the nature of an upwarp and did not involve folding. Subsidence took place in the Lower Devonian and this was followed by the accumulation of a thick series of sediments which began locally with a coarse, basal conglomerate. The west end of the Chaleur Bay region during Helderberg time was marked by intense volcanic activity. Lava flows and tuffaceous beds were deposited with the marine sediments and towards the close of the period great thicknesses of volcanic material accumulated.

At the close of the Lower Devonian, mountain-building movements once more began. These were accompanied by the intrusion in both Gaspe and New Brunswick of acid porphyries, syenite, and granite.

The deposition of the Lower Devonian shales and limestones was followed by the deposition of the Gaspe sandstone series. The lower part of the latter was laid down in marine waters, but as the land rose and the sea margin withdrew, the upper part of the Gaspe sandstone series and the Malbaie conglomerates were probably deposited largely under continental conditions. Movements continued and the Gaspe sandstones became involved in folding. This Devonian revolution is known as the Acadian or Shickshockian. The latter term is preferable because Acadian was early proposed for a land movement of Middle Cambrian time. The pressure that produced this folding, like the pressure of the earlier Taconic, came from the south and against the Canadian Shield composed of Precambrian rocks. The Devonian folding was accompanied by thrust faulting on a large scale. In Upper Devonian times, before these movements finally ceased, beds that are noted for their content of fossil fish and plants were deposited near the head of the present Chaleur bay. These beds were laid down under freshwater conditions.

Following the Devonian orogeny was a long period of erosion, during which the products of denudation were carried from the region, probably to the south. The next event of which there is record is the accumulation of the Bonaventure conglomerate. This took place in a basin that had roughly the outlines of the present Chaleur bay. Side valleys entering this larger one were also filled with Bonaventure sediments. Their deep red colour suggests that accumulation took place under continental conditions. At Percé there were two basins of deposition separated by the Percé anticline. At that time the Murailles limestone probably extended farther to the west, forming the dividing line between two basins, in the southern of which the Bonaventure beds accumulated and in the northern the Cannes de Roche. The latter are known from fossil evidence to be of probable Pennsylvanian age and it is thought that the former are also. Later in this period extensive sedimentation took place in the eastern part of New Brunswick.

The Appalachian revolution only slightly affected the Chaleur Bay region. The Pennsylvanian rocks are but slightly disturbed, and only locally do they dip more than a few degrees. The history of the region during the Mesozoic and Tertiary is one of erosion, for no sediments younger than Pennsylvanian are found in the area. An intrusion of diabase followed by faulting took place at some period after the deposition of the Bonaventure conglomerate. This may have occurred during the Appalachian revolution or later in Triassic times.

The later history of the region as deduced from the land forms and from the glacial and recent deposits is summarized in the chapter on physiography. It is marked by a series of vertical movements.

Faulted dyke cutting Bonaventure strata in shore section 4 miles southwest of Percé.

CHAPTER V

PHYSIOGRAPHY

GENERAL

In Chapter II a general description of the physical features of Chaleur Bay region was given: the present chapter is concerned chiefly with how these features were produced. This will involve reference to a larger area surrounding Chaleur Bay region. To the north lies the Gaspe plateau; to the south is northern New Brunswick, whose western part is a plateau continuous with that of Gaspe. In the interior of New Brunswick is a region commonly called the central highlands, which extends northward towards Chaleur bay; to the east of Nipisiguit river lies what is termed the eastern or Carboniferous lowlands.

The central part of Gaspe peninsula is occupied by a range of mountains known as the Shickshocks. West of lake Matapedia these are continued through southeastern Quebec as the Notre Dame mountains, which in turn on passing into Vermont are known as the Green mountains. The Shickshocks form a belt from 2 to 15 miles wide, parallelling the St. Lawrence and situated 15 to 25 miles from it. In the region of lake Matapedia their trend is northeast, in central Gaspe east, and towards the eastern end of the peninsula, southeast. This broad curve has its origin in geological structure. The summits of the range reach elevations of from 3,000 to 4,200 feet, and all are flat or gently rolling. Tabletop, lying east of Ste. Anne river, has a length of 12 miles, a width of 5 miles, and an average elevation of about 3,700 feet. Its surface consists of a series of low domes separated by depressions containing lakes and ponds, some of which are over a mile long. Its highest dome is mount Jacques Cartier, 4,200 feet high. To the west of Ste. Anne river, mount Albert rises to an elevation of 3,700 feet. Its summit for a length of 3½ miles and a width of 1½ miles presents a surface of bare rock almost as flat as the western prairies. Mount Logan, near Cap-Chat river, with an elevation of 3,754 feet, consists of a small peak rising above a broad, flat summit. Nearby, mounts Collins and Matawees have similar flat tops. Near the headwaters of Matane river, mount LeClercq (or mont Blanc) has a broad, flat surface and many others show identical features. These tops quite evidently represent an old erosion surface developed on hard rocks. Tabletop is Devonian granite; mount Albert is serpentine surrounded by amphibolite; and farther west the part of the range consisting of Logan, Collins, Matawees, LeClercq, and others, is made up of hard volcanic rocks. The age of this old surface cannot be definitely stated. The youngest rocks it truncates are Devonian. The greatest age that has been assigned to it has been Cretaceous, but considering the amount of it which is still preserved it would seem more probable that it dates from the early Tertiary.

This high country is surrounded by a lower plateau. To the north in the region of Cap-Chat river this plateau stands 2,000 feet below the

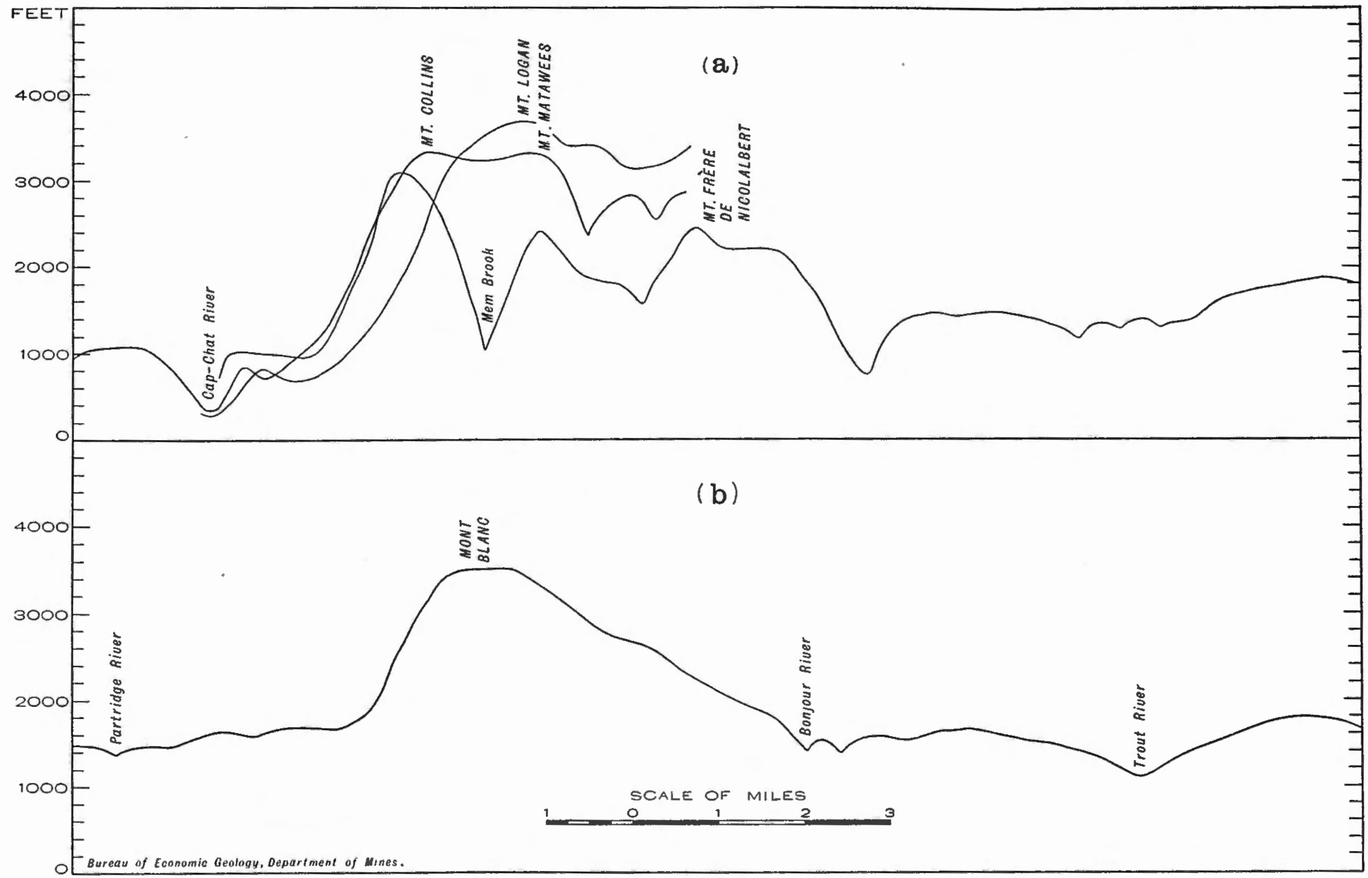


Figure 10. Profiles of the Shickshock mountains in the neighbourhood of (a) Cap-Chat and (b) Matane rivers, Quebec.

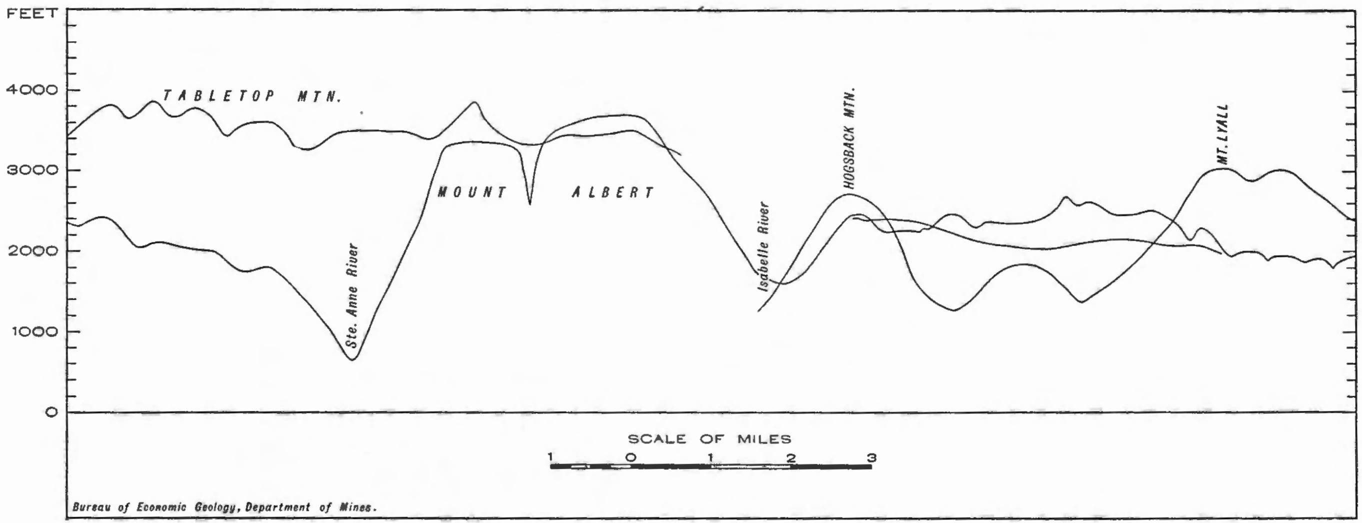


Figure 11. Profiles of the Shickshock mountains in the region of Ste. Anne river, Quebec.

mountain summits or upper plateau. It is developed chiefly on shales and has a very mature surface consisting of broad, flat, interfluvial areas separated by deeply entrenched, steep-sided valleys. To the south there is a similar plateau standing at elevations of from 1,500 to 2,000 feet and developed largely on Palæozoic limestones and sandstones. It, too, shows broad, flat, interfluvial areas separated by steep-sided valleys. A few summits such as the granite masses of Barren and Barn-shaped mountains rise slightly above the general level. This lower plateau clearly represents a second peneplain developed on softer rocks in Tertiary times and the valleys a still younger cycle of erosion.

The central highland region of New Brunswick is made up of ridges, most of which have rounded or flat tops. Some, however, have narrow, irregular summits and in addition a few sharp peaks stand out as prominent landmarks. From the summit of any of these the general picture presented is that of a high tableland broken into hills and ridges. The skyline shows a general concordance of summits with a few peaks rising above the general level. The highest point is mount Carleton, 2,689 feet high. It and two other peaks, mounts Head and Sagamook, respectively 200 and 100 feet lower, are projections rising above a broad mass known as Governors plateau whose average elevation is around 2,200 feet.

The only contoured map of any part of the interior highland belt is that of the Tobique country where Victoria, Northumberland, and Restigouche counties meet. Figure 12 shows composite profiles in a northeast-southwest direction across this area. It will be noticed that there is a series of concordant summits at elevations of about 2,200 feet and that more striking still is a plateau surface at elevations of about 1,200 feet. This surface has been trenched by streams, particularly Tobique river. The region, therefore, shows features analogous to those of Gaspe. Where there are large areas underlain by hard, igneous rocks remnants of an early peneplain are left; where there are wide areas of softer sediments, these form a lower plateau marked by broad, flat, interfluvial areas.

Newfoundland and Nova Scotia also show similar features. The former is a dissected plateau whose uplands are flat-topped with local elevations of a few hundred feet rising above the general level. The accordance of the summit levels forms a plane that truncates complex geological structure and slopes southeastward. Its average elevation on the western border is about 2,000 feet and on the east some 700 feet. The rise from east to west is approximately 6 feet a mile, and carried over to Gaspe at the same rate it presents a remarkably close agreement with the upper plateau of the Schickshocks.

Nova Scotia furnishes data concerning the southward slope of this upland surface. Southern Nova Scotia is an upland presenting an undulating surface rising from the coast to an elevation of 600 or 700 feet in the centre of the peninsula. Other upland surfaces of the province include North mountain, Cobequid mountains, the highlands of Pictou and Antigonish counties, and the uplands and northern tableland of Cape Breton Island. The last has an elevation of about 1,200 feet. The upland rises to the northeast and projected meets the upland of Newfoundland, the rise in this direction being approximately at the rate of 4 feet to the mile.

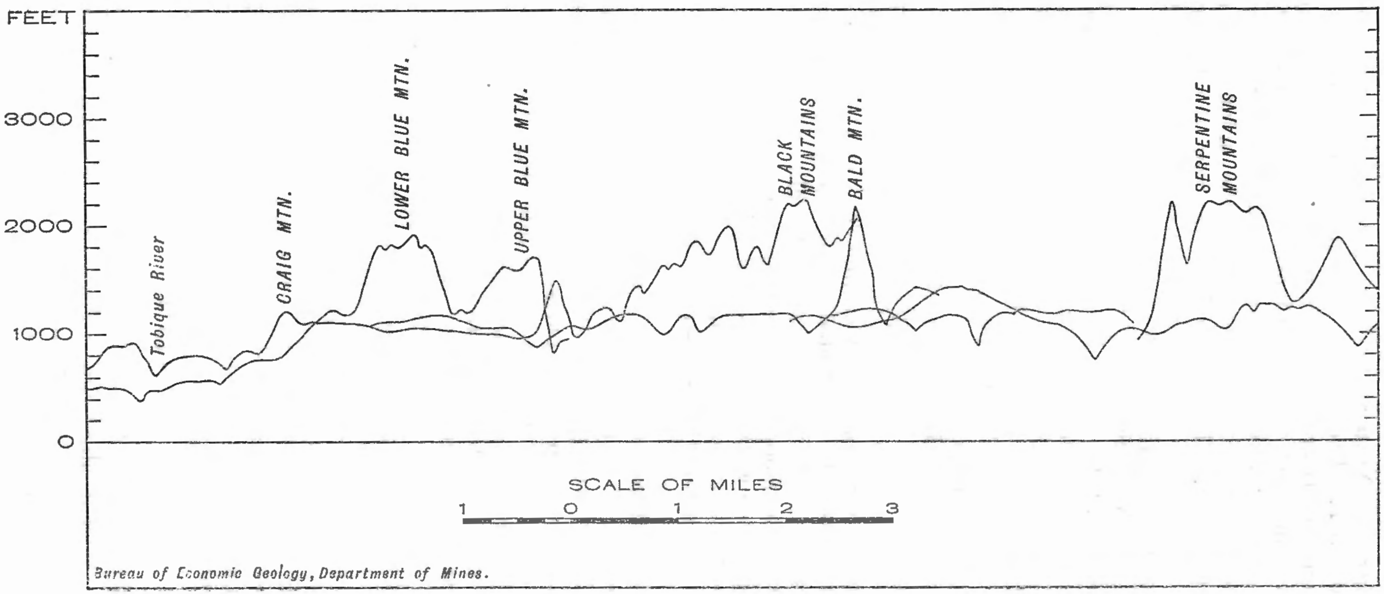


Figure 12. Profiles of the Tobique area, New Brunswick.

The uplands of Nova Scotia show also a westerly rise corresponding to that of Newfoundland to Gaspe. If a generalized profile is taken from the Atlantic coast westward from Chester, Nova Scotia, to the Caledonia highlands it is found that the concordance of summits rises at the rate of about 6 feet a mile, similar to what it does farther north. Projected over to the Tobique country this corresponds to the upland surface of 2,200 feet already mentioned. The southerly slope from the higher plateau of central Gaspe to that of central New Brunswick is only slightly greater than that from Newfoundland to Nova Scotia.

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

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

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

The uplift that initiated this late stage carried the region to a height greater than that at which it stands at present. Borings in the valley of the Restigouche at Matapedia show 70 feet of unconsolidated material below the level of the river and Chaleur bay itself has a depth of over 300 feet. Evidence from a wider field points to the same conclusion. The valley of the St. Lawrence extends over 1,200 feet below sea-level and valleys of New England such as the Hudson have similar, deep, submarine channels. These cannot be older than Pliocene or they would have been long since filled. In the late Pliocene and early Pleistocene it may be concluded, therefore, that the region stood from 1,200 to 1,500 feet or perhaps even more above its present elevation.

LOCAL

Chaleur bay and the lower Restigouche occupy a depression in the lower plateau. A basin along this site has been a feature of the region for long periods, perhaps continuously from the Devonian to the present. As has already been shown a structural depression was produced here in Middle

Devonian times. In the Upper Devonian it was the site of the accumulation of clastic sediments. In the Pennsylvanian period the Bonaventure sediments accumulated to great thicknesses in a basin that had somewhat the same outlines as the Chaleur Bay trough today. During the long periods of erosion in the Mesozoic and Tertiary, which at least twice reduced the country to the north and to the south to base level, a valley probably existed continuously here.

The Upland

The country immediately adjacent to Chaleur bay and the lower Restigouche may be considered under four heads: the upland, the valleys, the coastal border, and the coast itself. In Gaspe the upland is the lower plateau referred to in the general statement. The boundary between it and the coastal border is practically coincident with the edge of the belt of Carboniferous rocks that borders the coast. In places, as in the region around St. Omer and Carleton, there is an abrupt rise from the lowland developed on these younger rocks to the plateau summit developed on the pre-Carboniferous complex. In others, as north of New Richmond and New Carlisle, there is a more gradual rise. Plate XI B is a typical view of the Gaspe plateau north of the Restigouche and Plate III B is a scene on the gently rolling surface itself. The average elevation of the upland surface of Gaspe in the area covered by the Chaleur Bay map is around 1,100 feet. It rises gently to the north. Locally, monadnocks composed of harder rocks rise above the general level. The volcanic hills north of Escuminac and Tracadigash mountain at Carleton, composed of hard Ordovician conglomerate, are examples that were mentioned in Chapter II.

Northwestern New Brunswick presents features identical with Gaspe. It is a plateau at an elevation of about 1,000 feet, developed on Ordovician, Silurian, and Devonian sediments. The highway from Campbellton to St. Leonard follows this plateau and particularly in the region around Kedgewick the extreme maturity of this surface is very striking. Here, however, as elsewhere, the streams are deeply entrenched into it. In the section between Campbellton and Upsalquitch a number of hills, of which Squaw Cap and Slate mountains are the highest, rise above the general level. Like the greater elevations north of Chaleur bay, they consist of rocks harder than the surrounding country and are to be regarded as monadnocks on the old peneplained surface.

Valleys

The deep and steep-sided character of the valleys has already been mentioned in Chapter II. Plate I shows a view looking down the lower part of Matapedia valley. It is seen that the upper parts of the valley slopes dip gently towards the river at angles of about 15 degrees, truncating the upland surface. These upper slopes are in turn truncated by steeper slopes which extend down at angles of from 30 to 35 degrees to the river with but little flattening. The first stage of downcutting was evidently interrupted by uplift when the valley had reached early maturity and the present stage is still one of youth. Plate XV B shows the youthful character of Hall River valley, a tributary of the Bonaventure, which was evidently deepened rapidly in this late stage of downcutting. As has already been mentioned, the small headwater streams commonly flow through broad, gentle valleys before descending rapidly to join the main stream. These flat, upper portions of the valley are clearly inherited from the previous cycle of erosion.

Some of the valleys show anomalies that suggest that in the course of their development important changes in direction of drainage have taken place. In the parts of the interior of Gaspe where contoured maps have been made it is possible to recognize examples of such drainage diversion and to infer the stages by which these changes were brought about (Alcock, 1928 a). The lack of contoured maps of the region around Chaleur bay prevents the detailed working out of any similar examples.

The ordinary drainage map of the region, however, suggests that certain changes of this type have taken place. The upper part of the East branch of the Little Cascapedia follows a nearly straight course, slightly east of south, for many miles, to a point where it turns abruptly west to follow a general southwesterly course to join the Little Cascapedia. A few miles south of the abrupt bend and in line with the upper course of the East branch of the Little Cascapedia, a branch of the Bonaventure rises. This branch, known as the West fork, follows a southerly course to join the Bonaventure and the main river follows the same course to the sea. The upper part of the branch of the Little Cascapedia, the West fork of the Bonaventure, and the lower part of the Bonaventure are in line, and though there are no contoured maps of the region, the presence of a lake and tributary streams along this line in the divide area indicates there is a through valley. This suggests that a river, the ancestral west branch of the Bonaventure, followed this course. Subsequently, a branch of the Little Cascapedia by headward erosion finally captured its upper part. If this interpretation of drainage changes be correct the Little Cascapedia has robbed the Bonaventure of nearly half its drainage area.

Matapedia valley is also one that suggests that drainage changes have taken place in it. As mentioned in Chapter IV, lake Matapedia and lac au Saumon owe their origin to glacial damming, but there are changes indicated that are probably preglacial. From Causapscal north to lake Matapedia the valley is broad and the slopes are gentle, a topography developed in the early stage of the last cycle: from Causapscal south to Matapedia the lower part of the valley, as already stated, is narrow and steepsided, showing the effects of downcutting in the late stage. The tributary valleys of these two sections show corresponding differences. Below Causapscal all the main tributaries of the Matapedia, such as Clarks brook, Millstream, Assemetquagan, Milnikek, Matalik, and Causapscal, with one exception, the Matalik, show the two stage valley slopes. The Matalik flows across a series of arkosic sandstones, which may in part account for its more gentle valley slopes. On Clarks brook and on the Assemetquagan the steep slope of the late stage almost obliterates evidence of the earlier one. North of Causapscal, Causapscal river maintains the two-stage valley, but with the gentle upper slopes better developed than on the Assemetquagan or Clarks brook, erosion in the late stage having evidently not progressed so far in the removal of the upper slopes.

A. The junction of Restigouche and Matapedia rivers, Matapedia, Que.

B. Hall River valley below the power dam, Bonaventure, Que.

North of Causapscal the tributaries of the Matapedia show quite different features. The two largest, the Amqui and the Tobegotte, flow in broad open valleys, whose slopes are low corresponding to the slopes of the upper Matapedia itself.

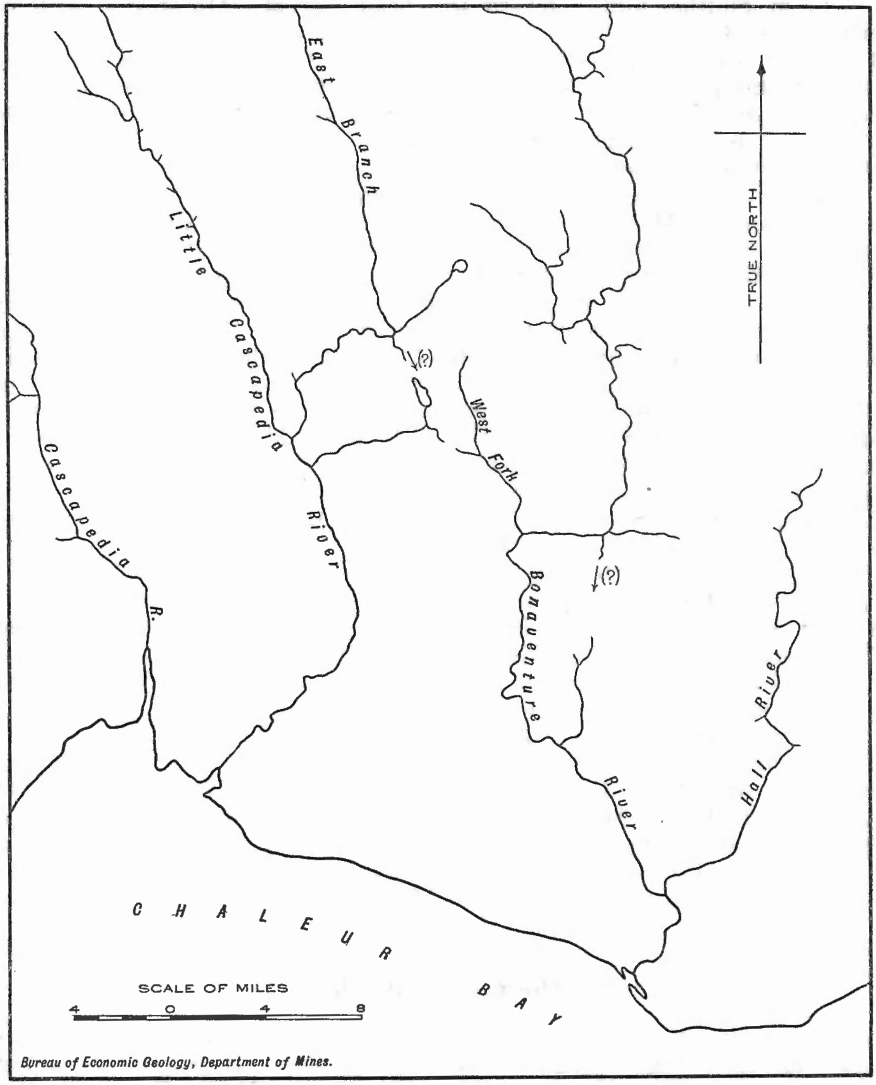


Figure 13. Diagram showing probable drainage changes in the valleys of Little Cascapedia and Bonaventure rivers, Quebec.

The profile of Matapedia river also shows that it consists of two main parts, corresponding to these physiographic divisions. The lower part from its junction with the Restigouche at Matapedia up to Smiths' mill pond near Heppel has an average gradient of 12 feet to the mile. Near the mouth the gradient is 11 feet to the mile and this gradually increases to a maximum of 20 feet to the mile between Ste. Florence and Smiths' mill pond. This even, concave profile is apparently the product of a single physiographic stage.

From Smiths' mill pond to the head of lake Matapedia, a total distance of 31 miles, there is a rise of 115 feet, an average gradient of 3 to 5 feet a mile. As would be expected from the fact that there are two lakes in this part of the valley, lake Matapedia and lac au Saumon, the profile is very irregular. Below lac au Saumon, the lower of these lakes, the river has a gradient of 8 feet a mile. The contrast with the profile of the part below Causapscal is, therefore, quite striking.

The explanation of these features appears to be that these grades and divisions of Matapedia valley were made by two distinct rivers, one of which now forms the lower part of the Matapedia and another that flowed northwestward to the St. Lawrence, and that the present drainage is the result of piracy. Since the northern part has the more mature valley it is probable that Causapscal river flowed into it. If that were so the diversion was caused by a headwater tributary of the original Matapedia river working its way backward by headward erosion and the point of capture was Causapscal. The captured stream was beheaded west of lake Matapedia between St. Pierre river and Grand Metis river. Matapedia valley at the upper end of lake Matapedia turns westward from the lake and is occupied by the St. Pierre and several small streams. The divide between the St. Pierre and the Grand Metis is low and at present is occupied by lakes (Figure 14).

The drainage pattern of the tributary streams offers confirmatory evidence of this interpretation. North of Causapscal, the Tobegotte, Amqui, Sauvage, and other streams flow in directions that suggest that the Matapedia should be flowing northwest instead of southeast; south of Causapscal, on the other hand, the tributaries flow in directions that would be expected in a region whose drainage is to the south.

To summarize—in the early stage of the present cycle a stream rising to the northeast of Causapscal flowed in a general westward direction along the site of the Causapscal, the upper Matapedia, and St. Pierre valleys to the Grand Metis. It was beheaded by a branch of a southward flowing stream occupying the lower Matapedia valley. The upper or Causapscal portion of the northern stream was thus diverted southward. The diversion of the St. Pierre-Lake Matapedia part took place later and was probably the result of glacial damming.

The Coastal Border

The coastal border is a lowland region developed on soft Carboniferous rocks during the early stages of the present cycle. It reaches its widest development on the south side of the bay east of Nipisiguit river. The country is here a gently rolling plain rising gradually from the sea. On the Gaspe side a similar, low, rolling region underlain by Carboniferous rocks forms a border zone along the bay varying in width from 2 to 8 miles. On the New Brunswick side, west of Nipisiguit river, the areas of Carboniferous sediments are mere patchy remnants of a once continuous

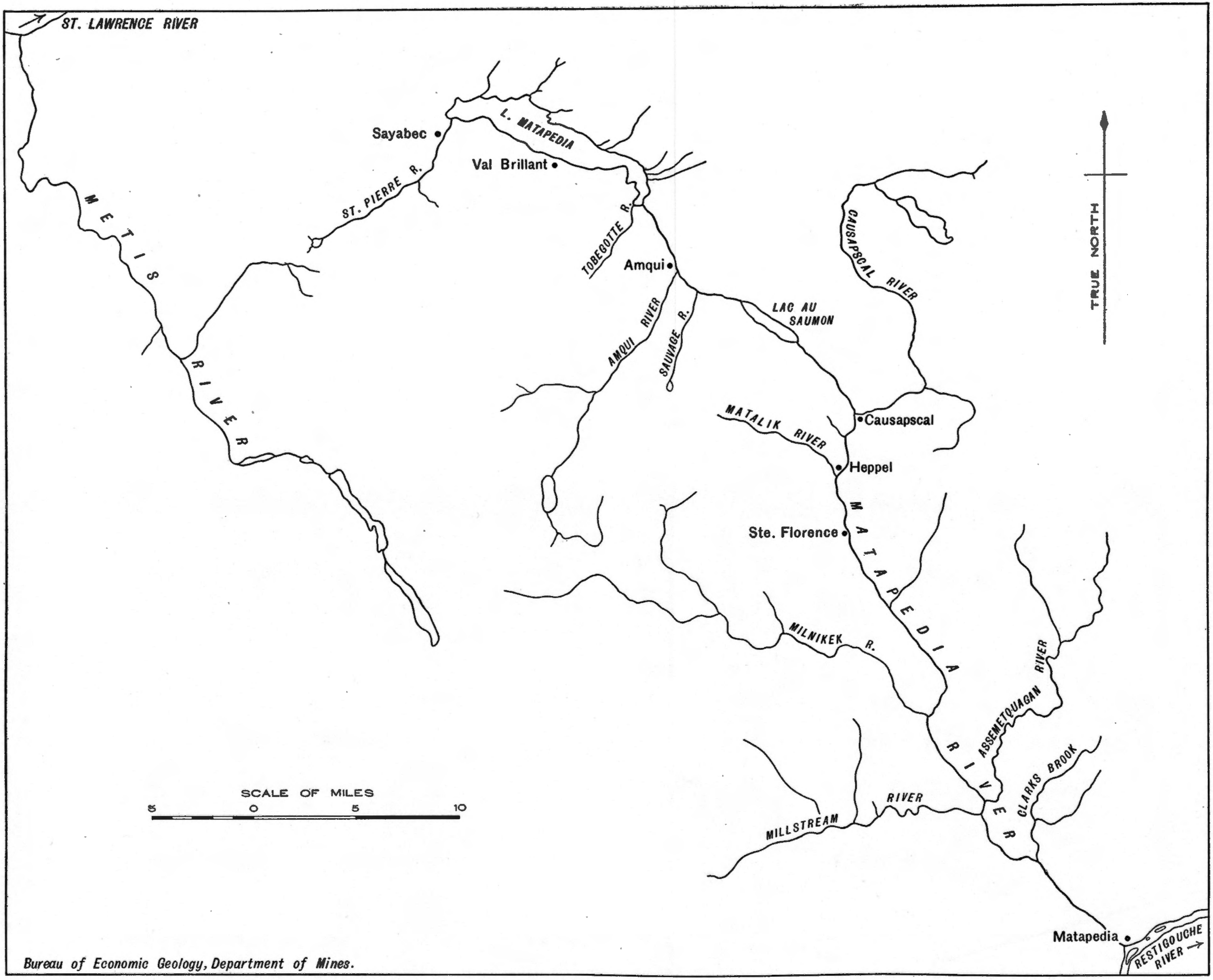


Figure 14. Diagram showing the Matapedia drainage system.

formation. As stated in Chapter II the country here rises slowly from the coast and there is evidently exposed, in part at least, the old pre-Carboniferous peneplain surface exhumed from its former cover of Carboniferous sediments.

Terraces are present locally along the coast and the lower parts of the river valleys. In places they are cut in the pre-Carboniferous rocks of the plateau where these border the coast. On either side of Gascons cove a terrace developed in Silurian rocks rises inland from an elevation of about 20 feet to over 30 feet. It is backed by a cliff over 12 feet high. Beyond this a second narrower terrace rises 4 feet to the second cliff which has a height of about 10 feet. East of Chouinard brook higher terraces occur. The base of the highest has an elevation of 90 feet. At Carleton, Coleman's elevations for three terraces are 48, 77, and 175 feet, respectively, and at New Richmond are terraces at 37, 50, and 185 feet. West of Battery point, near the mouth of Busteed brook, an old beach at an elevation of approximately 20 feet borders the present low clay shore. Near Bathurst the upper limit to beach deposits appears to be 195 feet and at Caraquet 138 feet.

As stated in Chapter II river terraces are well developed in the unconsolidated material along many of the rivers of the region. A very prominent one on the Nouvelle and the Cascapedia has an elevation of about 100 feet and others occur at lower levels.

The Coast

The coast of Chaleur bay shows a considerable variety of shore forms. In places the country rises back from a low beach; in others it is bordered by vertical cliffs sometimes rising over 100 feet in height. As stated in Chapter II, spits, baymouth bars, and cuspate bars are characteristic features. The shore features are those of a submerged topography in a youthful or adolescent stage of coastal development. Hard rock headlands have been attacked but little. A flowerpot sea-stack at Fleurant point east of Escuminac shows that the cliff has been cut back by wave-action. At Percé, on the gulf of St. Lawrence, the Murailles form a striking example of cliff retreat due to wave-action, but in Chaleur bay such retreat of any considerable extent is apparently limited to shores composed of soft rocks. On the south coast east of Bathurst where the rocks bordering the shore are easily eroded sandstones, and where the width of the bay has afforded the maximum amount of wave-action, the coast is approaching the more regular, smooth outline of early maturity. The section opposite, on the Gaspe side, underlain by Bonaventure rocks, is in a similar stage of development. Spits and bars are a mark of a youthful stage. The stage of maturity will have been reached when the lagoons back of the baymouth bars have become filled up, the initial shoreline obliterated, and a smooth, regular one produced. Where hard rocks form the coast this process has hardly as yet begun.

GLACIATION AND ITS EFFECTS

There is abundant evidence that in Pleistocene times Chaleur Bay region was glaciated. The glacial effects are of two kinds, those due to erosion and those due to deposition. Many of the rock surfaces of the region are smoothed and rounded, giving the type of outcrop known as roches moutonnées. A considerable number of these occur in the settled region between Dalhousie and Bathurst, particularly in areas underlain by massive rocks such as volcanic flows. In places lee and stoss stopes can be differentiated with sufficient clearness to ascertain the direction of the glacial movement that produced them. Locally in rocks broken by joint planes there is superimposed on the general smoothed surface a series of smaller lee and stoss slopes which are equally effective in pointing out the direction of ice advance. A good example of this type of surface is seen at the Drummond iron mine south of Bathurst (Plate XVI B).

The roches moutonnées surfaces are smoothed and locally polished and in addition many of them show grooves, furrows, and striations. On the whole, however, for the size of the area under consideration the number of recorded striation bearings is small and most of these are within a few miles of the coast. The reason for this is that although along the coast outcrops are fairly numerous and easily accessible, inland the main exposures are along swiftly flowing streams and steep valley slopes where striations have had less opportunity of being preserved. Lists of striation bearings are given by Chalmers (1886 b); many of these have been checked by the writer and a number of additional ones recorded (Figures 15). They indicate several directions of ice movement: an advance down Matapedia valley, an eastward one along Chaleur bay, a southeast advance from Gaspe, and a northeastward advance from central New Brunswick.

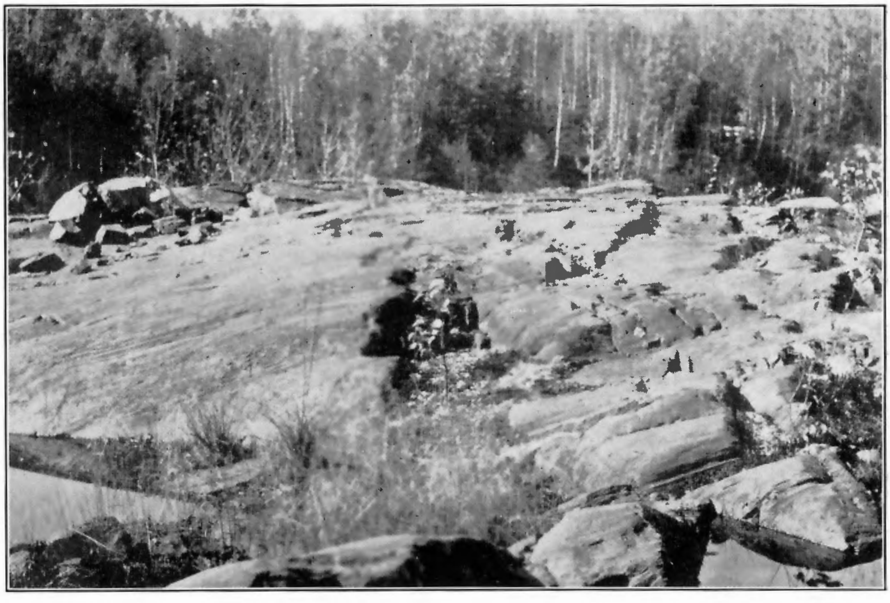
On the south side of Chaleur bay between Jacquet River and Elmtree, a late set of striæ, according to Chalmers, crosses earlier, heavier, eastward trending striæ. This younger set is nearly at right angles to the older and the stoss side is everywhere towards the bay. They are, moreover, limited to a zone lying between 60 feet and 150 feet above sea-level. Below the 60-foot contour none of these striæ was seen, although rock exposures are numerous; and similarly none was observed above 150 feet. Chalmers concluded that these striations were produced by ice jams impinging against the coast when it stood 75 to 100 feet or more lower than it does at present.

The products of glacial deposition have been discussed in Chapter III and the discussion in this chapter will be limited to erratics and the evidence they afford as to ice movements. Erratics are found along the shore, in the streams, and irregularly scattered over the entire region. On the Gaspe side where the character of the bedrock is not such as would preserve striæ, and where no boulder clay is present, the assorted variety of rock fragments and blocks resting on an area underlain by a single type of bedrock forms the chief evidence of the passing of a glacier. Most of the erratics of the region have travelled no great distance. On the Gaspe side, in general, the most abundant type of erratic and the largest blocks at any given place consist of rocks of the hardest formation that lies immediately to the north. For example, from Cross point to Maguasha, Devonian volcanics predominate in size and numbers; from Carleton to Cascapedia, Ordovician conglomerate; from Cascapedia to Port Daniel, Silurian limestone and conglomerate; and north of Port Daniel, granite and other local rocks.

In addition to the erratics of local origin and those that have travelled only short distances there are some consisting of granite, granite-gneiss, anorthosite, quartzite, and other rocks, whose source it is more difficult to

73504

A. Gaspe plateau from the Kempt road.



B. Glaciated surface at Drummond iron mine, south of Bathurst, N.B.

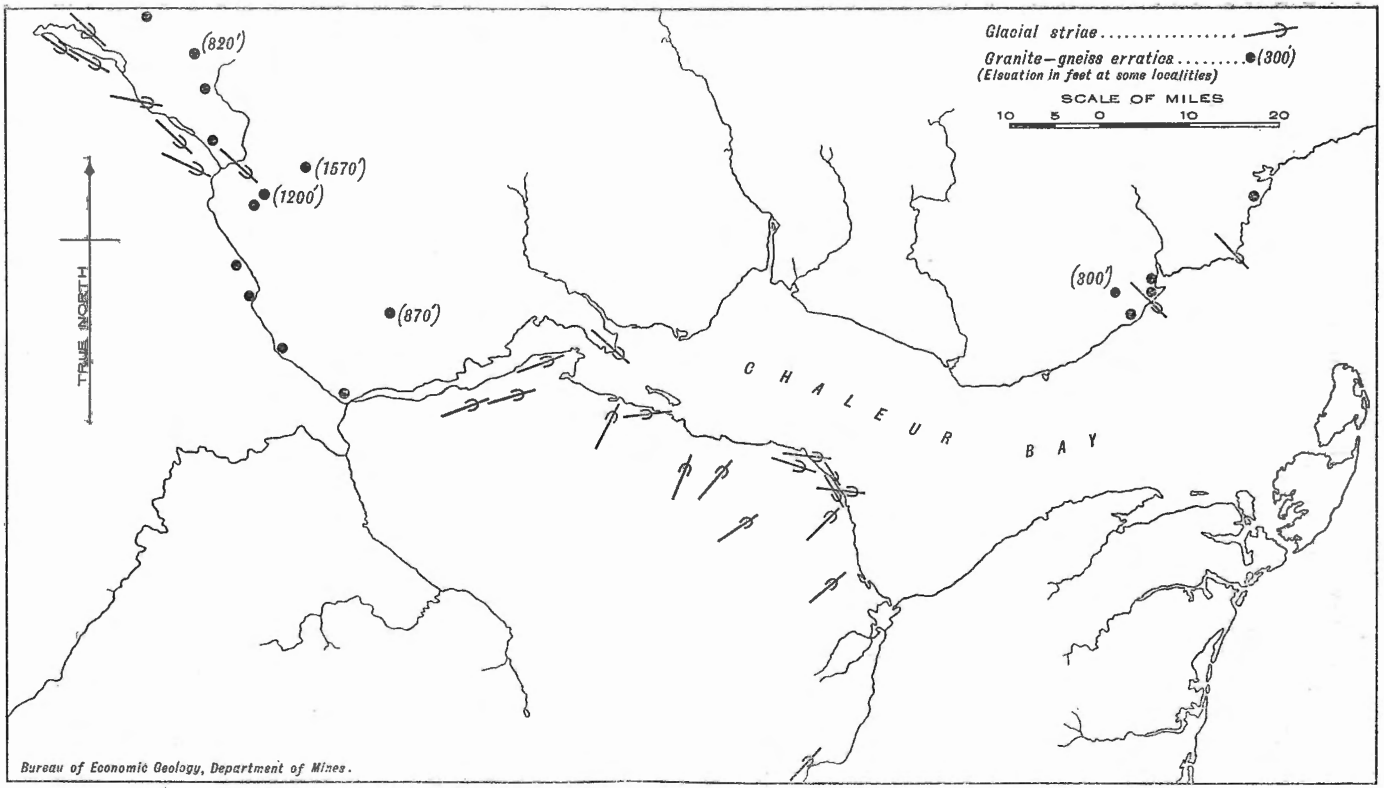


Figure 15. Index map of Chaleur Bay region showing directions of glacial striæ and localities where granite-gneiss erratics were observed.

place. For example, it is known that large granite masses occur in the interior of New Brunswick, in Tabletop mountain and other localities of central Gaspe, and in the Precambrian region north of St. Lawrence river. It is difficult, therefore, to determine the direction from which the granite erratics, which occur over practically the entire area under discussion, have come. Granite-gneiss boulders, similar to those found in great numbers and of large size along the St. Lawrence side of Gaspe, are, however, considered to have come from the Precambrian gneisses of northern Quebec. Search was made for boulders of this variety on both sides of Chaleur bay in order to get information regarding the problem as to whether the Labrador ice-sheet overrode all of Gaspe or only a part of it. In the farming areas, which in places extend 10 miles back from the shore, huge piles of stones in the fields and along fences greatly facilitated this work. The following summarizes the information obtained.

Erratics from north of the St. Lawrence occur all down Matapedia valley. At St. Tharsicius, east of lake Matapedia, solid granite-gneiss boulders were observed at an elevation of 820 feet, and near St. Jean Baptiste de Vearney, others were found at about the same altitude. Southeast of Causapscal along the Kempt road in the neighbourhood of Ste. Marguerite a considerable number of subangular, Precambrian granite-gneiss erratics were found at elevations of about 1,200 feet, and 10 miles east of Causapscal along a private highway of the International Power and Paper Company anorthosite and gneiss boulders were seen at elevations of 1,570 feet. Sandstone blocks of local origin and quartzite erratics from Palæozoic formations to the north occur also and in much greater abundance. Farther south on the Kempt road, at a distance of 8 miles from Restigouche river, a few, rounded granite-gneiss boulders were located in rock piles at an elevation of 870 feet. Though these boulders are not numerous their presence clearly indicates that the western part of Gaspe peninsula at least was crossed by the Labrador ice-sheet.

The plateau country at the headwaters of river du Loup, which joins the Restigouche near Cross point, was searched for erratics. Boulders of limestone, volcanics, porphyry, and quartz are common, but none of undoubted Labrador origin was observed. Search in the region from Escuminac to Cascapedia similarly failed to locate any foreign erratics. On the conglomerate summit of Tracadigash mountain a few, small, rounded boulders of basic volcanics showed that a glacier passed over the mountain.

The Silurian belt north of Bonaventure shows many erratics. Boulders, some of them 3 feet across, form huge piles in the fields. Most of them are of local origin and consist of limestone, sandstone, and conglomerate. A number consisting of red granite and granite porphyry were found, but none that could be definitely recognized as Labradorean. Back of the settled region on the flat plateau country near the headwaters of Hall river there is also abundant evidence that the region was overridden by an ice-sheet. Here, at elevations of 1,500 feet and more, large rock fragments of different types rest on a single variety of bedrock. One large erratic some 3 feet long was seen to consist of a quartzose, pegmatitic granite different from anything the writer has seen in the Tabletop region of central Gaspe; this may be Labradorean.

North of St. Godfroi the country shows abundant evidence of having been glaciated. Erratics of many varieties exist. By far the most abundant are conglomerates and limestones of local origin. In addition, rounded red granite boulders were found in a number of places. On range III, Hope township, several distinctly gneissic granite boulders were found at elevations over 400 feet, and on range V reddish granite boulders were seen at elevations over 600 feet. The former are almost certainly of Labradorean origin, and the latter may be.

In the region around Port Daniel, in the streams entering Port Daniel bay, and along the shores of the latter, are many boulders. In Middle Port Daniel river where it flows through a region of Ordovician shales there are many grey granite erratics, some weighing tons. In North Port Daniel river, also, there are many of these white to grey granite boulders some over 10 feet in diameter. Farther upstream, in Weir township, the river has cut a gorge through bedrock composed of this granite, so evidently this was the source of the erratics. Other boulders in the stream consist of serpentine, hornblende schist, quartz, etc. One serpentine block in the middle of the river has dimensions of 17 feet by 10 feet by 10 feet, much too large to be moved by a stream of the size of the Port Daniel. Serpentine cutting hornblende schist forms large outcrops along Port Daniel river in Weir township, 3 miles above this erratic. Blocks of fossiliferous Silurian limestone from north of the serpentine zone and greenstone erratics apparently of Shickshock origin occur to the south of the granite and serpentine outcrops. A few reddish granite boulders, one distinctly gneissoid, and several grey gneiss boulders, probably of Labrador origin, were also seen in the river.

Reddish granite-gneiss boulders, which certainly came from the Precambrian area north of the St. Lawrence, were also found in the vicinity of Port Daniel. On the beach slightly to the west of the Bank of Nova Scotia occur some half dozen, the largest having a length of about 3 feet. Near the Anglican church on Port Daniel hill similar, red, granite-gneiss boulders were found at elevations of 200 and 280 feet. On the Marcil road one was found near highway number six at an elevation of 70 feet, and 3 miles farther north along the same road others were found in stone piles in fields at elevations of over 300 feet. With them occur a great quantity and variety of boulders derived from local formations, including conglomerate, limestone, serpentine, hornblende schist, grey granite, pegmatite, quartzite, volcanics, etc.

The boulders around Newport are chiefly of local origin, being made up for the most part of rocks of the Macquereau group. Two, large, reddish granite-gneiss boulders, typically Precambrian of northern Quebec, were, however, found at an elevation of 50 feet, near the highway to the west of Newport.

Along the shore at Percé and southward occur Precambrian granite-gneiss boulders. More abundant types are limestone, volcanics, sandstone, and red conglomerate. Back of Percé along the Grande Coupe road a number of erratics composed of various varieties of granite were observed at elevations of from 150 to 200 feet. Some of these may be Labradorean. On the road between Corner of the Beach and Percé, Coleman reports a granite-gneiss boulder at an elevation of 262 feet and on Bonaventure island another at an elevation of 295 feet.

On the New Brunswick side of Chaleur bay, as on the Gaspe side, the great majority of the scattered boulders are of local origin. Many can be recognized as having travelled eastward. For example, near the mouth of Armstrong brook are large blocks of Lower Devonian limestone apparently brought from the Dalhousie region, and on the shore near Petit Rocher huge boulders of conglomerate can be identified as having come from outcrops to the west. In a number of streams large boulders of granite and some of gneissic granite were seen, but whether they all came from the interior of New Brunswick or whether some came from northern Quebec is not known. On the shores south of the mouth of Nigadu river boulders of gneiss occur, which were apparently derived from the boulder clay that here forms low cliffs along the coast. The region from Bathurst to Miscou, underlain by flat-lying Pennsylvanian sandstone, shows a large number of erratics of granite and some of granite-gneiss. One granite block was found to have a diameter of 8 feet. Near Grande Anse large granite boulders occur in stratified gravels. On Shippigan island are numerous granite erratics.

The higher elevations of the New Brunswick part of the map-area, such as Squaw Cap and Slate mountains, consist of a rubble of fragments similar to the bedrock below, a dense acid intrusive. Search made for foreign material on Squaw Cap, elevation 1,585 feet, revealed one rounded boulder of white quartz about 6 inches in diameter at a point about 200 feet below the summit, and several, smaller, rounded quartz boulders 100 feet lower. It would appear that in spite of the apparently unglaciated character of the summit the latter was crossed by a glacier. The loose slabs of rock are considered to be due to exfoliation in post-glacial time, the disrupting of the massive intrusive rock being due to changing temperatures.

Conclusions Regarding Glacial Movements

That the whole Chaleur Bay region was glaciated is shown clearly from the evidence of erosion and deposition, particularly that of the erratics. That it was glaciated more than once is quite possible, but absolute proofs are difficult to obtain.

It was held by Bell and Chalmers, and in this they were followed by Coleman and the writer, that the high plateau country of central Gaspe, known as the Shickshock mountains, was not crossed by the Labrador ice-sheet. The evidence advanced for this view was twofold: (a) the absence of Labradorean drift on the mountain summits and to the south of the range; and (b) the unglaciated character of the summits. There is an apparent absence of smoothed, striated, and grooved surfaces characteristic of glaciated regions; the rock surfaces are rough and angular; the loose blocks of rock abundant on the summits correspond to the bedrock beneath. It was considered, however, that this mountainous region was a centre of local glaciation, for there is an abundance of evidence, in the form of cirques on the mountain flanks, that local glaciers were once active. According to Coleman, the Labrador ice-sheet on reaching Gaspe divided into two lobes, one of which advanced eastward down St. Lawrence valley and the other crossed Gaspe in the vicinity of Matapedia valley and continued eastward along Chaleur bay. Labradorean boulders in the vicinity of Chaleur bay were explained either as having been deposited by this lobe or as having been rafted in by ice blocks during the period of post-glacial marine submergence. Even if the latter is a possible source, it is not to be expected that Labrador boulders transported in such a way could be found at elevations much over 200 feet.

In his later work in the interior of Gaspe the writer began to have some doubts regarding the non-glaciation of the Shickshock summits by the Labrador ice-sheet. Blocks of serpentine from mount Albert were found on Barren mountain to the southwest, at elevations of 2,800 feet, a height that it is difficult to conceive of glaciers reaching if they were of local origin from the flanks of the former mountain: nor did the still more recent evidence of the erratics found in the region north of Chaleur bay seem to be in harmony with the idea of local glaciers. Glaciation north of Chaleur bay was not confined to the valleys. The whole plateau country with elevations up to 1,800 feet shows drift, and the Shickshock region appears to be too small to have supplied the drift that spread out so far. The evidence of Labradorean erratics also appears to demand that the ice-sheet crossed the peninsula. It either did this or lapped around the Shickshocks.

If the ice crossed the Shickshocks what is the explanation of the apparently unglaciated character of the mountainous summits? The mountain tops have no residual soil, a fact that would point to their having been glaciated. They are, however, covered by angular blocks of rock, a felsenmer, which correspond to the bedrock beneath. These can be perhaps best explained as due to the disrupting effects of changing temperatures since the disappearance of the ice. Bare slopes, isolated hills, crystalline rocks, and temperate latitudes form the most favourable conditions for exfoliation of this type, and these conditions are all met with in the high Shickshock summits. The type of summit is identical with that of Squaw Cap, Slate mountain, and others in New Brunswick. The passing of an ice-sheet over the mountains removing all soil and vegetation would render the conditions ideal for the development of this type of surface. Miller has described surfaces in the Adirondacks of New York, which were certainly glaciated but now show features closely resembling those displayed by Gaspe mountains.

A fact that also must always be considered in connexion with the subject of glaciation in the Shickshocks is that mountains considerably higher than any in that range and much farther away from the centre of ice dispersal show evidence of having been crossed by the continental glacier. Mount Katahdin in Maine, elevation 5,150 feet, and mount Washington in the Presidential range of the White mountains of New Hampshire, elevation 6,293 feet, both show glaciated surfaces and numerous foreign erratics consisting of granites, gneisses, etc. With a continental glacier crossing these peaks it would seem that a thickness of ice of some 2,000 or 3,000 feet must at that time have covered the highest Shickshocks.

The following interpretation appears to best explain the glacial features of the region. In Pleistocene times when the land stood at elevations considerably higher than it does today and when the continental glacier was gathering to the north, the highlands of central New Brunswick and central Gaspe were local centres of glaciation. Ice moved out from the former in a northeast direction to Chaleur Bay region and local glaciers flanked the Shickshocks, moving out both to the north and to the south. Later, when the Labrador ice-sheet had attained a sufficient thickness to override the mountains it crossed the whole region, removing the residual soil and leaving the summits denuded to bedrock. This ice, however, was the upper part of the continental glacier which had but little debris in contrast with the heavily loaded basal portion which left numerous erratics along the St. Lawrence side of Gaspe. This offers a possible explanation why Labradorean erratics, showing from what centre the ice advanced, occur only locally in the Chaleur Bay region.

SUMMARY OF PHYSIOGRAPHIC HISTORY

The oldest physiographic feature in the general region surrounding Chaleur bay is the summit of the Shickshocks which is a peneplain probably completed in early Tertiary times. Uplift in the early Tertiary inaugurated a new cycle of erosion and a second peneplain was produced on the soft limestones, shales, and sandstones of the region. This peneplain forms the upland surface north and southwest of Chaleur bay. This cycle was in turn terminated by uplift. The succeeding cycle is made up of two stages: (1) an early one in which a fairly mature topography was produced; (2) which was followed by renewed uplift in late Pliocene times carrying the country to an elevation considerably greater than that at which it stands today. This high elevation continued into Pleistocene times and was one reason why local glaciers accumulated in central Gaspe and in northern New Brunswick, giving rise to local centres of dispersal.

In the Pleistocene glaciers advanced down the valleys from these centres in the mountainous part of the interior. A large glacier advanced eastward along the valley of the Restigouche and Chaleur bay, and ice moved northeastward from northern New Brunswick. Finally, the whole region was overrun by the Labrador ice-sheet. On the retreat of the glaciers gravels were washed out under and in front of the thinning ice masses, giving rise to the kame deposits of the lower parts of the Restigouche and other tributary valleys of Chaleur bay. The region at this time was depressed and much of this detritus was deposited in standing water. During this period of depression marine beds consisting of clay and sand were deposited. Their occurrence at all levels from sea-level up to 200 feet indicates that the maximum depth to which the region was depressed below the present elevation was approximately that amount.

Recent uplift is shown by the presence of terraces along the rivers and by the marine clay beds which, as mentioned above, occur at elevations up to 200 feet above sea-level. This uplift, however, has been insufficient to offset the Pleistocene depression. As has already been mentioned the shore features of Chaleur bay are those of a submerged topography in an adolescent stage of coastal development. The recent uplift was intermittent in character. A prominent terrace at 100 feet indicates a considerable halt and other terraces mark halts of smaller duration.

The most recent movements of all may have been oscillatory. At Charlo a peat bog bordering the coast was taken by Chalmers as proof that the region has sunk at least 5 feet since the bog was formed. On the Gaspe coast there is some evidence that within recent years there has been uplift. Inhabitants at Maria say that at certain places on the coast severe storms used frequently to send waves over the main shore highway, but that during the past fifteen years there has not been a single case of this.

CHAPTER VI

ECONOMIC GEOLOGY

IRON

DRUMMOND IRON MINE

The largest metalliferous deposit known in the region is that called the Drummond iron mine, situated on Austin brook, a tributary of Nipisiguit river, some 17 miles south of Bathurst. This deposit lies just outside the area described in the present report. A detailed description of it is given in Geological Survey Memoir No. 18-E (Young, 1911).

MILLSTREAM

A deposit of iron lies near a small stream entering Millstream river about 8 miles from the coast. It is of contact metamorphic origin and consists of magnetite in a gangue of garnet (Young, 1911).

COPPER

BALDWIN COPPER MINE

Copper mineralization has been found in a number of localities, but nothing of sufficient importance to encourage development work has yet been located. The Baldwin copper mine (Ells, 1881, page 26) is an old prospect on the southeast side of Nipisiguit river 13 miles from Bathurst. The rocks are highly altered Ordovician sediments consisting of slates and grey micaceous schists, in places having a purplish tinge and containing red stains and small stringers of hematite. The ore mineral consists of small amounts of chalcopyrite in quartz veins cutting these rocks. The quantity is apparently too small to be of economic importance. The source of the mineralization was evidently the granite that intrudes the sediments and outcrops on Nipisiguit river immediately to the north of the prospect.

TETAGOUCHE FALLS

At the falls of Tetagouche river, some 8 miles west of Bathurst, small quantities of chalcopyrite are associated with pyrite in quartz veins cutting slates of Ordovician age (Bailey, 1889, page 26). Within a distance of 60 feet there are at least seven of these veins which locally reach a width of 5 feet. A small amount of work was carried out about the year 1859 or 1860 and some ore, in conjunction with that of the manganese beds nearby, was shipped to England. Work, however, was soon discontinued and nothing further has been done.

SCAUMENAC RIVER

A small amount of native copper was found in volcanic rocks of Devonian age on Scaumenac river about 5 miles from its mouth (Chalmers, 1900, page 149). The copper occurs in small stringers or grains associated with calcite and other minerals resembling zeolites, and is accompanied by malachite stain. The stringers occur along a zone some 10 to 15 feet wide trending east and west. The amount of copper is too insignificant to be of economic importance.

BATHURST

South of Bathurst the Pennsylvanian rocks that outcrop along the lower part of the Nipisiguit locally contain small, irregular masses and narrow stringers of chalcopyrite. Accompanying these occurrences are small amounts of malachite and green copper stain. Similar deposits are known in other parts of the Pennsylvanian belt of the province, particularly at Dorchester in Westmorland county, and at New Horton in Albert county. It is stated that in 1859 some 20 or 30 tons of ore were shipped from a prospect 3 miles south of Bathurst, but that work was soon discontinued (Bailey, 1889, page 26).

Though this occurrence of copper is of no economic importance, its origin is of interest. The older rocks of New Brunswick, which supplied the material for the Carboniferous sediments, contain quartz veins locally carrying chalcopyrite and bornite, and these minerals were, as a result, contributed in small amounts to the sediments. Where the copper sulphides now occur they are always in association with organic matter, such as plant remains and thin coal seams. It is believed that circulating meteoric waters took the copper minerals disseminated in the sediments into solution and that the copper was redeposited as sulphides through the reducing action of carbonaceous material below the zone of oxidation.

SILVER-LEAD-ZINC

CROSS POINT

A silver-lead deposit (Alcock, 1930, page 107) was staked on lot 1, Restigouche range, Mann township, Bonaventure county, by Mr. J. C. Beidelman, in the spring of 1927. A small amount of surface work was carried out that year and in the following summer four diamond-drill holes were put down to intersect the mineralized zone. The results were, however, discouraging. In December 1928, and January 1929, electrical prospecting for the owners was carried out on the property by the Radiore Company.

The rocks on the claims are Lower Devonian volcanics. The mineralization consists of argentiferous galena with some associated quartz and calcite and occurs as replacements along fractures in the volcanics. The main fracture strikes northeast and dips steeply to the southeast. Mineralization occurs along it with widths up to 9 inches in the cut in the face of the cliff where the discovery was made. In a trench 50 feet to the southwest of the discovery cross-fractures intersect the main fractures and the best ore occurs at such intersections. Solid sulphides with widths up to 6 inches occur here along the main fracture; along the cross-fractures the ore commonly fingers out to nothing in a few inches. In addition to the mineralization along the fracture, galena is present in massive rock near the fractures and in one place a matrix of galena was found surrounding some feldspar phenocrysts that remained unreplaced. Across the small creek that lies to the east of the discovery small showings of galena have been found in volcanic rocks.

The deposit is believed to have had its origin in an underlying intrusive mass. Intrusions of granite, as stated in Chapter III, occur in the interior of both Gaspe and northern New Brunswick and there are probably others that erosion has not as yet uncovered.

Enough exploration work was carried out on the property to show that the amount of ore present is too small to be of economic importance. The occurrence, however, indicates the possibility that larger deposits may somewhere be present in the region.

BIGHOLE BROOK

Small mineral showings occur on Bighole brook (Alcock, 1930, page 75), a tributary of Jacquet river, Restigouche county, New Brunswick. They can be reached most readily by a wood road from Lorne settlement.

The deposits are veins and replacements in volcanic rocks of Lower Devonian age. The largest vein, which has a width of 8 inches, occurs immediately above the falls on the brook. The ore minerals are galena and sphalerite in a gangue of quartz and carbonate. Two miles above the falls a shear zone in the volcanics on the right bank of the stream is mineralized with solid sulphides, chiefly dark sphalerite with some pyrite. The exposed width of the sulphide zone is from 1 to 3 inches. The showings are much too small to be of economic importance.

ELMTREE

A deposit of sphalerite (Alcock, 1930, page 74) occurs on Elmtree river about 4 miles in a direct line from its mouth on Chaleur bay. An automobile can be driven to the property. The occurrence has been known since 1880 and in 1882 the Elm Tree Mining Company was incorporated to work it. About 1918 further exploratory work was done on the property. This included a few diamond drill holes and a considerable number of trenches excavated to bedrock. Sulphides were found in some of the latter, but nothing of sufficient importance was uncovered to encourage further work.

The rocks consist of Palæozoic slates. Devonian granite, which occurs in the region, is undoubtedly responsible for the mineralization.

The deposit as exposed in the stream consists of a mineralized zone from 1½ to 13 feet wide striking in a north-northwest direction. From the main exposure in the creek a branch mineralized zone strikes northeast, the best mineralization occurring at the junction of the two. The zones consist of country rock cut by calcite and quartz stringers and mineralized with sulphides. The latter consist of pyrite, chalcopyrite, sphalerite, and galena in scattered grains and small aggregates. The relative amounts of galena and sphalerite vary greatly, but in general the latter mineral predominates. On the west side the main zone has a fairly distinct wall, but the east boundary is less definite, the slates here being altered, cut by calcite stringers, and partly mineralized.

Other zones mineralized with small veins occur along the upper parts of Elmtree river, on Rocky brook, a tributary of Millstream river, and on Nigadu river.

ROCKY BROOK

Development work on a mineral showing on Rocky brook 12½ miles northwest of Bathurst revealed small, irregular patches of sulphides, sphalerite, pyrrhotite, pyrite, arsenopyrite, and a little galena, but nothing of economic importance (Alcock, 1930, page 72).

ARSENIC

Development work has been carried out on a deposit of arsenopyrite on Stevens brook, a tributary of Millstream river, 12 miles northwest of Bathurst (Hurst, 1927, page 125). A wood road, 1½ miles long, leads from the end of the motor road near Ste. Rosette to the property.

The region is underlain by metamorphosed sediments, and dark tuffs and volcanic breccias of Ordovician age. The sediments include cherty argillites and argillaceous limestones. At intervals for 200 feet small bodies of sulphides, chiefly arsenopyrite, pyrite, pyrrhotite, and chalcopyrite, have been exposed by trenching. Although these exposures lie on a line running north 20 degrees east, the mineralized zones appear to be unconnected and to consist of separate replacements along different, slaty bands. In the largest open-cuts the zone carrying the sulphides does not appear to exceed 3 feet in width; local solid masses of arsenopyrite have widths of 6 to 8 inches. In most places the sulphides occur as tiny veinlets or fine-grained patches disseminated through the altered and silicified country rock. Assays of the mineralized rock gave values of from 80 cents to $7 a ton in gold.

Development work consisted of a series of trenches, a pit about 10 feet deep, and a shaft 15 feet deep, on the east side of the brook. About 350 feet farther north on the opposite side of the stream similar mineralization has been exposed by trenching.

Owing to the fact that the mineralization is irregular and scattered more work is required to determine the extent and value of the deposit.

ANTIMONY

NEW RICHMOND

A vein containing stibnite is exposed on lot 9, range VI, New Richmond township, Bonaventure county. It lies on the summit of a ridge about ½ mile southeast of Brûlé brook. A car can be driven to within half a mile of the showing.

The outcrops on the slope and summit of the ridge consist of dense sandstones and well-cemented conglomerates of Ordovician age, standing at steep angles. The vein strikes north 20 degrees west and dips vertically. Its maximum width is about 3 feet and it has been followed for 80 feet, but here and there in this distance it pinches out to almost nothing. Its walls are slickensided, showing horizontal striations. The minerals present consist of quartz and stibnite. At one place a 4-inch width of solid stibnite occurs and one pocket is said to have shown a width of 18 inches of solid sulphide.

STEWART RIVER

A small amount of work has been done on a showing of stibnite in a field about 150 feet west of Stewart river, Bonaventure county, 2½ miles north of highway No. 6. A wood road can be followed to the exposures.

The rock is dense, grey Ordovician quartzite cut by quartz stringers. The stringers are irregular and branching, running in all directions. Most of them are less than 1 inch in width; the greatest width observed was 3 inches. Both the rock and the quartz stringer contain sparsely disseminated pyrite. The stibnite occurs in the quartz veinlets as streaks, most of which are less than a quarter of an inch in width. One has a width of three-quarters of an inch.

The exploration work includes one pit in bedrock 10 feet by 8 feet and 5 feet deep; one trench 90 feet long, not down to bedrock; one pit 6 feet deep in rock; and another pit not to bedrock.

MOLYBDENITE

A deposit of molybdenite occurs at Pabineau lake some 10 miles south-west of Bathurst. A trail 8 miles long leads to it from the end of the motor road that follows the north side of Little river.

The rocks along Little river consist of Devonian granite intrusive into Ordovician sediments and volcanics, outcrops of which occur along Middle river about 2 miles to the west. In the region around Pabineau lake no outcrops were observed within 3 miles of the lake. The country is of low relief, is covered with drift, and is wooded.

In the lake are huge blocks of granite and 300 yards west of the north end of the lake a nest of granite blocks is exposed in an open muskeg area. The fact that all the blocks are of granite suggests that the bedrock is the same and that it lies not far beneath the blocks. In the blocks is molybdenite, in some places as flakes as if it were an original constituent of the granite, in other places concentrated along tiny seams showing that part of the granite had cooled before the mineral was deposited. The occurrence is clearly a pneumatolytic type, the molybdenite being derived from the granite itself, from a part of the intrusive mass that was still in a molten condition and giving off vapour.

The area covered by the molybdenite-bearing blocks has a diameter of about 30 feet. Only parts of the rock contain the sulphide in appreciable quantities, however, and of these only a fraction could be considered as ore of molybdenum. The occurrence indicates the possibility of a concentration of larger quantities at some place in or near the granite mass.

MANGANESE

" One of the earliest attempts, if not the first, at mining in New Brunswick, was made in connexion with the manganese deposit lying on the south bank of Tetagouche river just below the falls, at a point about 5 miles inland. Writing, in 1843, Gesner states that the deposit had already been opened, and 125 tons, valued at $1,000, shipped.

"It is now many years since mining ceased, and the tunnel leading into the old workings has caved in. The deposit appears to consist of a nearly vertical quartz vein, carrying manganite, that cuts a zone of red slates interstratified with the black Tetagouche slates. At its outcrop on the steep river bank, the vein is seen, in places, to be at least 13 feet wide, to be nearly vertical, and to be accompanied by roughly parallel narrow veins. The quartz is coarse, and white in colour; it forms most of the vein, the manganite occurring in narrow seams, and small patches or aggregates of plates, or in semi-detached, imperfect crystals or fine grains. The vein is irregular in outline, holds inclusions of country rock, and is much fractured. From information gained from nearby residents, it is believed that during mining operations solid, or nearly solid, ore was found to occur in pockets. At a point several hundred yards farther down stream, manganite in small quantities occurs in the dump of several shallow trenches sunk a short distance back in the bank" (Young, 1911, page 77).

BUILDING STONE

The sandstone of the Val Brillant formation has been quarried for building stone. At most places it is thinly bedded and not adapted for structural purposes. Heavier beds exposed about 5 miles north of Amqui have been used, however, for the Amqui church. The stone has a rather attractive, pale brownish tint due to impurities of iron which weather on the surface.

A more important building stone is the limestone of the Sayabec formation, which is hard, dense, and not quickly attacked by weathering processes. There are three quarries near lake Matapedia, one on the shore about 3 miles east of Sayabec and the other two close together, 6½ miles north of Val Brillant. Only the first is now worked. In most places throughout the region where the formation occurs the limestone is too thinly bedded to make good building stone, but at the quarries heavy beds of varying thicknesses occur. The dense character of the rock causes some difficulty in fashioning the stone to dimensional blocks. The methods of quarrying are primitive. The cover of till is removed by farming implements. The stone is blasted out and the irregular blocks chiseled by hand to the required dimensions. The larger pieces are handled by an improvised winch, the smaller by hand. The churches at Causapscal, Val Brillant, and Sayabec are made of this limestone.

Silurian limestone of the La Vieille formation was quarried near Culligan station, New Brunswick, for railroad bridge supports. Brown sandstone from near the top of the Cannes de Roche formation at Cannes de Roche was used for the Roman Catholic church at Percé.

The sandstones of the Clifton formation on the south side of Chaleur bay have been quarried for many years, particularly in the parishes of New Bandon and Caraquet. Two types of sandstone have been used. The first is an even-grained, bluish stone of fine quality, for the manufacture of grindstones and whetstones. Quarries of this type have been operated at Clifton, Stonehaven, and New Bandon, and the industry is still an important one. The second type of stone has been quarried farther east, more particularly at Grande Anse. This rock, which is of the olive-green class, has been used for churches at Caraquet, Grande Anse, and other towns, and for the post office at Bathurst. There is no production of the variety at present.

LIME

The Sayabec formation at the quarries north of Val Brillant has been burned for lime, but owing to its argillaceous character is rather a poor source. An old kiln is still standing but has not been used for some years.

The West Point limestone near the wharf at Port Daniel has been quarried for use at the pulp mill at Bathurst.

The Bonaventure formation locally contains limestone and near St. Jules de Maria the rock has been quarried and crushed for use as a fertilizer.

SILICA

The sandstone of the Val Brillant formation consists of quartz sand. The lower part of the formation contains considerable iron, a highly undesirable impurity, but the upper part is clean and as such is a potential source of pure silica.

ROAD METAL

Gravel suitable for road metal and railway ballast occurs in great abundance in the Pleistocene gravel deposits of the region and in the beach gravels along Chaleur bay. Important deposits are located near Ste. Florence, Pointe à la Garde, St. Omer, the mouth of North Grand Pabos river; and on the New Brunswick side the region from Tide Head to Nash creek has numerous similar deposits.

COAL

PORT DANIEL

At several different times work has been carried out on Middle Port Daniel river in the hopes of finding coal. The rocks in which the work was done are shales of Middle Ordovician age, which have local carbonaceous phases resembling coal. There is, of course, no coal in this area and considerable money would have been saved if the geology of the region had been understood.

ESCUMINAC

A 2¼-inch coal seam occurs in the Gaspe sandstone beds at Pirate cove near Escuminac. The occurrence is of interest on account of its Devonian age, but is of no economic importance.

STONEHAVEN

Two seams of coal can be seen in the cliffs of Pennsylvanian sandstone along the south shore of Chaleur bay near Stonehaven. The lower has a thickness of 6 inches and the upper, which lies 132 feet stratigraphically above it, has a thickness of 8 inches. A thin seam of coal has also been found near Maltempeque river, 5½ miles south of Caraquet (Hayes, 1917; Young, 1921). A seam has also been reported on Shippigan island. None of these, however, is of sufficient thickness to be profitably worked.

OIL-SHALES

The shales of the Mictaw formation on Middle Port Daniel river are oil-bearing. They were investigated for their petroleum content by A. A. Swinnerton of the Mines Branch, in the summer of 1930 (Swinnerton, 1933, page 145). He concluded that there is little or no possibility for the economic extraction of oil from them, the best yield from any of his samples being less than one gallon a ton.

MARL

In several, small, freshwater lakes of the region are deposits of white shell marl which is locally used for fertilizer. One of these, Goose lake, lies immediately to the northeast of the Gaspe branch of the Canadian National railway, about half-way between Cascapedia and New Richmond. The marl is obtained from the shallow bay at the southeastern end of the lake. It is light grey to white in colour and contains abundant shells of the genera Planorbis, Lymnaea, Physa, Pisidium, and Sphaerium. The deposit is high in lime, much of which was probably deposited by algæ.

Another deposit, which has also been worked, occurs at a small lake on the New Brunswick side of Chaleur bay, immediately south of the Balmoral road, approximately 4 miles west of Balmoral church.

CHAPTER VII

BIBLIOGRAPHY

Alcock, F. J.
(1924): Across Gaspe; Geog. Rev., April, pp. 197-214.
(1926) a: The Shickshock Mountains of Central Gaspe; Geol. Surv., Canada, Sum. Rept. 1924, pt. C, pp. 127-133.
(1926) b: Geology of Mount Serpentine, Gaspe, Quebec; Geol. Surv., Canada, Sum. Rept. 1924, pt. C, pp. 134-141.
(1926) c: Mount Albert Map-area, Quebec; Geol. Surv., Canada, Memoir 144.
(1928) a: Zinc-lead Field of Central Gaspe, Quebec; Geol. Surv., Canada, Sum. Rept. 1927, pt. C, pp. 27-46.
(1928) b: Rivers of Gaspe; Bull. Geol. Soc. Am., vol. 39, No. 2, June, pp. 403-420.
(1929): Notes on a Devonian Plant and Other Observations on a Visit to Cross Point, Gaspe; Can. Field-Nat., March, vol. XLIII, No. 3.
(1930): Zinc and Lead Deposits of Canada; Geol. Surv., Canada, Ec. Geol. Ser. No. 8.
(1931): Relationship of the Devonian and Silurian in Gaspe Peninsula and Northern New Brunswick; Trans. Roy. Soc., Canada, sec. IV, pp. 113-117.

Ami, H. M.
(1902): Equisse geologique du Canada.
(1905): Appendix to Summary Report for 1904, of L. W. Bailey; Geol. Surv., Canada, Sum. Rept. 1904, pp. 289-290, 292.

Bagg, R. M.
(1920): The Foraminifera of the Bonaventure Cherts of Gaspe; N. Y. S. M. Bull. 219-220, pp. 149-204, 6 plates.

Bailey, L. W.
(1864): Notes on the Geology and Botany of New Brunswick; Can. Nat., 2nd ser., vol. I, pp. 80-97.

Bailey, L. W., and McInnes, Wm.
(1889): Report on Explorations and Surveys in Portions of Northern New Brunswick; Geol. Surv., Canada, Rept. of Prog. 1887-88, pt. M.

Bailey, L. W.
(1889): The Mineral Resources of the Province of New Brunswick; Geol. Surv., Canada, Pub. No. 661, pt. M, Ann. Rept., vol. X.

Bailey, L. W., and McInnes, Wm.
(1893): Report on Portions of the Province of Quebec; Geol. Surv., Canada, Rept. of Prog. 1890-91, pt. M.

Bailey, L. W.
(1901): On some Geological Correlations in New Brunswick; Trans. Roy. Soc., Canada, sec. 4, ser. 2, vol. 7, pp. 147-150.
(1902): Report on the Carboniferous System of New Brunswick with Special Reference to Workable Coal; Geol. Surv., Canada, vol. XIII, pt. M.
(1910): The Geological Factors in the Present Configuration of New Brunswick; Roy. Soc., Canada, Proc. and Trans., 3rd ser., vol. III, sec. IV, p. 60.
(1920): The Paleogeography of Acadia; Trans. Roy. Soc., Canada, ser. 3, sec. 4, vol. 13, pp. 1-16.

Barrande, J., Logan, W. E., and Hall, J.
(1861): Correspondence; Am. Jour. Sci., vol. 31, pp. 210-225.

Bell, Robert
(1863): On the Superficial Geology of the Gaspe Peninsula; Can. Nat. and Geol., vol. VIII, 1st series, pp. 175-183.

Bell, W. A.
(1927): Outline of Carboniferous Stratigraphy and Geologic History of the Maritime Provinces of Canada; Trans. Roy. Soc., Canada, sec. IV, pp. 75-108.

Chalmers, R.
(1881): On the Glacial Phenomena of the Chaleur Bay Regions; Can. Nat., vol. 10, pp. 37-54.
(1885): Report on the Surface Geology of Western New Brunswick, with Special Reference to the Area Included in York and Carleton Counties; Geol. Surv., Canada, Rept. of Prog. 1882-84, pt. GG.
(1886) a: Surface Geology of Northern New Brunswick; Geol. Surv., Canada, vol. I, 1885, pp. 60-63 A.
(1886) b: Preliminary Report on the Surface Geology of New Brunswick; Geol. Surv., Canada, Ann. Rept. 1885, pt. GG, vol. I (Lists of Striæ, p. 20).
(1886) c: On the Glaciation and Pleistocene Subsidence of Northern New Brunswick and Southeastern Quebec; Trans. Roy. Soc., Canada, sec. IV, vol. 3, pp. 139-145.
(1887) a: Surface Geology of Northern New Brunswick; Geol. Surv., Canada, vol. II, 1886, pt. A, pp. 40-41.
(1887) b: Report to accompany quarter-sheet maps 3 S.E. and 3 S.W.; Surface Geology Northern New Brunswick and Southeastern Quebec; Geol. Surv., Canada, Ann. Rept. 1886, new ser., vol. II, pt. M.
(1889): Report on the Surface Geology of Northeastern New Brunswick; Geol. Surv., Canada, Ann. Rept. 1887-1888, new ser., vol. III, pt. 2, pt. N.
(1896) a: Summary of Work on the Surface Geology of Portions of New Brunswick, Nova Scotia, and Quebec; Geol. Surv., Canada, Ann. Rept. 1894, pt. A, pp. 80-88.
(1896) b: Report on the Surface Geology of Eastern New Brunswick, Northwestern Nova Scotia, and a Portion of Prince Edward Island; Geol. Surv., Canada, Ann. Rept., 1894, new ser., vol. VII, pt. M.
(1899): Report on the Surface Geology and Auriferous Deposits of Southeastern Quebec; Geol. Surv., Canada, Ann. Rept. 1897, pt. J.

Chalmers, R.
(1900): Geol. Surv., Canada, Sum. Rept. 1899, pp. 148-155.
(1905): The Raised Shorelines of the Province of New Brunswick; Proc. Miramichi Nat. Hist. Ass., No. 4, pp. 6-7.
(1906): Surface Geology of Eastern Quebec; Geol. Surv., Canada, Ann. Rept., vol. XVI, 1904, pt. A, pp. 205-263.

Clark, T. H.
(1921): A Review of the Evidence for the Taconic Revolution; Proc. Bost. Soc. Nat. Hist., vol. 36, pp. 135-163.

Clarke, John M.
(1905): Percé: a Brief Sketch of Its Geology; New York State Museum Bull. 80, p. 135.
(1907): Barachois, Bar and Tickle; New York Education Department, Secondary Education Bulletin No. 34, Science Teachers Association Proceedings, 1906, 1907, pp. 123-131.
(1908) a: Sketches of Gaspe; privately printed, 85 pp., Albany.
(1908) b: Early Devonic History of New York and Eastern North America; New York State Museum, Memoir 9.
(1910): Eruptive Contacts in the Marine Devonic Dalhousie Beds; New York State Museum, Rept. Director, pp. 125-128.
(1912): Remarkable Siluric Section on the Bay of Chaleur; New York State Museum, Rept. Director, 1911, pp. 120-126.
(1913) a: Dalhousie and the Gaspe Peninsula; Twelfth Inter. Geol. Cong., Guide Book No. 1, pt. 1.
(1913) b: The Heart of Gaspe, Sketches in the Gulf of St. Lawrence; McMillan Company, New York.
(1915) a: The Rifted Relict Mountain, a Type of Old Red Orogeny; New York State Museum Bull. 177, pp. 155-161.

(1915): The Oriskany-Pic d'Aurore Episode of the Applachian Devonic; New
b York State Museum Bull. 177, pp. 147-153.
(1915): Conceptions Regarding the American Devonian; New York State
c Museum Bull. 177, pp. 115-133.
(1920): The Microscopic Fauna of the Bonaventure Conglomerate; New York State Museum Bull. 219-220, pp. 147-148.
(1923): L'Ile Percé; New Haven, 1923.
(1924): The Geological Age of the Bonaventure Formation; New York State Museum Bull. 251, pp. 123-127.

Coleman, A. P.
(1920): Extent and Thickness of the Labrador Ice-Sheet; Bull. Geol. Soc. Am., vol. 31, pp. 319-328.
(1921): The Gaspe Peninsula. A Study of the Geology of the Region and Its Influence on the Inhabitants; Trans. Roy. Soc., Canada, Appendix A, XXXVII-LV.
(1922): Physiography and Glacial Geology of Gaspe Peninsula, Quebec; Geol. Surv., Canada, Bull. 34.

Cooney, Robert
(1832): A Compendious History of the Northern Part of the Province of New Brunswick and of the District of Gaspe in Lower Canada; Halifax, N.S., printed by Joseph Howe.

Crickmay, G. W.
(1932): Evidence of Taconic Orogeny in Matapedia Valley, Quebec; Am. Jour. Sci., vol. XXIV, Nov., pp. 368-386.

Daly, R. A.
(1901): The Physiography of Acadia; Bull. Mus. Comp. Zool., vol. XXXVIII, pp. 73-103.
(1920): A Recent Worldwide Sinking of Ocean-level; Geol. Mag., vol. LVII, pp. 246-261.

Dawson, J. W.
(1868): Acadian Geology, p. 578; Geology of Dalhousie by Professor Hind summarized by Sir William Dawson.
(1872): The Fossil Plants of the Devonian and Upper Silurian Formations of Canada; Rept. of Prog. 1871-72.
(1873): Fossil Plants of the Devonian and Upper Silurian of Canada; Rept. of Prog. 1871-72, 1872-73.
(1882): The Fossil Plants of the Erian (Devonian) and Upper Silurian Formations of Canada, Part II.

Dawson, Wm., and Penhallow, D. P.
(1888): On Nematophyton and Allied Forms from the Devonian (Erian) of Gaspe and Baie des Chaleurs; Trans. Roy. Soc., Canada, sec. IV, pp. 27-47.

Dawson, W. Bell
(1895): Report of Progress for the Year 1894 in the Survey of Tides and Currents in Canadian Waters; Trans. Roy. Soc., Canada, vol. I.

DeGeer, Gerard
(1892): On Pleistocene Changes of Level in Eastern North America; Bost. Soc. Nat. Hist., Proc., vol. XXV, pp. 454-477.

Eastman, Chas. R.
(1907): Devonic Fishes of the New York Formations; New York State Museum, Memoir 10.

Ells, R. W.
(1881): Report on the Geology of Northern New Brunswick Embracing Portions of the Counties of Restigouche, Gloucester, and Northumberland; Geol. Surv., Canada, Rept. of Prog. 1879-80.

(1883): Report on the Geology of Northern and Eastern New Brunswick and the North Side of the Bay of Chaleur; Rept. of Prog. 1880-81-82, pt. D.

(1885): Report on Explorations and Surveys in the Interior of Gaspe Peninsula, 1883; Geol. Surv., Canada, Rept. of Prog. 1882-84, pt. E.

(1905): Some Interesting Problems in New Brunswick Geology; Trans. Roy. Soc., Canada, sec. 4, ser. 2, vol. 11, pp. 21-25.

(1907): The Geology and Mineral Resources of New Brunswick; Geol. Surv., Canada, Pub. No. 983.

Fairchild, H. L.

(1918): Post-Glacial Uplift of Northern America; Bull. Geol. Soc. Am., vol. 29, p. 217.

Ganong, W. F.

(1901): Notes on the Natural History and Physiography of New Brunswick; Bull. Nat. Hist. Soc. N.B., vol. IV.

(1906): On the Physical Geography of Miscou; Nat. Hist. Soc. N.B., Bull. V, No. XXIV, pp. 447-462.

(1908): Nicolas Denys 1598-1688; The Description and Natural History of the Coast of North America (Acadia) by Nicolas Denys; tr., and ed., with a memoir of the author, collateral documents, and a reprint of the original; Toronto, The Champlain Society.

(1908): The Physical Geography of the North Shore Sand Islands; Nat. Hist. Soc. N.B., Bull. VI, No. XXVI, pp. 22-29.

(1910): New Relation of Gaspesia, with the Customs and Religion of the Gaspesian Indians, by Father Christien le Clercq; Translated and edited with a reprint of the original. The Champlain Society.

(1913): Further Data upon the Rate of Recession of the Coast Line of New Brunswick; Nat. Hist. Soc. N.B., Bull. VII, No. XXXI, pp. 1-5.

Gesner, A.

(1843): Report on the Geological Survey of the Province of New Brunswick; Saint John.

(1847): New Brunswick with Notes for Emigrants. London: Simmonds and Ward.

Goldthwaite, J. W.

(1911): Raised Beaches of Southern Quebec; Geol. Surv., Canada, Sum. Rept. 1910.

(1912): Records of Post-glacial Changes of Level in Quebec and New Brunswick; Geol. Surv., Canada, Sum. Rept. 1911, pp. 296-302.

(1913) a: Following the Trail of Ice Sheet and Valley Glacier on the Presidential Range; Appalachian, May, vol. xiii, pp. 1-23.

(1913) b: Physiography of Eastern Quebec and the Maritime Provinces; Twelfth Inter. Geol. Cong., Guide Book No. 1, pt. I.

(1913) c: Chaleur Bay; Physiographic Note; Twelfth Inter. Geol. Cong., Guide Book No. 1, pt. I, pp. 119-120.

(1914): Supposed Evidence of Subsidence of the Coast of New Brunswick Within Modern Time; Geol. Surv., Canada, Mus. Bull. No. 2, pp. 61-66.

(1924): Physiography of Nova Scotia; Geol. Surv., Canada, Memoir 140.

Hardman, J. E.

(1908): A New Iron Ore Field in the Province of New Brunswick; Jour. Can. Min. Inst., vol. II, pp. 156-164.

Harrington, B. J.

(1883): Life of Sir William Logan, Bt.; (Dawson Brothers, Montreal).

Harvie, Robert

(1914): Geology of Orford Map-area, and the Southeastern Part of the Serpentine Belt, Potton Township, Quebec; Geol. Surv., Canada, Sum. Rept. 1913, pp. 212-216.

(1921): Asbestos: Weir Township, Bonaventure County, Quebec; Geol. Surv., Canada, Sum. Rept. 1920, pt. D, page 84.

Hayes, A. O.

(1917): Coal Prospect at Maltempec, Gloucester County, N.B.; Geol. Surv., Canada, Sum. Rept. 1916, pp. 269-270.

Henwood, W. J.
(1842): Notes to Accompany a Series of Specimens from Chaleur Bay and the Restigouche River in New Brunswick; Proc. Geol. Soc. Lond., vol. 13, pp. 454-6.

Hind, H. Y.
(1865): Preliminary Report on the Geology of New Brunswick. Fredericton.

Honeyman, D.
(1875): A Month Among the Geological Formations of New Brunswick; Trans. Nova Scotia Inst. Nat. Hist., vol. IV, pp. 5-21.

Howard, W. V.
(1926): Devonian Volcanic Rocks near Dalhousie, New Brunswick; Bull. Geol. Soc. Am., vol. 37, pp. 475-496 (Sept. 30).

Hurst, M. E.
(1927): Arsenic-bearing Deposits of Canada; Geol. Surv., Canada, Econ. Geol. Ser. No. 4.

Hussakof, L.
(1912): Notes on Devonic Fishes from Scauminac Bay; New York State Museum, Rept. Director.

Johnston, Douglas Wilson
(1919): Shore Processes and Shoreline Development; New York.
(1925): The New England-Acadian Shoreline; New York.

Jones, I. W.
(1930): The Berry Mountain Map-area, Gaspe; Report of the Minister of Quebec, 1929-30, pt. D, pp. 1-40.
(1931): The Lesseps Area, Gaspe Peninsula; Rept. Minister of Mines, Quebec, 1930-31, pt. D, pp. 195-226.
(1932): The Bonnecamp Map-area, Gaspe Peninsula; Rept. Minister of Mines, Quebec, 1931-32, pt. C, pp. 43-75.

Kindle, E. M.
(1930): Stratigraphic Relations of the Upper Devonian Beds and the Bonaventure Conglomerate, at Escuminac Bay, Que.; Geol. Surv., Canada, Sum. Rept. 1928, pt. C, pp. 83-89.

Langlier, J. C.
(1884): Esquisse sur la Gaspesie; Mercier and Cie, Proprietaires du "Quotidien," Levis.

Logan, W. E.
(1846): On the Geology of the Chat and Cascapedia Rivers, Gaspe, and Part of Chaleur Bay; Rept. of Prog. 1844, and appendix; Geological Sections on Chaleur Bay and Coast of Gaspe.
(1863): Geology of Canada; Chap XVI.

Low, A. P.
(1885): Report on Explorations and Surveys in the Interior of Gaspe Peninsula, 1883; Geol. Surv., Canada, Rept. of Prog. 1882-84, pt. F.

MacWhirter, Margaret G.
(1919): Treasure Trove in Gaspe and the Baie du Chaleur, Quebec; (The Telegraph Printing Co.).

Miller, W. J.
(1910): Exfoliation Domes in Warren County, New York, New York State Museum, Rept. 64, vol. 1, pp. 187-194.

Murray, A.
(1846): On the Geology of the Bonaventure River; Rept. of Prog. 1844, p. 67.
(1847): On the Topography and Geology of the Matane, Ste. Anne, and St. John Rivers, Gaspe; Geol. Surv., Canada, Rept. of Prog. 1845-6.

Paisley, C. H.
(1875): On the Post-Pliocene Formation near Bathurst, New Brunswick; Can. Nat., vol. 7 (N.S.), pp. 41-43 and pp. 268-270.
(1875): Notes on the Marine Clays Occurring at the Railway Cutting on the Left Bank of the Tetagouche River; Can. Nat., vol. 7 (N.S.), pp. 41-43.

Parks, W. A.
(1914): Report on the Building and Ornamental Stones of Canada; vol. II, Maritime Provinces. Mines Branch, Dept. of Mines, Canada.
(1930): Report on the Oil and Gas Resources of the Province of Quebec; Ann. Rept. Quebec Bureau of Mines, 1929.
(1931): Geology of the Gaspe Peninsula; Bull. Geol. Soc. Am., vol. 42, No. 3, Sept., pp. 785-800.

Patten, Wm.
(1912): The Evolution of the Vertebrates and Their Kin; p. 368.

Pelland, Alfred
(1914): La Gaspesie, Esquisse Historique, ses ressources, ses progres et son avenir; Dept. of Colonization, Mines, and Fisheries, Quebec.

Penhallow, D. P.
(1889): Notes on Devonian Plants; Trans. Roy. Soc., Canada, sec. IV, vol. 6, pp. 19-30.

Raymond, P. E.
(1913): Quebec and Vicinity; Geol. Surv., Canada, Guide Book No. 1, pt. I, pp. 25-48.

Richardson, J.
(1858): On the Topography and Geology of Magdalen River and Part of the Gaspe Peninsula from Magdalen River to Gaspe Bay, and to Lake St. John; Geol. Surv., Canada, Rept. of Prog. 1857, pp. 29-93.
(1859): On a Portion of Gaspe Peninsula including an Examination of the Coast from Marsouin River to Rivière du Loup; Geol. Surv., Canada, Rept. of Prog. 1858, pp. 105-169.

Ries, Heinrich
(1912): Report on Progress of Investigation of Clay Resources; Geol. Surv., Canada, Sum. Rept. 1911, p. 239.

Schuchert, C.
(1925): Significance of Taconic Orogeny; Bull. Geol. Soc. Am., vol. 36, pp. 342-350.
Schuchert, C., and Dart, J. D.
(1926): Stratigraphy of the Port Daniel Gascons Area of Southeastern Quebec; Geol. Surv., Canada, Mus. Bull. No. 44, pp. 35-58.

Schuchert, C.
(1927): Winters in the Upper Devonian of New York and Acadia; Am. Jour. Sci., vol. XIII, pp. 126-132.

Schuchert, C., and Cooper, G. A.
(1930): Upper Ordovician and Lower Devonian Stratigraphy and Palæontology of Percé, Que.; Am. Jour. Sci (5), vol. 20, pp. 161-176, 265-288, 365-392.

Schuchert, C.
(1930): Orogenic Times of the Northern Appalachians; Bull. Geol. Soc. Am., vol. 41, pp. 701-724, Dec.

Stead, Geoffrey
(1903): Notes on Surface Geology of New Brunswick; Nat. Hist. Soc. New Brunswick, Bull. V, No. XXI, pp. 5-13.

Swinnerton, A. A.
(1933): Report on Oil Shales from New Glasgow Area, Pictou County, Nova Scotia, and from Port Daniel, Bonaventure County, Quebec; Mines Branch, Dept. of Mines, Canada. Investigations of Fuels and Fuel Testing 1930 and 1931.

Termier, P.
(1914): La region appalachienne du Canada (translation); New York State Museum Bull. 173, pp. 75-79.

Traquair, R. H.
(1890): Notes on the Devonian Fishes of Scauminac Bay and Campbellton in Canada; Geol. Mag. N.S., Dec. iii, vol. VII, pp. 15-22, 55-60.
(1914): Fishes of the Old Red Sandstone; Mon. Pal. Soc.

Twenhofel, W. H.
(1912): Physiography of Newfoundland; Can. Jour. Sci., Jan.
(1928): Geology of Anticosti Island; Geol. Surv., Canada, Memoir 154.

Ulrich, E. O., and Schuchert, C.
(1902): Palæozoic Seas and Barriers in Eastern North America; New York Museum Bull. 52, pp. 633-663.

Whiteaves, J. F.
(1880): On a New Species of Pterichthys, Allied to Botriolepis Ornata Eichwald, from the Devonian Rocks of the North Side of the Baie des Chaleurs; Am. Jour. Sci., vol. V, pp. 132-136.
(1881): On some Fossil Fishes, Crustacea and Mollusca from the Devonian Rocks at Campbellton, N.B., with Descriptions of Five New Species; Can. Nat., new ser., vol. 10, pp. 93-101.
(1888): Illustrations of the Fossil Fishes of the Devonian Rocks of Canada; Trans. Roy. Soc., Canada, vol. 6, sec. 4, pt. II, pp. 77-96 (Scauminac Bay and Campbellton); 1886, vol. IV, pt. I, pp. 101-110 (Scauminac Bay).

Williams, H. S.
(1910): Age of the Gaspe Sandstone, with comments by J. M. Clarke and C. Schuchert; Bull. G.S.A., vol. 20, pp. 688-689.
(1916): The Fauna of the Chapman Sandstone of Maine; U.S.G.S., p. 89.

Woodward, A. Smith
(1892): On the Lower Devonian Fish Fauna of Campbellton, New Brunswick; Geol. Mag., pp. 1-6.
(1898): Outlines of Vertebrate Palæontology.

Young, G. A.
(1910): Bathurst District, New Brunswick; Geol. Surv., Canada, Sum. Rept. 1909, pp. 217-224.
(1911): Bathurst District, New Brunswick; Geol. Surv., Canada, Memoir No. 18-E.
(1913): Annotated Guide, Nipisiguit Junction to Bathurst Mines; Twelfth Inter. Geol. Cong., Guide Book No. 1, pt. I, pp. 125-129.
(1921): Coal Seams of Gloucester County, N.B.; Geol. Surv., Canada, Sum. Rept. 1920, pt. E, pp. 1-5.

INDEX