CANADA
DEPARTMENT OF MINES AND RESOURCES

MINES AND GEOLOGY BRANCH
BUREAU OF GEOLOGY AND TOPOGRAPHY

GEOLOGICAL SURVEY

MEMOIR 227

# JACQUET RIVER AND TETAGOUCHE RIVER MAP-AREAS, NEW BRUNSWICK

BY

F. J. Alcock



OTTAWA
EDMOND CLOUTIER
PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
1941

*Price, 25 cents*

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## Illustrations

# Jacquet River and Tetagouche River Map-areas, New Brunswick

## CHAPTER I

## INTRODUCTION

### GENERAL STATEMENT

Jacquet River and Tetagouche River map-areas are south of Chaleur Bay in northern New Brunswick, between latitudes 47° 30′ and 48° 00′ and longitudes 65° 30′ and 66° 30′. The map-areas are of equal size and Jacquet River area adjoins Tetagouche River area on the west. The town of Bathurst is in the eastern part of Tetagouche River area, and Dalhousie in the northern part of Jacquet River area. About half of the combined area lies in Restigouche county; a small part at its southwestern border is in Northumberland county; the remainder forms part of Gloucester county. The drainage of the whole area is to Chaleur Bay. The two main rivers are the Jacquet and the Tetagouche.

The region shows widespread signs of mineralization, and during the past few years has been prospected to a considerable extent. The only geological maps showing any degree of detail that have been available up to the present time cover merely a narrow zone along the coast comprising the settled part of the region. As a result, there has been a considerable demand for more geological information concerning a wider area, and the present report and accompanying maps are the result of field work carried out in response to this demand.

### PREVIOUS WORK

Early geological work was carried out by R. W. Ells of the Geological Survey. In 1879 he traversed Nipisiguit, Upsalquitch, Restigouche, and Tetagouche Rivers, and, in addition, studied the rocks of Dalhousie region. The following year he mapped in a reconnaissance way the Jacquet River region and carried out surveys in adjacent parts of New Brunswick and in Gaspe. His description of the geology of the region is included in Part D of the Report of Progress for 1879-80. His geological surveys were later issued as maps on a scale of 4 miles to 1 inch. The Jacquet-Tetagouche area included parts of four such regional sheets, Nos. 3 SW., 3 SE., 2 NW., and 2 NE.

In 1908 and 1909 G. A. Young mapped topographically and geologically an area of 315 square miles surrounding the town of Bathurst. This work resulted in the publication of a Geological Survey memoir, No. 18-E, Bathurst District, New Brunswick, accompanied by a map on a scale of 1 mile to 1 inch.

During the seasons 1928 to 1931, inclusive, the writer studied the geology of a belt of country surrounding Chaleur Bay, and in 1935 a report, Memoir 183, Geology of Chaleur Bay Region, was published, accompanied by a geological map on a scale of 4 miles to 1 inch. The field work for this project had been so carried out that for the present compilation of the Jacquet-Tetagouche map very little of the coastal part of the area was re-examined. There remained to be surveyed, however, about 700 square miles, consisting chiefly of wooded country lying south and west of the settled belt, and this part of the area was mapped in the field seasons of 1938 and 1939.

## FIELD WORK

Owing to the lack of a good base map all the geological work carried out in the region had to be accompanied by topographic surveying. In preparing the base for the present geological compilation, use was made of all available topographic information. The primary control consists of points fixed by the Geodetic Survey to which as many as possible of the Geological Survey traverses were tied. These fixed points include stations at Blue Mountain and Middlebrook in the western part of the area, one at Upsalquitch tower about 2½ miles south of the area, and certain others along the coast, such as church spires, which had been cut in by the Geodetic Survey from their triangulation stations.

In 1908 and 1909 G. A. Young carried out a transit and chain survey along a section of the coastal railway as a control for his Bathurst map; secondary traverse lines were run by transit and stadia or plane-table and stadia over the roads and along the principal streams. In 1926 and 1927 H. N. Spence, of the Topographical Division of the Geological Survey, carried out transit control surveys along some of the main roads in the coastal part of the region. In 1938 the writer's party ran transit and stadia surveys along roads in the region of Nigadu, Millstream, and Tetagouche Rivers.

The intervening country between such surveys was mapped by traverses carried out largely in connection with the geological mapping. The methods employed consisted of: cyclometer and compass surveys along roads in the settled parts of the coastal zone; telemeter and compass surveys along certain streams and portage roads; chain and compass surveys along streams, wood-roads, and trails, and pace and compass traverses along headwater tributaries and through wooded country. Each traverse was tied in as many places as possible to the control surveys, and also to the provincial block and range lines wherever these could be located. In most places these lines are now grown over, but blazed trees and a rare post were locally picked up where the lines cross streams and old portage roads. Survey plans of these lines supplied by the provincial surveys department at Fredericton were used in checking the geological surveys and in filling in the headwater drainage of certain local areas.

The basis for the geological mapping is the succession of formations as revealed by certain sections along the coast and the lower parts of some of the rivers. These sections were studied in detail in the earlier work of 1928-31. In the wooded country back of the settled belt outcrops, except along the streams, are scarce, and what exposures there are have to be interpreted in the light of the coastal sequence. As a result, the work inland lacks the detail given for much of the settled country.

## ACKNOWLEDGMENTS

In his work along the coastal part of the area, the writer was assisted in 1928 by H. Johnson; in 1929 by G. W. Crickmay, H. Johnson, R. O. Monahan, L. C. Robinson, and J. S. Murray; in 1931 by R. C. Hart. In 1938, D. S. Estabrooks, assisted by D. O. Jenkins and T. E. Lunney, ran the control transit surveys, and C. S. Clements, A. C. MacCallum, and H. F. Belding assisted in the geological and topographical mapping. In 1939 C. S. Clements, H. F. Belding, A. J. Ring, and S. Sutherland acted as field assistants. During these last two seasons the party had camps at intervals along the various portage roads of the area and moving was carried out by team and wagon.

The writer wishes to thank Dr. W. J. Wright and Mr. J. H. Ramsay of the Department of Lands and Mines at Fredericton for their courtesy in supplying all available plans connected with the region. He is under obligation also to officials of the International Power and Paper Company of New Brunswick, particularly Mr. L. S. Webb of Campbellton, for copies of the company's map of the region and for other courtesies. Mr. Hans Lundberg of Hans Lundberg, Limited, supplied information about the exploration that company carried out, and the officials of the Tetagouche Exploration, Limited, supplied surveys and information about their property. Thanks are also due to local fire-wardens, game guardians, and other individuals in the region for help of various kinds, which aided in the carrying on of the work.

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# CHAPTER II

## GENERAL CHARACTER OF THE REGION

### TOPOGRAPHY

Viewed from an outside elevated point, as, for example, the summit of Tracadigash Mountain at Carleton, on the north side of Chaleur Bay, this part of New Brunswick appears as rather a low region with a skyline as smooth and regular as if it had been ruled with a straight-edge. From elevated points within the area more detail can be observed, but essentially the same picture meets the eye, flat-topped, interfluvial areas or low ridges succeeding each other with only slight irregularities in the skyline. This upland surface rises gradually from the coast until in the middle of the area its average elevation is about 1,200 feet. Blue Mountain, which rises above the surrounding region, stands at 1,733 feet. From it one can see the surface falling off to Chaleur Bay, and in the opposite direction a succession of rounded, wooded ridges. The highest part of the general upland surface in the area is in the southwest corner. Middlebrook observation tower stands on a flat-topped summit 1,674 feet high, and adjacent tops have about the same elevation. Upsalquitch tower, just south of the southwest border of the Jacquet River shed, is on a flat summit with a height of 2,149 feet, and from it one sees to the southwest still higher country and can distinguish the broad, flat-topped mass carrying Mount Carleton, 2,689·7 feet high, the highest point in the province.

This elevated region is part of what is commonly referred to as the central highlands of New Brunswick. Within the area its surface, flat or gently rolling, as distinguished from that marked by ridges and broad depressions, depends to a large extent on the character of the bedrock. The depressions and the flat-topped, interfluvial areas are commonly developed on sedimentary rocks, whereas many of the ridges are underlain by igneous rocks. The surface is evidently an erosional one of great maturity.

The valleys are deeply entrenched below this upland surface. The valley bottoms are narrow and the valley sides steep. The streams are uniformly swift and most of them show falls, cascades, and rapids. In places they flow through narrow rock gorges, above which the steep valley sides may rise for several hundreds of feet. The change from the gentle slopes of the upland surface to the steep sides of the valleys is in general so abrupt that where one can obtain a view over the region, as in the settled region of the coastal belt or from an observation tower or bare summit in the wooded country, it is unusual to see any indication of the deeply incised lower parts of the valleys. The valleys are clearly in a state of topographic youth, evidently rejuvenated as a result of uplift. In following a stream to its headwaters one finally passes from the part marked by canyons and rapids into a broad depression in which the stream flows sluggishly through a thicket of alders, evidently the old valley of the previous cycle. Side streams commonly show within short distances this change from the mature topography of the upland surface to the youthful valleys of the present cycle.

The portage roads throughout the region more or less parallel the main streams, but for the most part are situated far enough away to take advantage of the flat, interfluvial country. As a result, the only steep grades that are commonly encountered are where the roads cross tributary valleys. The road up the Jacquet is an exception to this rule. Above the mouth of Bighole Brook it follows the valley, taking advantage of what local terraced stretches there are and crossing the river at two places to avoid steep valley slopes.

The southeastern corner of the area lying beyond Nipisiguit River presents somewhat different features from the rest of the area. It is a low, flat-lying region underlain by horizontal or gently dipping beds of Carboniferous rocks, and is thus part of the great Carboniferous lowland that occupies all of northeastern New Brunswick. It rises gently from the coast and its highest point in the area is about 250 feet.

## DRAINAGE

The west-central part of the area is the rising ground of a number of rivers that radiate out in all directions. The Charlo, Benjamin, Louizon, Jacquet, Nigadu, Millstream, Tetagouche, and Middle fan out to the northeast and empty into Chaleur Bay. In the southwest corner of the area the drainage is to the Upsalquitch, whose waters reach the same bay by way of the Restigouche. In the southern part of the area Fortymile Brook and some other streams drain to the Nipisiguit, whose lower part is included in Tetagouche map-area. The rivers are all short and all have steep gradients. Their volumes vary greatly at different times of the year. In the spring with the melting of the snow and occasionally after long heavy rains they are torrential; in dry seasons the flow falls off so much that it is not difficult to wade almost anywhere along them.

The North Charlo and the South Charlo empty into the same lagoon. The North Charlo has the wider valley and more gentle valley slopes; the South charlo for much of its course flows through a deep-cut gorge with rock walls ranging up to 400 feet in height. At one place, about 12 miles from the coast, the sharply V-shaped valley narrows down to a gorge about 4 feet wide, through which the river cascades over rock falls. A portage road parallel to the South Charlo is the regular route to the country drained by the Southeast Upsalquitch.

Benjamin River is made up of two branches, which unite about 2 miles from the coast. The headwaters of both rise very close to the South Charlo. As in the case of the Charlo, the South Branch has a valley marked by steeper slopes and more rock cliffs than the North Branch. A portage road follows the course of the South Branch and a side trail branches off to Blue Mountain. The route more generally used to that station, however, is by way of the Louizon portage from Lorne settlement.

Jacquet River drains the middle part of the area. It rises in a belt of volcanic rocks whose mature surface has broad depressions in which are a number of lakes and ponds. The main valley near where it is crossed by the Charlo portage is a broad flat occupied by a slough. A dam where the valley narrows formerly flooded this flat, but with the washing out of the dam the lake was drained. Below this old dam the river has cut its valley into bedrock, giving rise to narrow gorges and almost continuous outcrops. About $1\frac{1}{2}$ miles above the mouth of Rocky Brook the river tumbles over several falls in a deep, narrow canyon. Rocky Brook and a tributary nearly opposite, Rocky Gulch, show almost continuous rocky gorges with cliffs several hundred feet high. McNair Brook and Lower McNair are also both deeply entrenched in narrow, deep-cut valleys marked by local narrow gorges cut in volcanic rocks. The Southwest Branch and the South Branch of Jacquet both flow in valleys deeply incised in sedimentary strata. The former is marked by two falls, and both are lined by almost continuous rock cliffs. The lower parts of other tributaries such as Ramsay, Twomile, Bighole, Lake Branch, and other brooks also show deep-cut trenches in their lower parts, whereas their headwater tributaries flow gently on the broad depressions of the upland surface.

The triangular-shaped area between the Jacquet and the Tetagouche is drained by a number of short streams, among which the chief are Belledune, Elmtree, Nigadu, and Millstream Rivers and Grant and Peters Brooks. These are all swift, flow in youthful valleys, and are in places marked by falls and rapids.

The Tetagouche is the longest river lying wholly in the area. Like the other streams, it is deeply entrenched and for long distances along its course shows rock cliffs rising to 100 feet or more in height. At one gorge it falls about 50 feet and a dam and power plant here at one time supplied the town of Bathurst with electricity. In part of its upper course the valley is broad, and there the river widens at three places into Lower, Middle, and Upper Lakes, also known locally as First, Second, and Third Lakes, respectively. A few exposures of Carboniferous rocks in this part of the valley suggest that in Carboniferous time a valley that existed here became filled with sediments and that the present valley is the result of the eroding out of much of these softer rocks.

## THE COAST

In the eastern half of the area the shore is low, sand beaches with banks only a few feet high alternating with rocky stretches marked by minor points and small, open bays. In the western half a larger proportion of the shoreline is bordered by rock cliffs. East of the mouth of Jacquet River and at Charlo are two such zones, where for considerable distances cut banks and vertical rock cliffs are continuous for long, straight stretches. At New Mills and Black Point the rocky shores are more irregular, due to the association of hard volcanic rocks with softer sediments.

Many of the streams empty into lagoons formed by baymouth bars. The Eel, the Charlo, the Jacquet, the Millstream, and Grant Brook all show examples of such bars. The one in front of the mouth of Millstream River and Grant Brook is about 2 miles long and averages about 250 feet in width. It continues southward as a broad sand beach to Youghall where it terminates as a sand spit. This spit and another from the east terminating at Alston Point enclose Bathurst Harbour, an area of about 5 square miles into which empty Tetagouche, Middle, Little, and Nipisiguit Rivers.

Belledune Point is a good example of a cuspate bar. It is a triangular area with a base about a mile long composed of sand, and encloses an irregular, shallow, salt water pond.

The coastal features of the area, as those elsewhere along Chaleur Bay and the Gulf of St. Lawrence in general, are forms characteristic of a submerged topography in a youthful or adolescent stage of development.

## POPULATION AND INDUSTRIES

The settled belt along the coast varies considerably in width. In places, as near the mouth of Benjamin River, the wooded country comes almost to the coast highway; in Tetagouche River region, on the other hand, the cultivated area extends back for a distance of some 12 miles. Most of the people are engaged in agriculture, raising mainly hay, oats, potatoes, and dairy products. The next major industry is the cutting of pulpwood, timber, and wood for fuel. There is a large pulp-mill at Bathurst and another at Dalhousie. A certain amount of fishing is carried on and some fox and mink ranching. A mill for the production of limestone fertilizer gives employment to a number of people at Elmtree.

The region has special attractions for the tourist and for the sportsman interested in fly-fishing or hunting. The splendid beach at Youghall draws many summer visitors, as do also to a less extent those at Jacquet River, New Mills, and Charlo. The Jacquet and Nipisiguit are both salmon streams, and good trout fishing can be had at many places throughout the area. A fish hatchery is maintained on the South Charlo where large quantities of salmon and trout fry are raised for planting in various lakes and streams.

## CHAPTER III

## GENERAL GEOLOGY

The oldest rocks of the region that have been definitely dated by fossil evidence are of Middle Ordovician age. Typically developed along Tetagouche River, they consist chiefly of argillaceous sediments altered to slates and locally to schists and gneisses; minor amounts of volcanic rocks are associated with them. In the southern part of the area a complex of rocks that are associated with similar slates appears to be of the same age. It consists of volcanic rocks with subordinate amounts of sediments, all more or less metamorphosed and in places schistose or gneissic. The rocks of the group are in most places readily distinguished from the Silurian and later rocks by their greater degree of metamorphism. Some of the earlier workers regarded much of this complex as Precambrian.

Silurian strata are exposed in several belts in the coastal region, the type section being along the shore east of Jacquet River. The rocks are nearly all sediments, commonly fossiliferous, but volcanic members occur at two points. A much larger part of the area is covered by Lower Devonian rocks, consisting of interbedded sedimentary and volcanic rocks, the type section for which is along the coast at Dalhousie. For mapping purposes a division of these rocks into three units was found useful. In the first, sediments predominate; in the other two, volcanic rocks are more abundant than the sediments. In division number two the volcanic members are mostly intermediate to basic in composition, whereas in the third the volcanic rocks are mainly acidic. The rocks up to and including those of Lower Devonian age are intruded by dykes and masses of granite and quartz-feldspar porphyry.

Along the shore west of Dalhousie are outcrops of sandstone and conglomerate belonging to the Middle Devonian Gaspe sandstone formation. Carboniferous rocks in the area belong to two formations, the Bonaventure and the Bathurst. The former is made up of flat-lying, red conglomerate and sandstone beds covering areas along the Chaleur Bay coast and a few patches of country inland. The latter consists of buff to reddish sandstones, which cover the eastern part of the area. The unconsolidated deposits of the region consist of glacial drift, stratified gravels, and post-Glacial clays, sands, and river alluvium.

*Table of Formations*

| | | | |
|---|---|---|---|
| Cenozoic | Quaternary | Recent | Alluvium<br>Marine clays |
| | | Pleistocene | Stratified gravels<br>Glacial drift |
| Palæozoic | Carboniferous | Pennsylvanian | Bathurst formation |
| | | Pennsylvanian (?) | Bonaventure formation |
| | Devonian | Middle Devonian | Gaspe formation |
| | | | Granite; porphyry |
| | | Lower Devonian | Dalhousie formation |
| | Silurian | Niagaran | Chaleur Bay series |
| | Ordovician | Middle Ordovician | Tetagouche series |

# DESCRIPTION OF FORMATIONS

## ORDOVICIAN

### *Tetagouche Series*

The Tetagouche series is typically developed along Tetagouche River. It is made up mainly of cleaved argillaceous strata with associated quartzite, limestone, conglomerate, and volcanic rocks of both flow and fragmental origin. Fossils have been found in only one locality and these are graptolites, which indicate a Middle Ordovician age. The deformation that the rocks have undergone and the lack of horizon markers render it impossible to definitely establish the succession of strata within the series.

Along the course of the Tetagouche outcrops are numerous, and in certain gorge-like stretches almost continuous. The rocks are dominantly slates, mostly dark grey, but including black, red, and greenish grey varieties. They grade into dense, hard, quartzitic argillites, and in places include bands and lenses of limestone. Some of the black slates present a lustrous appearance. The red varieties vary from soft, slaty material to hard, massive, cherty argillite. Pebbles of this brilliant red rock are common in the Silurian and Devonian conglomerates of northern New Brunswick and afford evidence of a period of deformation in post-Tetagouche, pre-Middle Silurian time. These red rocks are particularly well exposed immediately below the main falls on the Tetagouche and on the south bank of the same stream a short distance below Little Narrows.

Limestone zones are associated with dark slates at several places along the Tetagouche. One band outcrops on the southeast bank near the DeGrace road crossing. It is about 100 feet wide, strikes northeasterly, and crosses the stream about a quarter mile to the northeast. Immediately below Big Narrows similar limestone, striking northeast, crosses the river and about half a mile farther downstream another exposure is to be seen. Similar beds outcrop north of the Tetagouche portage on the summit of the upland surface about half a mile west of Armstrong Brook crossing and near an old lime kiln. The limestone in all these exposures is white to bluish, massive, and cut by numerous carbonate veins. In places it shows a good colour banding. The uniform character of the rock suggests that the various exposures belong to the same horizon repeated by folding. An outcrop of similar rock occurs north of Lower Tetagouche Lake, on Arleau Brook, a short distance from its mouth.

Coarser clastic beds associated with the slates include dark sandstones with rounded quartz grains in an argillitic matrix, feldspathic sandstones, in places, at least, of tuffaceous origin, and, more rarely, conglomerate. One band of conglomerate exposed on the west bank of the river about half a mile upstream from the railroad bridge contains well-rounded granite boulders.

Associated with the slates are greenstones and greenish schists, the latter apparently representing altered tuffs. About 1½ miles below the mouth of the South Branch the typical dark slates pass over into greenish schists and slates, and from there westward volcanic and schistose rocks predominate. The sediments are locally cut by dark intrusive rocks. Little Narrows is a gorge where the river has cut through a northeast-trending dyke.

On Armstrong Brook, a tributary of the Tetagouche, the rocks are mainly dark grey to black slates and argillitic quartzites locally showing good colour banding, which is for the most part highly contorted. In the upper part of the same brook, greenish grey, schistose rocks, which appear to be altered tuffs, are associated with the typical slates, and at one place about half a mile below the main falls on the stream limestone accompanies slate.

Along Middle River the same general assemblage of rocks is to be seen. The chief types are dark slates, locally greenish, and banded argillites with limy beds and lenses. Similar slates and quartzites with minor amounts of volcanic rocks occur on Little River.

On Grant Brook the rocks are black slates, hard, black, well-bedded, quartzitic argillites, fissile chlorite schists, and massive volcanic rocks. About 4 miles above the railway bridge a band of bright red argillite crosses the stream. The upper part of Millstream River and its main tributary, Rocky Brook, show rocks apparently similar to those along the Tetagouche. Sediments, including grey to black slates and local bands of limy argillites, predominate. Associated with these are dark, dense, volcanic rocks and intrusives. Near the dam on Millstream River, about 15 miles from the coast, the sediments change to shales and slates similar to the Devonian strata along the upper branches of the Nigadu.

As previously mentioned, fossils in rocks mapped as Tetagouche have been found at only one locality. This is on the north side of the Tetagouche above the railroad bridge. The first collection was made here by Ells, and later Bailey made a collection, which was examined by Ami. Ami's list is as follows:

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

A Brachiopod, *Leptobolus* sp., was found with the graptolites.

Concerning this fauna Ami states (1905, pages 289, 290): "These black and at times pyritiferous shales appear to be synchronous or homotaxial with the shales of Norman Kiln, near Albany, N.Y.; of the City of Quebec; of the north shore of the Island of Orlean; of the Marsouin river and of numerous other localities in the Gaspe peninsula." He also states:

"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* Hall with branch of *Dicranograptus*
*Cryptograptus tricornis* Carruthers
*Diplograptus aculeatus* Lapworth, or *D. whitfieldi* Hall
*Diplograptus* cf. *D. whitfieldi* Hall
*Diplograptus* allied to *quadrimucronatus* Hall
*Diplograptus foliaceus* Murchison
*Diplograptus* sp."

A collection made in 1929 by the writer was forwarded to Rudolf Ruedemann, who determined the following species:

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

Ruedemann states that this fauna is undoubtedly of Normanskill age.

A belt of altered sediments bordering the western margin of the Nipisiguit River granite mass outcrop in Middle River for a distance of about 4 miles. These altered rocks apparently represent members of the Tetagouche series metamorphosed by contact action of the granite. Outcrops occur along the river, the road that parallels it, and in the adjacent fields. The rocks for the most part are dark, dense, and hard, and may best be described as hornfels, but they pass into biotite schists and in places they have a banded gneissic appearance. They are traversed by quartz veins and at several places are cut by aplite and granite dykes. In thin section the rocks are seen to consist of a mass of secondary minerals, mainly biotite, quartz, muscovite, and pyrite. The biotite, which is very abundant, is reddish brown and consists of small crystals with a common orientation. The muscovite crystals, which are much scarcer, commonly lie at angles to this general direction. The biotite occurs along certain lines or bands and also irregularly scattered through the rock.

### *Volcanic and Metamorphic Complex*

The southern part of the area is underlain by a complex of volcanic and metamorphic rocks that may include members of more than one age. Good exposures occur along several of the headwater branches of the Tetagouche, but elsewhere outcrops are few and relationships between rock types are difficult to determine. On the main Tetagouche and its tributary Armstrong Brook the Tetagouche slates and their associated volcanic rocks appear to pass over, as has already been mentioned, into a dominantly volcanic complex. In the latter are slates of the Tetagouche type, and it would appear as if all may belong to the same series. Certain members are, however, highly metamorphosed, and for this reason early workers regarded them as Precambrian. All that can be definitely said is that the complex is pre-Silurian. It is possible that certain volcanic rocks that have been mapped with the complex may be infolded Devonian varieties, but if such occur they are very subordinate in amount.

The best sections of these rocks are exposed along the main Tetagouche and its chief tributary, the South Branch. On the main river between the mouth of Armstrong Brook and that of the South Branch the dark slates and limestone have associated with them banded, greenish rocks and zones of sericitic schist, which apparently represent volcanic tuffs. In thin section the massive green rocks are found to consist of a mass of secondary minerals, including much carbonate. They pass into chlorite schists that locally contain many veins of quartz, which for the most part follow the planes of schistosity. Approaching the mouth of the South Branch grey, sericitic rocks become the most abundant varieties. These vary from hard, cherty types containing but little sericite to highly schistose types containing much. Many show crystals of feldspar, giving them a pseudoporphyritic appearance. In thin section they are seen to consist largely of quartz and sericite with large, irregularly shaped crystals of orthoclase and plagioclase. Above the mouth of the South Branch similar sericitic and chloritic schists continue along the main river, but near the Rocky Turn dam, well-banded, dark green varieties like the massive rocks farther down stream again outcrop, some bands carrying considerable amounts of epidote.

Numerous exposures of thinly banded and schistose rocks occur along the South Branch of the Tetagouche and its tributaries. Above the dam at the Keepover the rocks along the stream right to its headwaters are grey to greenish schists locally showing colour banding, dark, chloritic bands alternating with light-coloured, sericitic ones, and occasional black, slaty members. Carbonate-bearing quartz veins and local small dykes and stringers of pegmatite cut the rocks. Similar grey rocks with feldspar and quartz crystals developed as metacrysts also occur along Wildcat Brook and along the portage road from the Keepover to Big Moose Camp. Local bands of black, slaty rocks similar to the typical Tetagouche slates also occur along the South Branch.

In the southwest corner of the area grey, banded, quartzitic rocks, locally crumpled and drag-folded, outcrop along the trail to Upsalquitch observation tower, which is just south of Jacquet map-area. Similar rocks form the mountain on which the tower is located.

On the upper part of the main Tetagouche, its tributary Gambol Brook, and farther west on Eighteenmile Brook, dark greenstone rocks, apparently representing flows, occur with local dark banded varieties that are regarded as tuffs.

## SILURIAN

### *Chaleur Bay Series*

The section where the Silurian succession can best be studied in the region is along the shore east of Jacquet River. Railway cuts at Culligan expose parts of the same beds. Fragmentary sections also occur on the coast at Blacklands, Black Point, Turgeon, and Petit Rocher, and inland Silurian rocks are exposed along South Charlo River, and locally on Nash Creek and Nigadu River. The exposures inland, however, are so fragmentary that they offer no information about the succession and have to be interpreted in the light of the coast sections.

The Chaleur Bay series was originally zoned in the Port Daniel region on the north side of Chaleur Bay by Schuchert and Dart (1926), and the divisions as worked out there were found to apply also to the excellent section farther west on the Gaspe coast at Black Cape, where is exposed in regular sequence the greatest thickness of Silurian strata to be seen anywhere on the North American continent. The palæontology and stratigraphy of the Silurian of this Port Daniel-Black Cape region have recently been discussed by S. A. Northrop (1939). The Jacquet River section lies about opposite that of Black Cape and the same general zoning applies to it.

The following is the succession of formations at Port Daniel and Black Cape, with their thicknesses in these localities (Northrop, 1939).

| — | Port Daniel Feet | Black Cape Feet |
|---|---|---|
| Indian Point formation | 456 | ........... |
| West Point formation | 1,714 | 543 |
| Bouleaux formation | 888 | 2,594 |
| Gascons formation | 1,890 | 3,835 |
| LaVieille formation | 405 | 1,155 |
| Anse Cascon formation | 332 | 300 |
| Clemville | 824 | ........... |
| Total thickness | 6,509 | 8,427 |

At Black Cape, Indian Point beds may be included with the West Point formation. In addition to the 543 feet of sediments of this division, there is a thickness of 4,626 feet of lavas, giving a total coastal thickness of 13,053 feet of Silurian rocks. All the formations are of Middle Silurian age.

The various coastal sections of the Jacquet-Tetagouche area have been previously described and illustrated (Alcock, 1935), and as a result only a summary reference needs to be made to them here. At Jacquet River shore exposures extend from a point half a mile east of the mouth of Armstrong Brook eastward for 3 miles. The beds are folded and faulted, are overlain for long distances by the flat red strata of the Bonaventure formation, and locally are concealed entirely by the gravel and sand of the shore. The succession ranges from Clemville to Gascons. The striking features are the great thickness of the Clemville and the association in it of volcanic rocks with the sediments.

The eastern part of the section is an asymmetrical syncline slightly overturned to the east, involving beds of the Clemville, LaVieille, and Gascons formations. The exposures are fragmentary and some are to be seen only at low tide. The Clemville beds, exposed from 3,000 to 3,600 feet east of Belledune pier, consist of reddish sandstones. Farther west the LaVieille formation consists of fossiliferous, grey to bluish, knobby limestone and above are grey, sandy shales with thin beds of bluish limestone grading into reddish, sandy shales with limestone interbeds, whose lithology and fossil content correlates them with the Gascons. The prominent point about two-thirds mile west of Belledune pier consists of LaVieille limestone in the western limb of the syncline. In the bay immediately to the east, the knobby limestone grades upwards into sandy shales, marking the beginning of the Gascons formation. To the east of this transition zone a zone of conglomerate, bordered to both the east and west by faults, and containing waterworn Silurian corals and Silurian rock fragments, is believed to be of Devonian age.

West of Limestone Point is exposed a great thickness of grey grits, yellow and reddish to dark brown sandstones and arkoses, local beds of limestone, and one zone of conglomerate and associated arkose. The beds are folded and faulted, but altogether a thickness of at least 3,400 feet of Clemville sediments is exposed. Massive lavas with underlying fragmental volcanic material form an interbedded zone that outcrops for a length of over 1,000 feet along the shore and makes up an additional thickness of 600 feet. West of this volcanic zone are overlying shales and sandstones of the Clemville and then the section is terminated on the west by a belt of volcanic rocks, which may represent a repetition of the zone to the east.

Along the railway on either side of Culligan station are exposures of Silurian strata belonging to the same syncline referred to above as occurring in the eastern half of the Jacquet River shore section. The succession includes reddish sandstones of the Clemville, fossiliferous limestones of the LaVieille, reddish sandstone of the Gascons, and an overlying zone of conglomerate and sandstone that may be Devonian.

A fragmentary section of Clemville beds occurs both to the west and east of Black Point. The strata consist of calcareous shales, and limestones, carrying fossils. The lowest beds on the southeast side of the belt of volcanics consist of hard grey limestone with thin, shaly partings. Lithologically they resemble certain beds of the Upper Ordovician Matapedia series, but a few fossils, including a *Tentaculites*, a *Spirifer*, and *Buthotrephis*, suggest a Silurian age. Similar beds cross Nash Creek, but appear to lack fossils. On the road to Lorne settlement fossil-bearing

Silurian beds occur in a rock cut on the side of the road, and at the settlement numerous large slabs of rock of apparently local origin carry many large specimens of Silurian pentameroids.

Blacklands Point is composed of hard, bluish, nodular limestone, carrying abundant fossils. At least 290 feet of beds are to be seen at low tide. They belong to the LaVieille formation.

Silurian rocks also extend along the coast from Limestone Point south past Petit Rocher to near the mouth of Nigadu River. The succession includes Clemville, LaVieille, and Gascons beds. At Limestone Point the rocks are red shales, greenish grey, fossiliferous, sandy limestones and shales, reddish conglomerate, and grits, overlain by limestones with grit and sandy beds, all of which are regarded as Clemville, and which have an exposed thickness of 2,600 feet. These beds are overlain by nodular limestones of the LaVieille. Farther south, between the mouth of Elmtree River and Petit Rocher, strata of the Clemville, LaVieille, and Gascons are folded into a syncline that is separated from the Silurian rocks on either side of it by faults. To the south of the Petit Rocher fault, reddish and greenish, sandy sandstones regarded as Gascons are folded into a series of anticlines and synclines. Similar rocks outcrop along the lower part of Nigadu River.

A belt of Silurian rocks extends from north of the mouth of Hendry Brook southeast for 3½ miles to south of Green Point pier. The beds consist of sandy limestones, in places fossiliferous, sandstones, arkose, and conglomerate, all apparently belonging to the Clemville. The beds are cut at one place by a couple of small basic dykes, and for a distance of 1½ miles along the shore dark green, massive, volcanic rocks outcrop and rest in faulted contact with the Silurian strata.

South Charlo River has cut a deep gorge showing practically continuous outcrops from above the 12-mile dam almost to its mouth, and at several points along its course Silurian fossils were collected. Along the lower part of the stream the rocks are massive volcanics of probable Lower Devonian age. A quarter of a mile above the fish hatchery dam fossiliferous Silurian limestone beds outcrop with irregular strikes and dips. Above this band volcanic rocks continue for half a mile to where a belt of Lower Devonian limestone about a quarter of a mile wide forms a syncline overlying the adjacent volcanics. Upstream massive volcanic rocks again outcrop for a distance of 2½ miles and then to the stream's headwaters sediments predominate. These beds consist of limestones and shales with irregular strikes, but for the most part with gentle dips. They are locally broken by faults and are cut by dykes. Silurian fossils were collected below the 12-mile dam and towards the lower part of the sedimentary belt about half a mile upstream from the southern margin of the main volcanic area. Intermediate between these two points is a zone, apparently unfossiliferous, of shales and limestones with associated dark volcanic rocks resembling a Lower Devonian assemblage.

### LOWER DEVONIAN

Rocks of Lower Devonian age cover the greater part of Jacquet River map-area and a large part of the northern half of Tetagouche River map-area. They consist of sediments, mostly limestones and shales, with associated volcanic rocks of both flow and fragmental origin. In Restigouche River region immediately to the west sediments predominate in the lower part of the succession and volcanic members are more abundant in the upper part. The section where the interbedded relationships of the volcanics and sediments can be best and most readily studied is along the coast at Dalhousie. Detailed descriptions of this section have been given by Clark (1909), Howard (1926), and Alcock (1935), and only a brief summary is necessary here.

The section is best approached from the south by a road to the beach from Darlington. As one then proceeds northeast along the shore at the foot of the cliffs progressively younger beds are encountered. The following is the succession, in descending order:

| | 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 shales 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 0. Calcareous shales | 90 |

Zone O consists of thin-bedded, calcareous shales and shaly limestones, carrying a few brachiopods. A thickness of 90 feet is exposed at low tide. Both the Lower and Upper Dalhousie beds are highly fossiliferous, containing numerous species of Helderberg brachiopods, corals, lamellibranchs, and other varieties. The basaltic tuffs and flows below zone 1, including also possibly the associated palagonite tuffs and the Stewart andesites above zone 16, were deposited from eruptions of a volcano that occupied the site of the present Dalhousie Mountain. The tuffs and flows between the Lower and Upper Dalhousie beds, the Inch Arran andesites, and the intrusive andesites are believed to have probably come from the east or northeast.

The interbanded Lower Devonian sedimentary and volcanic rocks are exposed along Louizon and Jacquet Rivers. Along the former stream volcanic rocks predominate. About 2 chains above the Louizon River bridge, on the road from Archibald settlement to Doyleville, a 40-foot bank exposes fossiliferous shales dipping at a low angle to the northeast and overlain by a volcanic flow, the contact between the two rocks being conformable to the bedding of the shales. The lava is ellipsoidal, and in addition contains amygdules and masses of white calcite up to 5 inches across. Thirty chains below the same bridge a band of dark shales 4 feet thick and dipping 60 degrees to the north lies between two dark volcanic flows. The upper surface of the lower flow is amygdaloidal and the base of the upper flow is both amygdaloidal and ellipsoidal, the pillows resting directly on the shales.

Jacquet River drains a large area of Lower Devonian rocks, and the interbedded relationships of the volcanic and sedimentary beds are well exposed at many places along its course and along many of its tributaries, including Bighole Brook, Lake Branch, McNair Brook, Upper McNair, and Rocky Brook. The sediments consist chiefly of grey to black shales and shaly limestones, locally fossiliferous. They are jointed and fractured, and in places break into fragments of the size and shape of pencils. The associated igneous rocks are mostly dark grey to black. Some are ellipsoidal and amygdaloidal and clearly represent flows; other coarser grained varieties may be sills. A few outcrops of massive grey gabbro occur, and locally dykes of reddish feldspar porphyry cut the sedimentary beds. Fragmental volcanic rocks also occur locally. A mile and a half above the railway bridge cliffs of reddish and yellowish volcanic tuffs and breccias border the river, and half a mile farther upstream greenish ash beds are associated with massive volcanic rocks.

In Nigadu River and upper Tetagouche region the sediments are mainly argillaceous and limy varieties marked by a cleavage. Local conglomerate bands also occur. Fossil fragments were collected in this belt at a number of places, mostly in beds where the cleavage parallels the bedding planes. The forms collected include brachiopods and corals, but in most places nothing sufficiently diagnostic was found to determine definitely whether a Lower Devonian age or a Silurian one was represented. It is possible, therefore, that the belt of sediments mapped as Lower Devonian in this part of the area may include some Silurian beds.

### *Elmtree Group*

Along Elmtree River are dark, slaty and quartzitic rocks, which have yielded no fossils and whose age is, therefore, not known with certainty. Included with the slaty rocks are local bands of conglomerate carrying pebbles of quartz, volcanic rocks, granite, and quartzite. The writer formerly regarded these strata as probably of Ordovician age. Lithologically some of them resemble phases of the Tetagouche series and their degree of metamorphism appears to correspond more to that of the Ordovician rocks than to that of most of the Silurian and Lower Devonian beds. More recent work, however, in the upper Nigadu region has shown that some of the highly cleaved beds are of Lower Devonian age, and as the sediments on the Elmtree strike towards these beds it is probable that they are of the same age. The Elmtree sediments have associated with them dark volcanic and intrusive rocks that are also probably Devonian in age.

### *Lower Devonian Volcanic Rocks*

The Lower Devonian volcanic rocks vary from light-coloured rhyolites to dark, intermediate to basic rocks. Both acid and basic types include fragmental varieties as well as surface flows.

The most abundant variety of volcanic rock is dark andesite and it has associated with it dacites in subordinate amounts. The rocks are commonly fresh and massive. In hand specimen many of them can be seen to be porphyritic and in thin section all show phenocrysts of feldspar. Many of the flows are amygdaloidal and some are ellipsoidal.

The largest area occupied by these rocks lies northwest of Jacquet River and includes the drainage basins of Louizon and Benjamin Rivers. In this area local bands of sediments occur with the volcanic rocks. Most of the sediments are reddish clastic rocks and include conglomerate, grit, and sandy shale, locally showing ripple-marks. Such sediments occur in small amounts on both the North and the South Benjamin and on the tributaries of the Jacquet. Near the main dam on McNair Brook is a considerable development of these red, clastic rocks. On Rocky Brook, above McNair Brook, sediments with minor amounts of volcanic rock form cliffs along the lower part of the stream. About half a mile above its mouth volcanic rocks dominate, forming cliffs several hundred feet in height. Even in this zone, however, a few outcrops of sediments, locally containing fossils, occur along the border of the stream underlying the volcanic rocks. Farther upstream on the same brook reddish, sedimentary beds outcrop, and in this higher country where the valleys are broader outcrops are fewer and it is difficult to determine whether the volcanic or the sedimentary members are relatively more abundant.

The petrology of these rocks has been dealt with by Howard (1926) and Alcock (1935).

Light grey to reddish, acid, volcanic rocks are associated with the darker phases at a number of places in the area. The largest belt of these rocks, and the only one that has been differentiated on the map (No. 641A), is the coastal area drained by New Mills River and the lower part of Benjamin River. The rocks of this belt are light grey, pink, and red. Locally they show flow structure. On the shore about a mile northwest of the mouth of Dickie Creek a reddish variety is associated with reddish tuffs of a similar composition and with darker, amygdaloidal lavas.

Reddish sediments, including sandstones and conglomerates, are associated with these rocks, and west of New Mills they are developed in sufficient amounts to be differentiated on Map 641A. The conglomerate consists largely of volcanic material; the boulders are well rounded; bedding is well marked, showing coarse and fine layers; and dips are gentle, but range up to 35 degrees. The beds are more indurated than those of the Bonaventure formation, with which they might be confused.

## IGNEOUS ROCKS OF UNKNOWN AGE AND ORIGIN

In Tetagouche map-area are a number of zones of dark, igneous rocks whose age and origin are not known. Most of these rocks are associated with sediments of the Ordovician Tetagouche series and some are clearly of volcanic origin. It was probably these or similar rocks that supplied the numerous volcanic boulders that are present in the Silurian conglomerates, such as occur at Petit Rocher. Other rocks grouped with these are coarser grained and appear to be of intrusive origin, but as contacts can only rarely be observed the exact relationship cannot everywhere be definitely determined.

North of Elmtree River is a broad belt underlain by rocks that have been mapped with this group. The best exposures are to be seen along the coast north of Limestone Point. The rock types present include volcanic, intrusive, and sedimentary rocks. The most abundant variety is a dense, dark, volcanic rock with irregular streaks and masses of epidotized material and cut by quartz veins. Associated with these rocks are coarser grained types, which include gabbro, diorite, and granite. In addition, banded tuffs, red and green shales and slates, and greenish sandstones are present in minor amounts. The greenstone rocks are locally altered to hornblende schists, and in places dark diabase dykes cut the massive intrusive varieties. Some or all of these volcanic and intrusive rocks may be of Devonian age. Near the contact of rocks of the group with fossiliferous Silurian beds immediately south of the mouth of Hendry Brook the Silurian strata are cut by two small basic dykes, which may be related to the greenstone rocks of doubtful age.

The belt of rocks that follows the Sormany road south of Millstream is made up typically of a dark grey, fine-grained intrusive, which in thin section is seen to be hornblende granite. It shows orthoclase, microcline, and some albite, considerable quartz, including both free crystals and graphic intergrowths with orthoclase, pale hornblende, secondary chlorite, epidote, and zoisite, and accessory iron ore and apatite. A similar, massive, grey rock outcrops on what is known as the tractor road to the Tetagouche a mile north of Imhoff post office. It has, however, much less quartz and approaches a syenite. These rocks are intrusive into Ordovician sediments and their age may be as young as Devonian.

## MIDDLE DEVONIAN

### *Intrusive Rocks*

Acid intrusive rocks in the form of dykes and small stocks and masses occur in many places throughout the area. They range in composition from granite to syenite and locally there are associated gabbro phases. In texture they grade from medium-grained, even-textured rocks, through finer grained, porphyritic varieties to dense felsites. Locally this gradation can be seen in the same rock mass, border phases being commonly dense and porphyritic and the central part of the mass coarser grained. The largest of these masses lies along the west side of Nipisiguit Bay immediately south of Bathurst. It has a length of 10 miles and a greatest width of 4½ miles. Another mass runs northeast from Antinouri Lake. Along the South Benjamin there are two such areas, whose longer axes lie along the same general line, and still other bodies occur on the North Charlo and on Narrows Brook. All these intrusions trend in a northerly or northeasterly direction, corresponding to the axial trends of the main folds of the older sediments. To the southwest of the area in the central part of the province are larger masses of similar rocks. These masses, which are of batholithic proportions, have also northeasterly trends. It is believed that the small masses exposed in the area are merely the upper parts of a similar, large, unroofed batholith underlying the region.

### *Granite*

*Nipisiguit River.* The granite mass south of Bathurst is well exposed along stretches of Nipisiguit, Middle, and Little Rivers. Between these streams outcrops are lacking, but there is little doubt that all the neighbouring region is underlain by the granite body. The rock can be seen most readily at Rough Waters and at Pabineau Falls, both on the Nipisiguit, localities that can be reached by car. At the former, the fresh, massive granite exposed at the river passes up into weathered material overlain by flat-lying Pennsylvanian sandstones.

Throughout most of the mass the rock is pink to reddish, the colour being due to the orthoclase crystals that make up so much of the rock. The texture varies from coarsely granular to semi-porphyritic. In places the latter type shows feldspar crystals up to an inch in length lying in a rather even-grained matrix composed of pale pink feldspar and glassy quartz with numerous small flakes of biotite. Cutting the granite are dykes of pale pink, fine-grained aplite.

Under the microscope the granite is seen to consist of orthoclase, albite, quartz, and biotite, with accessory iron ore and apatite and a little secondary chlorite. Near Pabineau Lake the granite locally contains molybdenite and a little beryl.

On Little River some exposures of granite present certain features that are somewhat different from those of the normal variety referred to above. One such phase is a pale, greyish white, fine-grained, porphyritic granite with a speckled appearance produced by disseminated flakes of biotite. In thin section this variety is seen to consist of 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 rocks that are believed to be equivalents of the Ordovician Tetagouche slates, and has metamorphosed them along its borders into hornfels. The bordering rocks in places are cut by granite dykes. The eastern edge of the granite following Nipisiguit River disappears under overlying beds of the younger Bathurst formation of Pennsylvanian age.

*Antinouri Lake.* Exposures of granite begin on the northeast side of Antinouri Lake about three-quarters mile from its north end and continue to the south end. Scattered exposures belonging to the same mass are to be seen east of the lake in the headwater region of Elmtree River. The granite area is surrounded by dense, dark rocks, which apparently represent argillaceous sediments altered to hornfels. In thin section these older rocks show an abundance of reddish brown biotite and, in places, pyrite.

The granite on its freshly broken surface is light flesh coloured to pink, weathering dark. It is medium grained and massive. In thin section it is seen to consist of orthoclase, quartz, albite, and biotite similar to that exposed along the Nipisiguit.

*Benjamin River.* Two masses of granite are exposed along South Benjamin River. The lower one begins about 4 miles from the mouth of the river and continues up for a distance of about 3 miles. Exposures can be seen along the portage road that parallels the stream, but a much better section across the mass can be obtained by ascending the river along which outcrops are almost continuous.

The rocks along the lower part of the Benjamin are volcanics, mostly massive flow types, but about half a mile above where the South Benjamin is joined by the North Benjamin coarse agglomerates and fine tuffs also occur. The first intrusive encountered in ascending the river is a light grey, medium-grained variety, which in thin section is seen to have the mineral composition of gabbro and to consist of acid labradorite, large augite crystals, accessory iron ore, and secondary chlorite as an alteration product of the augite. The next outcrops consist of pink to reddish granite consisting of orthoclase, albite, quartz, and biotite. At one place the granite is cut by a fine-grained aplite dyke.

Towards the centre of the mass the rock is reddish and medium grained, and in thin section shows orthoclase, quartz, and also graphic intergrowths of quartz and orthoclase. Chlorite, apparently secondary after hornblende, is present in minor amounts, and considerable accessory iron ore occurs.

Towards the upper border of the mass the rock again becomes finer grained and darker in colour, and in places it is difficult to distinguish the intrusive from the older, intruded, volcanic rocks that surround it. In places the dense phase of the intrusive contains phenocrysts of reddish feldspar and small masses and dykelets of the reddish granite. A number of thin sections of the dense border phase show phenocrysts of orthoclase and albite in a groundmass of orthoclase, albite, and quartz, with secondary chlorite and accessory iron ore. The groundmass has a trachytic texture. In some specimens the quartz occurs in very minor amounts and the rock is a syenite.

The dense border zone of the granite mass locally contains blocks of the dark volcanic rocks; reddish dykes cut the surrounding dark rocks. Near the contact on the upstream side is a coarse grey phase similar to that observed at the lower contact. In thin section this rock is found to consist of acid labradorite with brown biotite and greenish augite altering to chlorite. Considerable iron ore and a little apatite are present as accessory minerals. The presence of this basic phase on either border of the granite mass suggests either assimilation of the bordering dark volcanic rocks by the intrusive or an actual remelting of the volcanic rock at the contact.

The upper granite mass on the South Benjamin shows outcrops on the downstream side, but upstream the evidence for delimiting the probable extent of the mass is the presence of large granite blocks in the stream and adjacent country. The river for a distance follows closely the contact of the granite with the volcanics. Dykes of granite intrude the volcanics and the granite mass contains inclusions of the volcanics. An excellent place for observing the contact zone is at the dam, about 10 miles from the mouth of the river, to which a good trail leads from the portage road. There, basic amygdaloidal lavas, locally epidotized, are cut by many small dykes of granite and granite-porphyry, and locally the contact is a shatter zone in which numerous blocks of volcanic rocks are surrounded by granite.

*Charlo River.* The limestones and shales of North Charlo River and Narrows Brook are intruded by dense acid rock; the exposures on these streams may form a continuous mass, whereas farther south, on the same general line, the Silurian sediments below the dam on the South Charlo are cut by dykes that may be connected with the same mass.

The rocks vary from pinkish to brick-red. They are commonly porphyritic, showing phenocrysts of feldspar and locally of quartz. On the North Charlo the belt mapped as intrusive consists of several bands of porphyry separated by zones of baked, indurated argillites. The bands either represent several sills or the same sill repeated by a number of faults with small throws. In places the contact phase of the intrusive is a dense rock carrying pyrite. A thin section of this border phase shows phenocrysts of albite in a dense matrix containing considerable secondary carbonate and some pyrite crystals. A slightly coarser grained phase shows phenocrysts of orthoclase and albite in a microcrystalline matrix of feldspar and quartz. A few, large, altered, hornblende crystals are present. The rock is apparently a syenite-porphyry.

*Other Areas.* A small mass of grey hornblende granite outcrops on Elmtree River about 2 miles from the coast. Stone has been quarried there for building purposes and reference will be made to it later, in Chapter V. Numerous boulders and blocks of granite in the region north of Rocky Brook, a tributary of Millstream, may mean that a granite mass is present in the region between that stream and Nigadu River, but no outcrops were observed.

*Age of the Acid Intrusives.* The acid intrusives cut rocks as young as Lower Devonian. At Rough Waters on the Nipisiguit it is quite apparent that the granite mass at this point was unroofed and weathered before it was covered by the sandstone of the Pennsylvanian Bathurst formation. The intrusion, therefore, took place at some time during the interval between the deposition of the Lower Devonian and that of the Pennsylvanian sediments. For a more precise dating reference must be made to a wider region surrounding the area.

Reference has been made to the large granite masses that lie in southwest and central New Brunswick just beyond the area. A similar granite mass is exposed at Tabletop Mountain in central Gaspe, and associated with it are dykes and masses of syenite and porphyry. These intrusives cut fossiliferous Lower Devonian sediments, and the latter contain as well numerous quartz-carbonate veins carrying sphalerite and galena, which are believed to be genetically related to the intrusives. In the immediate vicinity of the intruded and mineralized Lower Devonian beds the overlying strata of the Middle Devonian Gaspe sandstone formation are disturbed, but nowhere were found to be cut by any acid dykes or to contain any sign of sulphide mineralization. The intrusions there are, therefore, regarded as pre-Gaspe sandstone and must be either late Lower Devonian or early Middle Devonian. In Maine and southwestern New Brunswick beds of the Perry formation, whose Upper Devonian age is established from plant remains, rest unconformably on post-Silurian granite and granite boulders are abundantly present in the conglomeratic phases. The granite is, therefore, pre-Upper Devonian, similar to that in the northern part of New Brunswick.

### *Gaspe Formation*

The Gaspe sandstone is represented by a few exposures in the northern part of the area along the shore of the Restigouche. The formation covers much larger areas outside of the area on the north side of the river, and at the eastern extremity of Gaspe Peninsula. Marine fossils collected at a number of places in Gaspe indicate a Middle Devonian age.

On the shore about 2 miles west of Dalhousie two small areas are covered by the formation. The beds consist of sandstone, grit, and conglomerate. They overlie volcanic rocks of Lower Devonian age, outcrops of the latter occurring along the coast to the east and along the railway and highway immediately to the south. The beds contain *Psilophyton* plant remains characteristic of the Gaspe sandstone across the river in Gaspe.

Another belt of rocks, which may belong to the same formation, extends from Lanim Point, about 3 miles farther west of the exposures referred to above, southwest to Shaw Cove, a distance of about 1¼ miles. The beds strike northeast about parallel to the shore and dip to the northwest at angles of from 30 to 45 degrees. They consist of dark grey to black conglomerates, made up of well-rounded pebbles of volcanic rocks, tuffaceous beds, and red shales. A hard, grey, bedded member shows markings that may be organic. Towards the northeast end of the belt a coarse conglomerate carries well-rounded volcanic boulders that range up to 2 feet in diameter. The strata are overlain by flat-lying sediments of the Bonaventure formation.

An interesting feature is that on the shore about one-eighth mile north of the end of Shaw Cove are two bands of a red, medium-grained, intrusive rock carrying large flakes of biotite. The base of the lower igneous band is not exposed, but its upper border parallels the bedding of the overlying conglomerate. The second igneous belt lies 7 feet above the lower; it has a thickness of 3½ feet, and both its borders parallel the bedding of the enclosing conglomerate. The intrusives are, therefore, apparently lamprophyre sills. This belt of sediments is either of Lower Devonian age or else belongs to the Middle Devonian Gaspe sandstone formation. The lithology suggests the latter, but the fact that the beds are intruded by igneous rock makes it possible that they really may be of Lower Devonian age.

CARBONIFEROUS

## *Bonaventure Formation*

The Bonaventure formation receives its name from Bonaventure Island near Percé on the Gaspe coast, where it forms high cliffs. It is developed on either side of Chaleur Bay, the largest areas being along the Gaspe side. In New Brunswick an area around Dalhousie is underlain by the formation and patches of it are exposed along the coast from the mouth of Eel River to near Belledune Point. A small area occurs still farther south on Millstream River near the coast, and a few patches of red, horizontally lying, clastic beds on the upper part of Tetagouche River are regarded as belonging to the same formation.

The formation consists largely of conglomerate with associated sandstone, and in places shaly beds, all characteristically marked by a brilliant red colour. At several localities beds of dolomitic limestone occur with the clastic beds. On the shore southeast of Belledune, limestone in places forms the base of the formation. Nearly everywhere the formation is undisturbed. On the Gaspe coast, however, there are several places where the beds are tilted, and at one locality near Percé a basic dyke intruded normal to the bedding is broken by several faults. At many places, particularly in the Jacquet River coastal section, the flat red beds of the Bonaventure can be seen resting unconformably on the tilted strata of the older Palæozoic formations. The greatest thickness of the formation in the area is seen near Dalhousie where flat-lying beds occur at elevations over a vertical range of 600 feet. At Percé a still greater thickness is exposed.

A lack of fossils in the beds leaves the determination of the age of the formation uncertain. At Maguasha, on the Gaspe coast, it overlies unconformably fossiliferous Upper Devonian beds. Near Percé a few plant remains were found in beds that have been termed the Canne de Roche formation (Alcock, 1935, page 93), and which may really be the Bonaventure. The plants are Carboniferous, probably Pennsylvanian.

The Bonaventure was apparently deposited in a depression that corresponded in a general way to that occupied at the present time by Chaleur Bay. Accumulation evidently took place under conditions favouring oxidation, probably subaerial deposition in an arid climate.

## *Bathurst Formation*

The Bathurst formation covers the southeastern corner of the area east of Nipisiguit River. Exposures occur along the Nipisiguit and also on Redpine Brook, Bass River, Little Bass, and Cory Brook. At Rough Waters on the Nipisiguit the formation rests on weathered 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 consist predominantly of sandstone, but shales and fine conglomerates also occur. The latter occur as lenses at various horizons; the pebbles, most of which consist of quartz, rarely exceed 2 inches in diameter. Except for a few dark shaly beds, the characteristic colour of the formation is reddish. Beds are horizontal or have very low dips. On Redpine Brook a thickness of 125 feet is exposed.

The strata at Bathurst have yielded no fossils, but farther east along the coast similar red beds are succeeded conformably by grey beds of the Clifton formation containing an abundant Pennsylvanian flora of Pictou age. It seems fairly conclusive, therefore, that the Bathurst beds are also Pennsylvanian.

### QUATERNARY

The Quaternary deposits consist of unconsolidated material laid down during Pleistocene glaciation and in recent times since the disappearance of the ice. The glacial deposits consist of erratics, boulder clay, and gravels; the post-glacial include stratified sands and clays.

The whole region was glaciated during the Pleistocene. Rock outcrops in the settled country, on the plateau surface, and in places along the valleys are for the most part rounded and smoothed, and where they consist of resistant rock, striated. The rounded forms uniformly show lee and stoss slopes, and in all cases they indicate that the movement of the ice was to the northeast. The striation bearings vary in this general direction and on the same outcrop; more than one set of northeast-trending striæ can in places be noted. Apparently the ice that scoured the rocks smooth moved out from the central highland region lying to the southwest.

Erratics are numerous over the region and a mantle of unsorted gravel and boulder clay is widespread. Stratified gravels occur also at many places throughout the area. The most important deposit is an irregular one extending along the coast from Eel River Valley to Nash Creek, a distance of some 12 miles. This was named by Chalmers the Restigouche kame. Near New Mills station the railroad cuts through it. At its western end it has a height of 150 to 175 feet and at its eastern end 50 to 75 feet.

Post-glacial clays and sands occur at a number of places along the coast at elevations up to 150 feet, and locally marine shells and plant remains are to be found in the beds. The common genera represented include *Saxicava, Leda, Mya,* and *Nucula* (Alcock, 1935, page 38).

# CHAPTER IV

## STRUCTURAL AND HISTORICAL GEOLOGY

### STRUCTURE

Structurally the rock formations of the area fall into three main divisions. These are the pre-Silurian complex, composed of rocks that are for the most part slaty and in places even schistose; the Silurian and Devonian formations, which are deformed but on the whole to a much less extent that the Ordovician strata; and the Carboniferous rocks, which are only very slightly disturbed.

The Ordovician strata are highly folded and a lack of horizon markers prohibits the zoning of the beds or the working out of structure. The dominant structural feature is a cleavage that strikes in a northeast direction.

The Silurian and Devonian strata overlie the Ordovician beds unconformably. Evidence of the unconformity is to be seen in the great difference in the degree of metamorphism that the two groups locally show in adjacent outcrops. Another fact, which has already been mentioned, is the presence as pebbles in the conglomerates of Silurian and Devonian age of certain distinctive rocks such as red argillites, which are characteristic members of the Ordovician Tetagouche series. There can be no doubt that the Ordovician beds were deformed and were under erosion at the time the Silurian beds were laid down.

In a broad way the major structure of the region is simple, but in detail it is complex. To the west and north along the valley of the Restigouche a broad syncline involves rocks ranging in age from Upper Ordovician to Middle Devonian. The strata of the southern limb of this syncline continue eastward into the area where they are thrown into further folds. These, however, are broken by faults and complicated by intrusions, and as a result the details of structure are too complicated to work out from the limited number of exposures that are available. Only where outcrops are fairly continuous, as for example in the coastal sections of Jacquet River and Petit Rocher, can the faulting be worked out with confidence. Deformation has in places developed in the Silurian and Devonian rocks a slaty cleavage, and locally even a schistose structure. Such phases are difficult to distinguish from certain beds of the Tetagouche series. The sediments along the Elmtree are examples of this type.

The Carboniferous beds, including both the Bonaventure and the Bathurst formations, consist of flat-lying beds. At several places on the Gaspe coast beds of the former formation are tilted, and at one place on the coast near Percé they are cut across by a diabase dyke that is itself broken by several faults. East of Bathurst the Carboniferous beds are thrown into long low rolls, but the dips are everywhere very low.

## GEOLOGICAL HISTORY

The earliest event leaving a definite record in the area was the deposition in Middle Ordovician time of a thick series of shaly sediments. With these were deposited coarser clastic beds, limestone, and also volcanic material in the form of flows and tuffs. Whether deposition continued during Upper Ordovician times is not known. Farther west in this period a thick series of shales and limestone known as the Matapedia group accumulated, but if deposition took place in the Jacquet-Tetagouche area the beds were eroded before the next cycle of deposition in Silurian time. In late Ordovician time the region was folded along northeast-southwest lines, was lifted above the sea, and a period of denudation was initiated.

In Middle Silurian times the region was once more depressed beneath the sea and a thick series of sediments accumulated. Local volcanic activity took place during the period. The sediments include conglomerates, sandstones, shales, and limestones. Subsequent to the deposition of these rocks the region was uplifted and erosion was again begun. This elevation did not involve folding of the beds, but was in the nature of a broad upwarp. In Lower Devonian time the region again subsided beneath the sea and a thick series of sediments began to accumulate. This was a period of intense volcanic activity and lava flows and tuffaceous beds became interbedded with the sedimentary material. At the close of the Lower Devonian, mountain-building movements once again took place. The rocks were thrown into folds and the folding was accompanied by the intrusion of stocks and batholiths of granite and dykes of syenite and feldspar porphyry. Most of the mineral occurrences of the area date from this time.

In Middle Devonian time deposition of the Gaspe formation took place, a few exposures of which are to be found along the shore west of Dalhousie. Earth movements continued during the Devonian after this deposition had been completed and the beds were thrown into gentle folds.

The next event of which there is record is the deposition of the Bonaventure formation. This took place under continental conditions in a basin that corresponded roughly in outline to that occupied by the present Chaleur Bay. The date of the deposition was probably Pennsylvanian. In later Pennsylvanian time the eastern part of the region was covered by the clastic beds of the Bathurst formation. The Appalachian revolution at the close of the Palæozoic, which was the great mountain-building time in the eastern United States, affected only very slightly this region. During the succeeding Mesozoic and Tertiary times it is probable that the region was above the sea.

The late history of the area from the Mesozoic on must be deduced from the surface forms. The old age upland surface, which was described in Chapter II, is regarded as a peneplain that was developed during the long erosion interval of the Cretaceous. The mature surface developed at a lower level on the soft Carboniferous rocks is considered to be a second erosion surface carved in Tertiary times. This cycle of erosion was terminated some time during the Pliocene by uplift, and since that time the present youthful valley bottoms have been excavated. While the region stood high ice began to accumulate during the Pleistocene in the central highland region of the province. It spread out from this centre, the direction of movement in the region under discussion being northeast. Ice from the Labrador centre is believed to have crossed this whole region later. The weight of these ice masses depressed the whole region. Since the retreat of the ice there has been uplift, as is shown by the presence of terraces along the streams and by the presence of beds of clay carrying marine shells at elevations up to about 150 feet above the present level of the sea. This uplift, however, has not been sufficient to offset the depression of glacial times. The coast still shows the features characteristic of a drowned topography in a youthful stage of development.

# CHAPTER V

## ECONOMIC GEOLOGY

The area contains no producing mine nor any property that has at any time produced metal economically. There are, however, numerous mineral showings, some of which have been known for at least 100 years, and on a few of which exploration work has been carried out on a number of occasions.

From a geological point of view the area may be considered as one of the most favourable places in the province for the prospector. The geological map of New Brunswick shows a belt of granitic rocks extending in a northeast direction from the southwest corner of the province to the Chaleur Bay region at Bathurst. The belt includes a number of masses that are all probably part of a large batholith that underlies the central part of the province. It intrudes all the rocks up to and including those of Lower Devonian age. The belt has its greatest width towards the central part of the province, and it is there that the batholith has apparently been most deeply incised. In the area under discussion in this report the deep-seated rocks are exposed as small stocks, and it is believed that these represent cupolas on the larger mass below. In other words, erosion has here proceeded just far enough to expose only the upper parts of the batholiths' irregular surface.

A region that has reached this particular stage of dissection may be regarded as ideal from the point of view of search for mineral deposits. Ore-bodies are commonly formed from mineralizing solutions given off from a magma during late stages in its cooling. The solutions and vapours rise and their mineral content is deposited in fractures or other planes of weakness in the roof and the walls of the upper part of the intrusive mass. Where dissection has proceeded to such a depth that the batholith is unroofed and much of its upper part is gone as well, the probability is that the greater part of what ore deposits were originally present has been eroded away also. On the other hand, where dissection has been just sufficient to expose the high points of the intrusion, the probability is that any ore deposits that were formed as a result of the intrusion are still in place. That the granite masses to the southwest show a trend that strikes towards the area, and that acid dykes and small stocks occur at a number of places in the area suggest that the region has reached this favourable stage of dissection.

The next question to be considered is whether these intrusions produced any mineralization. This can definitely be answered in the affirmative. Numerous mineral showings occur along the borders of the granite masses at intervals for the whole distance from St. Stephen at the southwest to Bathurst in the northeast. Occurrences of sulphides of iron, copper, zinc, lead, and molybdenum are known at many places, and numerous other minerals have also been reported. In places schistose rocks along the flanks of the granite masses contain many lenses and veins of quartz. At two places, one near St. Stephen, and another near Tetagouche River, rather considerable amounts of sulphides have been proved.

In addition to favourable association of intruded and intrusive rocks, and to the fact that dissection has proceeded to about the ideal degree, structural conditions within the area may be regarded as favourable for the formation of mineral deposits. It is true that many of the rocks are soft sediments, types that deform readily and as a result are less likely to give rise to strong fractures than massive igneous rocks. On the other hand, there are wide areas covered by massive volcanic rocks that might readily have developed shear and fracture zones under deformation. The intimate association of sediments and volcanic rocks also offers conditions favourable for the opening up of channels of access for mineralizing solutions. The contacts of weaker bands of rock with stronger, more competent zones are likely places for such channelways.

These geological conditions, and in particular the fact that a number of mineral occurrences to which reference will be made later were known to occur in the area, led to a considerable amount of prospecting in the region during the field seasons of 1938 and 1939. In these years the Provincial Government, in connection with its youth training program, financed in part by assistance from the Federal Government, had a number of prospecting parties in the field, and several of these during both these seasons were at work in this area. A number of small mineral-bearing zones were found, but none appears to be of economic importance. The region is, however, one in which the prospector works under a heavy handicap. The country is forested and is covered by a mantle of drift. Outcrops are for the most part confined to the streams and valley slopes. As a result, it is not know whether the mineral occurrences in the region are all small and irregular like those that have been found so far, or whether somewhere in the region are located deposits of a tonnage sufficiently large to be developed economically.

## GOLD

### NIGADU RIVER

During the years 1935 to 1937 inclusive exploration work was carried out on a gold prospect on Nigadu River. The locality is about 6 miles upstream from Nigadu station on the Canadian National Railway and about 17 miles from Bathurst. It is readily reached by following a good motor road from Nigadu to Free Grant and from there a portage road northward for a distance of a little over a mile.

The property was staked by two local prospectors, Edward A. Comeau and Wilfred N. DeGrace, and a company known as the Nigadu Gold Mining Syndicate was organized to develop it. A considerable amount of trenching and diamond drilling was carried out, and in addition the company drilled what is known as the Old Silver mine, about 1¼ miles farther west on the same stream.

The rocks along this part of the Nigadu are soft slates, chiefly bluish grey on the fresh surface, weathering to grey. The main structure is a slaty cleavage, which strikes northeast. Bedding can locally be determined from colour banding. A few fossil fragments, most of which lie across the cleavage and as a result cannot be obtained intact, indicate either a Silurian or Lower Devonian age. A porphyry dyke, believed to be related to the Middle Devonian, acid, deep-seated intrusives, cuts the sediments.

The discovery was made in the face of a cliff on the south side of the Nigadu where a narrow shear zone in the slates carries some quartz with pyrite, a little chalcopyrite, and smaller amounts of sphalerite. The strike of this zone was projected to the southeast and a series of trenches was opened up along this line for a distance of 1,450 feet. Twenty-four drill holes, varying in length up to 550 feet, were put down to intersect the zone. An interesting feature was the tracing in this zone of a porphyry dyke for a distance of 600 feet. The dyke has almost vertical walls, is on the average about 4 feet wide, and at one place apparently sends off a side branch. In many of the trenches either no mineralization or only scattered pyrite is to be seen; in others there are small quartz veins and stringers, whereas in the better mineralized trenches small masses, lenses, and narrow seams of solid pyrite occur in the sediments. Locally along the borders of the dyke mentioned above the slates are rusty and pyritized for widths up to 3 feet.

Eighteen samples of typical mineralized material were sent in October 1936 to the Mines Branch at Ottawa for assay. One sample assayed $4.20 in gold a ton, another $1.40 a ton, five ran 17 cents to 70 cents a ton, eight showed only traces of gold, and the remaining three showed none. The silver value for the same set ranged from nothing to 1·54 ounces a ton. No large body of mineralized material was found in any of the trenches. In the diamond drill holes put down to intersect the zone at depth only small amounts of mineral-bearing rock were encountered.

Exploration was also carried out on a small showing on the north side of the Nigadu about 500 feet downstream from the discovery referred to above. A considerable amount of trenching was done and six diamond drill holes were put down, but no mineralization of importance was exposed. Trenches were also excavated 200 to 300 feet southeast of the camp on the east side of the portage road and exposed small amounts of quartz and sulphides.

The region is one that has been deformed and mineralized, but apparently the soft sediments allowed only minor instead of strong shears to form. The more important openings produced were apparently the contacts of the slates with the stronger rock of the porphyry dyke. Mineralizing solutions took advantage of these lines of access. The rather extensive development work, however, has revealed no body of ore of either sufficient grade or tonnage to be mined profitably.

## ZINC AND LEAD

Sphalerite and galena have been found in a considerable number of places throughout the area, and some of the deposits have been developed. There are two types of occurrence, veins and replacements. The veins consist of quartz or quartz with calcite and locally barite, and they commonly carry pyrite with some galena and sphalerite. They are for the most part narrow, irregular, and short. The replacement deposits usually consist of pyrite with dark sphalerite and smaller amounts of galena and other sulphides. Both types of deposit are believed to be related to the intrusions of granite and allied rock of Devonian age.

### TETAGOUCHE RIVER

In the summer of 1938 a deposit of sulphides was found on a small stream that flows northeast to join Tetagouche River between Lower and Middle Lakes. The finding of this body was the result of scientific prospecting of a type new to Canada and is, therefore, of rather special interest. It had been known many years ago that blocks consisting of solid sulphide occur in the lower Tetagouche region, and on a branch of Armstrong Brook near where some particularly large boulders of this type had been found a little exploration work had early been carried out. Nothing of value at that time, however, had been found in place, and as a result interest died out and was not renewed until 1937 when the attention of a local mining engineer, Mr. G. S. Gilbert, was directed to these sulphide blocks. Mr. Gilbert in turn interested Mr. Hans Lundberg, who in Sweden had made use of the method of tracing erratics of ore back in the direction along which they had been pushed by the Pleistocene glaciers in order to locate the source body. The work of the Geological Survey had shown the direction of ice movement in the Tetagouche region. Numerous striation bearings on polished rock surfaces with observations on the directions of lee and stoss slopes had definitely established the fact that the main ice movement in the region was in a northeast direction out from the central highland region of the province. In August 1937 a party under the charge of Dr. Graeme-Grimes of Hans Lundberg, Limited, began prospecting the region between Millstream and Tetagouche River, and south of the Tetagouche recording on their surveys the location of every observed piece of sulphide float. Work was carried westward until no further pieces of ore were being encountered. In November the work was taken over by a new company organized for this purpose, the Tetagouche Exploration Company, Limited, a subsidiary of International Mining Corporation (Canada), a subsidiary in turn of International Mining Corporation. Geophysical prospecting was begun for the new company by Hans Lundberg, Limited, in late 1937 near where the sulphide float material was thought to have died out, and was continued during 1938. Favourable indications were suggested at two places, and in the spring of 1938 diamond drilling was carried out at these localities, but with no encouraging results. In the meantime prospecting was resumed by a party under charge of Mr. D. Shean of International Mining Corporation. Soon more boulders of sulphides were discovered farther back along the direction from which the ice had advanced, and then early in August a band of material identical in character with that of the erratics was found in the bed of Orvan Brook, only a short distance from where the latter is crossed by the Tetagouche portage road. The prospecting crews were immediately concentrated there to begin trenching and the diamond drill outfit was shifted to explore the zone at depth. Exploration was continued during the autumn and the ensuing winter of 1938-39 and was then discontinued.

The deposit is situated 22½ miles west of Bathurst and is reached by a highway through Rosehill settlement, a distance of 14 miles, and thence by the Tetagouche portage road a further distance of 11½ miles. The discovery in the bed of Orvan Brook is about 1,000 feet north of the portage road and about a mile as the crow flies south of Tetagouche River. Equipment and supplies were hauled from the end of the motor road in wagons drawn either by teams or by tractor, and owing to the muddy condition of the portage road the cost of transportation was relatively high.

The rocks of the area around the discovery are schists of supposedly Ordovician age, which are overlain to the north by limestones carrying a few fossil fragments indicating either a Silurian or Lower Devonian age. The deposit occurs in the schists, which are composed mainly of quartz and sericite with metacrysts of orthoclase, oligoclase, and quartz. These rocks are banded, vary in colour from almost white to green, show drag-folding, and are locally cut by many small veins and stringers of quartz. They apparently represent altered rhyolitic tuffs.

The band of ore at the discovery stood up in the creek bed above the softer schists on either side. It is 27 inches wide and consists of solid sulphides showing a banded structure. The bands are in places crenulated, suggesting that the material is a replacement of the drag-folded tuffs. The banding strikes about north 65 degrees east, following that of the enclosing schists, and dips to the northwest at an average angle of about 75 degrees. The contacts between the sulphide zone and the enclosing schists are sharp, the latter only locally carrying any appreciable amounts of disseminated sulphides.

The sulphide material shows two interbanded and interfingered colour phases. In one the dominant mineral is pyrite; in the other, which is much darker, the most abundant constituent is sphalerite. Polished sections of both varieties were made and examined by Mr. Haycock of the Mines Branch, who reports that in both types pyrite, arsenopyrite, and sphalerite are all abundant, chalcopyrite is common, galena is common, but not abundant, occurring as small, irregular grains in the sphalerite, and small grains and masses of tetrahedrite or tennantite are associated with the chalcopyrite and in places include disseminated pyrite and arsenopyrite. Assays of two samples, A and B, which are fairly typical of the lighter and darker ore material, respectively, gave the following results:

| — | A | B |
|---|---|---|
| Cu | 1·71 per cent | 0·30 per cent |
| Pb | 1·02 " | 5·62 " |
| Zn | 2·34 " | 18·11 " |
| Au | 0·03 ounce | 0·02 ounce |
| Ag | 1·33 " | 1·57 " |

Trenches and test pits were put down along the strike of the deposit in both directions from the discovery at intervals of 50 to 100 feet through the overburden, which has a thickness of about 10 feet. A distance of 2,800 feet was explored in this manner and an equal additional amount of trenching was carried out on the continuation of the ore zone and in the search for parallel bodies. Diamond drill holes were also put down at intervals of 200 feet over a distance of approximately 6,000 feet. The total length of thirty-one holes was 6,281 feet. The ore zone is stated to be continuous throughout this length of some 6,000 feet. In the matter of width, however, the results proved to be disappointing. Throughout its length it apparently maintains an average width of less than 30 inches, and in places even pinched to less than a foot. Drilling showed that similar widths are maintained to a depth of at least 200 feet.

### ROCKY BROOK

Crossing Rocky Brook, a tributary of Millstream River, is a mineralized zone on which development work has been carried out on several occasions during the past 45 years. The showings are most readily reached by a portage road from Ste. Rosette. From the end of the motor road the distance to the deposit is about 6½ miles. The main workings can also be reached from the arsenic property on Stevens Brook by following a line, cut in 1937 by a provincial prospecting party, which lies south of and runs roughly parallel to the portage road mentioned above.

The first description of the occurrence is given in the 33rd annual report of the provincial Crown Lands Department by Edward Jock who describes what had been done up to 1893, and states that a shipment of 40 tons of ore was made in bags to Bathurst. In 1927 an examination of the property, involving an opening up of the old workings, was made by Mr. W. M. Goodwin for the Pioneer Mining Corporation. At that time the property was held by Messrs. G. S. Gilbert and George Gilbert of Bathurst. In 1937 the Consolidated Mining and Smelting Company of Canada, Limited, undertook to explore the zone, and carried out surface work and diamond drilling. Their option included a belt of country extending for about 4 miles along the north side of Millstream River from the Stevens Brook arsenic showing on the east to the Rocky Brook deposit on the west.

The region is heavily drift covered and outcrops are few. At the main showing on Rocky Brook the rocks are grey, banded, cherty argillites, which may in part at least be composed of tuffaceous material. Along the brook also are exposures of dark igneous rocks, which are either dykes or flows interbedded with the sediments. Numerous large blocks of granite, particularly in the area around Stevens Brook, suggest that granite may underlie part of the region.

The original discovery was made on the northeast side of Rocky Brook, where an iron-stained outcrop forms the bank of the stream. The rock there is mineralized with small, irregular patches of sulphides consisting of sphalerite, pyrrhotite, pyrite, arsenopyrite, and a little galena, and contains also a few quartz stringers. The old workings are on either side of the stream along a line that extends in a northeast-southwest direction for a distance of over 1,400 feet. They consist of eleven openings, two of which are shallow shafts. In the shafts disseminated sulphides and small masses of ore occur, but no large body was exposed and assays of samples gave only low values in lead, zinc, silver, and gold. In 1937 the Consolidated Mining and Smelting Company drilled at an angle of 45 degrees to the north from near the north bank of Rocky Brook east of the original discovery to intersect the mineralized zone at depth. Some mineralized rock was cut, but nothing as encouraging as the best material seen at the surface. The company in the same year also drilled a mineralized showing a short distance south of the portage road and some 2½ miles east of the Rocky Brook discovery referred to above. Trenching had revealed sphalerite and galena replacement mineralization across a width of 14 feet. Drill holes put down from the south to intersect the zone at depth showed, however, only a slight amount of mineralized material.

### ELMTREE RIVER

Sulphides occur at several places on Elmtree River, and at one locality about 4½ miles from the coast development work has been carried out on more than one occasion. The showings are readily reached by car from the coast highway at Elmtree by following a good gravel road past Madran.

In 1882 the Elm Tree Mining Company was incorporated to work the property. A description of the deposit as exposed by this early work is given by J. E. Hardman in the 32nd annual report of the provincial Crown Lands Department, 1893. About 1918 trenching and diamond drilling were carried out. In 1937 another attempt was begun to explore the deposit, this time by Mr. J. D. Dunlop of Bathurst. Some of the old trenches were cleaned out and in 1939 a number of diamond drill holes were put down at two places along the river.

The rocks of the region are black slates and quartzites of the so-called Elmtree group of Palæozoic age. The main deposit is a vein or vein zone exposed in the bed of the river and striking northwest. The material of the zone consists of sphalerite, galena, chalcopyrite, pyrite, quartz, calcite, and country rock. The average width is about 6 feet. To the northeast of this showing a shaft was sunk during the early development to explore a zone of slates cut by numerous small veins of quartz and calcite. The width of this zone is about 15 feet and the veins in it locally carry pyrite and some galena. Other showings of mineralized rock also occur along the river, but no large body of ore has been proved.

### MCNAIR BROOK

This mineral showing is in range 8, block 4, Restigouche county, on Upper McNair Brook, a tributary of Jacquet River. The easiest route to it is from Lorne settlement, which is on a good motor road about 5 miles southwest from the coast highway at Nash Creek. From Lorne settlement a wood road, known as the Louizon portage, leads to a set of lumber camps on Lower McNair Brook, a distance of 9 miles, and from there the portage continues for a farther distance of 3½ miles to an old camp-site on Upper McNair Brook. The mineral showing is on the river about 1½ miles below this camp-site. The brook there flows in a narrow valley with steep sides about 400 feet high and the valley bottom is narrow and marked by rapids, small falls, and rocky gorges. The mineralized showings occur both above and below a falls along a length of about 250 feet.

The rocks of the region are of Lower Devonian age and consist chiefly of volcanic rocks of varying composition. They are mostly dark grey andesites, but associated with them are reddish rhyolitic varieties. The greater part are massive flow types that are locally amygdaloidal and in places porphyritic, but tuffs and breccias also occur. On the river below the showing bands of red shale and conglomerate are associated with the volcanic rocks.

The main mineral showing is in the face of a cliff on the west side of the brook about 200 feet below the falls referred to above. The rock is fractured, contains crystals and small masses of sulphides, and is cut by narrow veins and stringers of quartz. In places thin seams of sulphides occur around the borders of the fractured blocks. The chief sulphide is pyrite, but chalcopyrite is also present in small amounts. Cubes of galena are scattered through the rock and galena and pyrite are present in the quartz veins and seams. A grab sample taken from some of the more highly mineralized rock assayed 2·66 ounces of silver to the ton and only a trace of gold. A second sample, taken from a mineralized part of a quartz vein, gave 1·34 ounces of silver to the ton and 0·005 ounce of gold.

Just above the falls a shear zone about 4 feet wide shows up on the east side of the brook in the wall of a gorge. The schistose rock is sparsely mineralized with pyrite.

### BIGHOLE BROOK

On Bighole Brook, a tributary of Jacquet River, a number of mineral showings are held by Mr. Alex. Doyle of Maple Green. They are most readily reached by a portage road, 2½ miles long, beginning at Lorne settlement. The deposits are veins and replacements in volcanic rocks of Lower Devonian age. The writer visited the showing in company with Mr. Doyle, in 1928. The latest work was carried out in 1938, concerning which W. J. Wright, provincial geologist, reports: "The exploration was devoted chiefly to showings on the brook which in this locality flows between steep banks about 50 feet high. Eight veins were exposed by trenching in a distance of 1,900 feet. They vary in width up to 24 inches and are composed chiefly of ankerite, with galena and sphalerite distributed in thin sheets and lenses. The veins strike approximately east and west magnetic, but a plan does not indicate that the individual showings belong to one lead. Ten assays indicate that the average values of lead and zinc combined are less than $5 per ton. Silver was not detected in 10 samples, and the maximum value of gold was 0·01 ounce per ton."

### NIGADU RIVER

An occurrence of galena on the North Branch of Nigadu River was investigated many years ago. The showing is on the south side of the stream about half a mile above the junction with the South Branch, a distance of about 8 miles from the coast. R. W. Ells, in the Report of Progress

1879-80, Part D, mentions having visited the locality in 1879, and states that subsequent to his visit mining operations had been started but the extent of the vein was not fully determined. The main work was the sinking of two shafts about 300 feet from the brook. In a later report, 1880-82, Ells states that the deposit was opened up to considerable depth, but that it did not fulfil the expectations of the proprietors of the property. A report by Hoffmann on a sample from the property states: "A fine crystalline galena, associated with a little zinc blende, in a more or less weathered rocky gangue. The metallic sulphides constituted but a small proportion of the whole. It contained:

| | |
|---|---|
| Gold | trace |
| Silver | 5·811 ounces to the ton of 2,000 pounds." |

In 1937 diamond drilling was carried out by the Nigadu Gold Mining Syndicate, but only small amounts of sulphide were encountered.

## MOLYBDENITE

A deposit of molybdenite occurs near Pabineau Lake, about 10 miles southwest of Bathurst. It is most readily reached from the road that follows up the north side of Little River. From the end of the car road the route continues along the Little River portage road for a distance of 2½ miles and then just south of where the road crosses the river a branch trail to the east leads to the showing, a farther distance of 3½ miles.

The rocks of the Little River region consist of Devonian granite and Ordovician sedimentary and volcanic rocks. In the region around Pabineau Lake the country is low and drift covered. In the lake are large blocks of granite and some 300 yards west of the north end of the lake is an open area in which several patches are covered by huge blocks of the same rock, suggesting similar material in place beneath. In one such nest about 30 feet in diameter many of the blocks carry molybdenite. The granite is pink to reddish, of medium grain, and consists of orthoclase, albite, quartz, and biotite, with accessory iron ore and apatite. It is locally cut by pegmatitic phases and small quartz veins. Where molybdenite is present it occurs as small masses disseminated in the granite, as flakes along seams in the rock, in small quartz veins cutting the granite, and as bunches associated with small, irregularly shaped masses of quartz in the granite. In places the molybdenite masses take a rosette shape. Some beryl is associated with the molybdenite and quartz, and at one place several crystals of topaz were found. The molybdenite and associated minerals were derived from the magma that produced the granite.

The property is held at present by Mr. Peter Bourque of Dalhousie. In 1933 he carried out development work to explore the bedrock beneath the boulders. A shaft was sunk to a depth of 29 feet, and 8 feet below the surface granite in place was encountered similar to that of the blocks above, and similarly mineralized. At the bottom of the shaft a quartz vein about 6 inches wide and carrying molybdenite was exposed along with several other stringers, one of which has a width of 2 inches. The more highly mineralized material was hand cobbed and a shipment of 700 pounds was made to the Mines Branch laboratories at Ottawa. This material ran 5·2 per cent molybdenite and it was found easy to separate the sulphide from the enclosing rock by crushing and flotation, getting a concentrate of 85 to 90 per cent $MoS_2$ with a high recovery of the molybdenite content.

In the autumn of 1939 further exploration work was carried out on the property by a group of prospectors working for the provincial department.

## ARSENIC

A deposit of arsenopyrite occurs on Stevens Brook, a tributary of Millstream River. The property is about 12 miles northwest of Bathurst and is reached by a wood road, 1½ miles long, leading from the end of the motor road near Ste. Rosette.

The rocks exposed along the stream consist of altered sediments, dark tuffs, and volcanic breccias, all probably of Ordovician age. The sediments are cherty argillites and argillaceous limestones striking about east and standing either vertically or with a steep dip to the north. Numerous granite boulders in the region surrounding the deposit suggest that an intrusive mass of this rock may be concealed by the drift.

A number of small open-cuts at intervals for a length of 200 feet along the eastern bank about 20 or 30 feet above the brook expose small bodies of sulphides, chiefly arsenopyrite, pyrite, pyrrhotite, and chalcopyrite. These mineral lenses appear to be unconnected with each other and to consist of separate replacements along different slaty bands. In the main open-cuts the sulphide-bearing zone does not appear to exceed 3 feet in width; local solid masses of arsenopyrite have widths of 6 to 8 inches. Commonly the sulphides occur as tiny veinlets or fine-grained patches disseminated through the altered and silicified country rock. Assays of selected mineralized rock gave values of 80 cents to $7 a ton in gold and from 22 to 28 per cent of arsenic.

The development work consists of trenches to bedrock, a pit about 10 feet deep, and a shaft 15 feet deep. About 350 feet farther north some trenches in the opposite, or west, side of the brook exposed similar deposits. Owing to the irregular nature of the deposits more development work is necessary to determine their extent and value.

## COPPER

Small amounts of chacopyrite are associated with pyrite and other sulphides in a number of places throughout the area, but nothing of sufficient importance to encourage development has been found. At the falls on Tetagouche River, about 8 miles from Bathurst, quartz veins cut slates of Ordovician age and carry a little chalcopyrite and pyrite (Bailey, 1889, page 26). Within a distance of 60 feet there are seven of these veins, which locally reach a width of 5 feet. About the year 1859 or 1860 a small amount of development work was carried out and some ore was shipped to England, along with some manganese-bearing material from the same locality. Work, however, was soon discontinued and no attempt has been made to further explore the occurrence.

The occurrences referred to above are believed to be related to the deep-seated intrusives of Middle Devonian age that occur in the region. An occurrence of chalcopyrite of different origin is found in the Pennsylvanian rocks that outcrop along the lower part of the Nipisiguit. Here a few, small, irregular masses and narrow stringers of chalcopyrite in the sandstone are accompanied by small amounts of malachite and green copper stain. 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). Occurrences similar to this are known in the Carboniferous rocks in other parts of the province, particularly at Dorchester, in Westmorland county, and at New Horton, in Albert county. The amounts of copper minerals in each case are small, but the mode of origin is of interest. The pre-Carboniferous rocks of New Brunswick, which furnished the detrital material for the Carboniferous sediments, contain locally quartz veins carrying chalcopyrite and bornite, and as a result these minerals were contributed in small amounts to the sediments. The copper sulphides are now commonly found 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.

## IRON

A deposit of iron ore occurs near the portage road that leads from Ste. Rosette westward towards Rocky Brook. The main showing is about 100 feet north of the portage about 5 miles from the end of the motor road. It is on the side of the valley of a small stream that drains through a series of ponds to Millstream River. A description of the deposit is given by G. A. Young in Memoir 18-E and is accompanied by a plan on a scale of 400 feet to 1 inch.

The region is heavily drift covered and rock exposures are few, occurring mainly in the stream beds and valley sides. The rock exposures include argillaceous limestone, cherty argillites, and tuffaceous beds, all probably of Ordovician age; in addition, there are associated dark, massive, volcanic rocks and diabase and serpentine. Many large boulders of granite may mean that rock of this variety is concealed by the drift.

The ore consists mostly of magnetite in a gangue of garnet. It has a banded appearance, streaks and lenses of magnetite alternating with similar zones of garnet. Other minerals present in the ore include pyroxene, epidote, chalcopyrite, and pyrite. The garnet is the andradite or calcium-iron variety, and is grey to white with brownish or reddish tinges. The magnetite is commonly granular, many of the grains showing crystal forms. In the few places where the enclosing rock is exposed it is seen to consist commonly of banded material made up of irregular streaks and layers of pale reddish grey garnet and dense, pale green epidote. In places also are outcrops of dense, dark, indistinctly foliated rocks; some of these are made up of fibrous green hornblende, in some cases impregnated with fine magnetite; others are mainly composed of finely granular augite embedded in chlorite or serpentine. At one place a dyke of light pink aplite cuts the banded garnet rocks.

There is no abrupt change from ore to country rock; the lenses and streaks of magnetite just become fewer and smaller and finally disappear. At the one place where the full width of the deposit was exposed it was about 40 feet wide, but only about half of this width could be considered ore. Lack of exposures prohibited the determination of its length, but outcrops of similar material occur along the same strike for a distance of over a mile. It is probable that the zone shows great irregularity along the strike as well as across it.

Assays of material from the surface and from diamond drill cores showed a considerable variation in the iron content, the results ranging from above 60 per cent iron to below 40 per cent. In some places the copper content in the drill cores for a few inches reached as high as 6 per cent.

The general character of the deposit and its mineral association suggest that it belongs to the contact metamorphic variety produced at high temperature by the action of an igneous mass intrusive into the sediments of the region. As has already been mentioned, the large number of huge blocks and boulders of granite occurring as erratics is an indication that an intrusive mass does occur here beneath the drift, though as yet no outcrop of such rock has been found.

## MANGANESE

"One of the earliest attempts, if not the first, at mining in New Brunswick, was made in connection 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 adit 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).

## LIMESTONE

Lying between Elmtree and Nigadu Rivers is an area underlain by Silurian rocks whose succession, as exposed in the shore section at Petit Rocher, has been described in the chapter on general geology. The beds include conglomerate, grit, sandstone, shale, and limestone of the Clemville formation, limestone of the LaVieille formation, repeated twice as a result of faulting and folding, and reddish and greenish sandstones of the Gascons formation.

Several quarries for the production of limestone have been opened up at various times in this area. At present the only activity is at a crushing plant operated by Mr. George Gilbert of Bathurst, where a production of limestone fertilizer has been maintained since 1933. The quarry is situated about a mile west of Petit Rocher Nord in a field just north of a motor road and south of a small brook. The limestone has a pink tint and strikes northeast, apparently in line with the limestone beds at Limestone Point. The following is a composite of several analyses of typical material:

| | Per cent |
|---|---|
| Loss on ignition | 42·65 |
| Silica and insoluble | 2·37 |
| Iron and aluminium oxides | 0·81 |
| Calcium oxide | 53·66 |
| Magnesium oxide | 0·52 |

## BUILDING STONE

Stone for the construction of the church at Petit Rocher was obtained from an exposure of granite on Elmtree River about 2 miles from the coast. The locality is at the bridge on the motor road leading south from Madran. Outcrops of the intrusive extend for a distance of 120 feet downstream from the bridge and for 50 feet upstream. The rock intrudes sediments of the Elmtree group.

The rock is fairly even textured and fine to medium grained, consisting mostly of light grey feldspar and quartz with abundant black hornblende. Small, scattered crystals of pyrite are present, and in thin section calcite and apatite are seen. The rock is irregularly jointed, but fairly large blocks can be broken out. The ease of access to the quarry renders it probable that further use of the rock may be made locally for such purposes as foundations for buildings or bridges.

## ROAD METAL

The region is well supplied with gravel for road construction. Reference to such occurrences have been made in Chapter III in connection with the description of the Pleistocene deposits.

84985

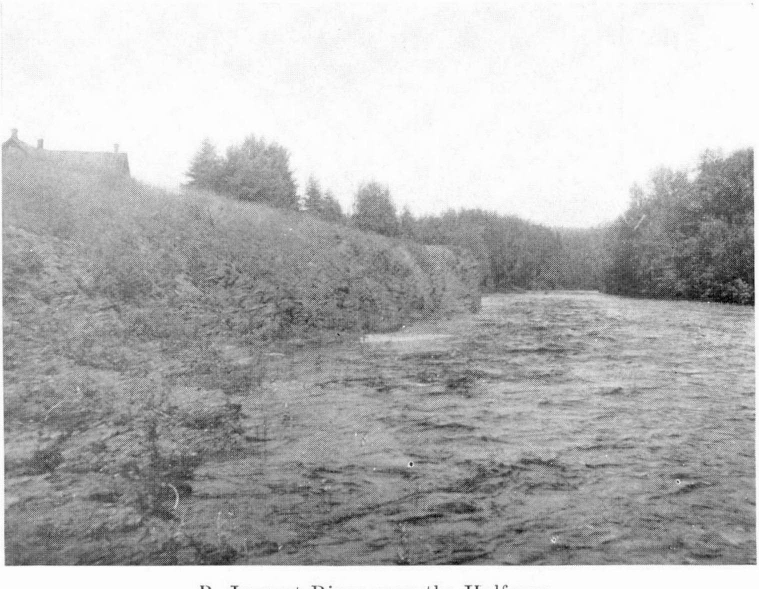
A. View from Middlebrook tower, showing the general character of the country.

B. Nigadu Lake.

PLATE II

85659

A. Falls on South Branch Nigadu River near Nigadu Lake.



B. Jacquet River near the Halfway.