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DEPARTMENT OF MINES AND TECHNICAL SURVEYS

GEOLOGICAL SURVEY OF CANADA

MEMOIR 276

LA POILE-CINQ CERF MAP-AREA, NEWFOUNDLAND

BY

J. R. Cooper

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EDMOND CLOUTIER, C.M.G., O.A., D.S.P.
QUEEN'S PRINTER AND CONTROLLER OF STATIONERY
OTTAWA, 1954

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Aerial photograph of La Poile Bay looking north. North Bay in distance. Royal Canadian Air Force photograph.

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PREFACE

La Poile-Cinq Cerf map-area extends inland from the southeast coast of Newfoundland, across a terrain of metamorphosed igneous and sedimentary rocks that had previously been referred with some conviction to the Precambrian.

During the field seasons of 1937 to 1940, the Geological Survey of Newfoundland investigated the geology of this area and its potential mineral resources. The present report, written by an officer of that organization, makes a number of significant contributions to our knowledge of the geology of the area, contributions that will profoundly modify our concepts of the geology of the entire island. Indisputable evidence is presented that some of the strata and most of the intrusive rocks are Devonian in age. The genesis of the mineral occurrences is treated in some detail.

A short time after Confederation between Newfoundland and Canada, this report, unpublished at that time, was handed to the Geological Survey of Canada. This organization now, with great pleasure, releases it.

W. A. BELL,
Director, Geological Survey of Canada

OTTAWA, July 1, 1953

La Poile-Cinq Cerf Map-area, Newfoundland

CHAPTER I

INTRODUCTION

LOCATION AND MEANS OF ACCESS

La Poile-Cinq Cerf map-area is an irregularly defined region on the south coast of Newfoundland about 35 miles east of Port aux Basques. In general the area extends from La Poile Bay to Couteau Bay and inland about 28 miles.

The most important settlements are the fishing villages of La Poile and Grand Bruit, and the lumber and boat-building village of North Bay.

La Poile and Grand Bruit are stopping points in the fortnightly steamship service between Port aux Basques and Argentia. There are no roads within the area.

FIELD WORK AND ACKNOWLEDGMENTS

Field work in this area was performed during the seasons of 1937, 1938, 1939, and 1940. George W. Dawson, Allen V. Heyl, Jr., Roy D. Hoke, and Robert Hutchinson served as geological field assistants. Reuben Skinner of Rose Blanche and Alex Strickland of North Bay served as prospectors, and Albert G. Chant of La Poile as cook and boatman. It is a pleasure to thank them all for their enthusiastic co-operation, often under trying circumstances.

The owners and managers of the various mining claims in the area have co-operated in many ways. Particular thanks are due the owners of the Strickland claims, the owners of the Chetwynd claim, and Mr. John Horwood of the Newfoundland Mining Syndicate for many courtesies.

British Admiralty charts of the shoreline and surveys by the Surveys Division, Department of Natural Resources, Newfoundland, were used as base maps. The latter include a contoured map of part of the area and a detailed survey of the Strickland prospect. Of necessity, much of the geological field study was made in areas not yet mapped topographically. This was done by pace-and-compass traverses controlled by triangulation with Brunton compass. In the northeast corner, mapping was carried 10 to 14 miles beyond the area for which precise topographic information is available. This was done by running compass-and-chain traverses of all the main streams and filling in details by pace-and-compass traverses between the main streams.

The microscopic study of polished specimens of the Strickland lead-zinc-silver ores was carried on by A. P. Beavan in the geological laboratories of Princeton University. A similar study of the Cinq Cerf gold-copper deposits was made by E. W. Greig, also at Princeton University. These metallographic studies yielded valuable data on the paragenesis and are gratefully acknowledged. General conclusions based on them are those of the writer.

The only published descriptions of the area are of the Cinq Cerf gold-copper deposits. These include some notes by Howley (15, pp. 521, 539, 565)[1], a brief description by Snelgrove (18, pp. 11-16), and the results of a reconnaissance geophysical survey ("spontaneous polarization") by Sherwin F. Kelley (6, pp. 170-171). These and an unpublished preliminary report on the Bay du Nord[2] area by C. K. Howse (12) have been used.

Professor Erling Dorf of Princeton University kindly identified the plant fossils.

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[1] Figures in parentheses refer to the Bibliography on page 3.

[2] Bay du Nord is local usage for the northern arm of La Poile Bay, termed North Bay on the map accompanying this report. The name Bay du Nord is, however, retained for a group of Devonian strata (*See* page 10).

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CHAPTER II

GENERAL CHARACTER OF THE REGION

TOPOGRAPHY

The region is rugged and ranges from sea-level to more than 1,300 feet in elevation. Much of the dissection has been due to stream erosion, but glacial action has been contributory. The latter has been responsible for the La Poile Fiord with its hanging valleys, a multitude of rock-basin lakes, and lee and stoss topography, which is evident in *roches moutonnées* and in some large hills.

Bedrock structure is clearly reflected in the topography. Shale, slate, and soft schist have been eroded to form valleys and subdued hills. Associated conglomerate, as well as massive lava, tuff, and chert underlie sharp hills and hogbacks. Near the coast, the granites and other intrusions do not cause conspicuous land forms, but farther inland form prominent summits.

The area may be described as a rolling upland in a youthful stage of dissection, except near the coast where the land is more mature. The coastal belt is 2 to 5 miles broad and is sharply dissected into steep-sided hills that rise 250 to 600 feet above sea-level. Elevations are higher inland, Baggs Hill and other summits exceeding 1,300 feet. The increase in altitude with distance from the sea is gradual, except between Cinq Cerf and Roti Brooks where the land rises precipitously about 2 miles from the coast. This upland, known as the Highlands of Grand Bruit, is the most striking physical feature of the area when seen from the sea. Its elevation is not accurately known, but exceeds 1,000 feet.

The higher interior part of the area is less dissected than the coastal belt, and valley bottoms are about 1,000 feet above sea-level near the north boundary. Here, as elsewhere in Newfoundland, a relatively recent rejuvenation has taken place. Recently Twenhofel and MacClintock have postulated three erosion cycles in Newfoundland prior to the present one (20). The writer is unwilling to attempt correlations with these three peneplains. The upland surface is generally quite irregular, much more so than on the Long and Serpentine Ranges in western Newfoundland. Beyond the boundaries of the area, the Blue Hills of Couteau, the Garia Hills, and others rise above the summit levels to a considerable but unknown height. As seen from the hilltops of the area, the horizon shows some low conical mountains resembling typical monadnocks, but most of the eminences have steep sides and rough summits. Because of this it is suggested that the oldest and best-developed erosion surface, the Long Range peneplain, has here been largely, if not wholly, destroyed by later erosion.

DRAINAGE

La Poile River[1] and Cinq Cerf Brook are the main streams in the area, the former being the larger. The La Poile River drainage basin widens inland and includes the northern part of the mapped area. The basin of Cinq Cerf Brook lies almost entirely within the area, as do those of all other streams except Broad Cove Brook, which flows into La Poile Bay from the west.

Excepting the lower reaches of La Poile River and Cinq Cerf Brook, which have narrow valley flats, the drainage is in a youthful stage of development. Marshes and ponds are common, and all streams have falls and rapids along their courses. The headwater streams flow in broad open valleys on the plateau and then drop by a succession of falls and rapids into narrow and typically youthful valleys. Small streams have falls near their mouths, larger streams farther inland; the main falls of La Poile River and Cinq Cerf Brook are, respectively, about 20 miles and 8 miles inland. Numerous waterfalls give the area a picturesque aspect and should not be overlooked as a potential source of hydro-electric prower[2].

COAST-LINE AND SEA FLOOR

The shoreline is intricate, with numerous bays, coves, peninsulas, and small islands. The general features and many details reflect the rock structure. La Poile Bay, the largest inlet in the area, is underlain by soft slate and schist lying between granite on the west and massive rhyolite and quartz porphry on the east. Roti Bay, Jacques Island, and the long peninsula east of La Poile Bay depend also on the strike of the rocks for their configuration. The gneiss and granite forming the coast in the eastern half of the area are too massive to form distinctive shore features, although Couteau Peninsula and the northeast arm of Cinq Cerf Bay parallel primary flow structure and, locally, secondary foliation in the granite.

The shore is narrow, rocky, and generally bordered by wave-cut cliffs. The cliffs are less than 50 feet high except on exposed headlands and in the northern parts of La Poile Bay, where they attain 200 and even 300 feet. Beaches are not prominent, being confined to coves, spits, bay-bars, and tombolos. As would be expected, they are best developed in the protected inner reaches of La Poile and Cinq Cerf Bays.

The features of the sea floor are due to recent submergence of the land. Small bays, such as Roti Bay and Little Bay, are stream valleys drowned by the sea. For a mile or two seaward from the southern shore, the sea is shallow, with many islets, rocks, reefs, and shoals. The 20-fathom line apparently marks the outer margin of this zone. Doubtless there has been glacial scour and deposition of drift throughout this zone, but such effects are evident only in La Poile Bay, which has been gouged into a fiord. It is a U-shaped trough 10 miles long and over 100 fathoms deep, which has a relatively shallow threshold at its southern entrance. Little Bay and La Poile Harbour are submerged, tributary hanging valleys. These have

[1] The name La Poile River is here applied to the main stream of the system. The part of La Poile River as thus defined, which lies above the mouth of Bunker Hill Brook, is known locally as Billiards Brook.

[2] *See* "Water Power", page 37.

not been deepened by glacial scour, but may have been partly filled with drift. The depth at the mouths of these submerged hanging valleys, as well as depths in Roti Bay and at the outer margin of the reef zone, suggest a submergence of at least 150 feet.

Northern and central Newfoundland have risen, with southward tilting, in post-Glacial time. Recently, Flint has made a comprehensive study of these movements, contributing much new data for western Newfoundland (7). He finds two shorelines clearly marked by wave-cut benches as well as by constructional forms like beaches and deltas. One of these is at present sea-level, the other, which he calls the Bay of Islands surface, rises from sea-level, in the vicinity of Port au Port, in a northwesterly direction. The rate of rise is about 1·7 feet per nautical mile along the coast and nearly 3 feet per mile in the steepest slope direction, which is approximately north-northwest (6, pp. 1770-71 and Fig. 2). He makes the logical inference that the Bay of Islands surface and the present shoreline features indicate long still-stands of sea-level. The highest marine limit was above the Bay of Islands surface, but is very indistinctly recorded. It is more than 60 feet above present sea-level in the southern part of Bay St. George (7, Plate I) and probably 50 feet along the west side of Fortune Bay (7, pp. 1773-74). Emerged marine features were not found in the La Poile-Cinq Cerf area, however, and Flint found none in the southwestern corner of Newfoundland. Flint interprets this as showing that this latter part of the coast was covered and protected by glacial ice during the earliest and highest stands of sea-level (7, pp. 1772-74). Future investigations along the south coast should be directed especially to headlands, points, and off-lying islands in an attempt to check this conclusion.

CHAPTER III

GENERAL GEOLOGY

GENERAL STATEMENT

The oldest known rocks in the area are those of the Keepings gneiss group. These rocks are intruded by granite and granite-gneiss. The whole assemblage is believed to be pre-Devonian and possibly Precambrian in age.

Rocks of the Bay du Nord group, of Devonian age and sedimentary origin, are separated from rocks of the Keepings gneiss by a later intrusive body. Sedimentary and volcanic rocks of the La Poile group are separated from those of the Bay du Nord group by intrusive bodies and by a fault. Rocks of the La Poile group are, however, together with a group of metamorphosed sedimentary and volcanic rocks, and a largely intrusive quartz porphyry, believed to be younger than rocks of the Bay du Nord group.

Intruding these rocks are several igneous bodies, which range in composition from acidic to ultrabasic, and which have undergone degrees of metamorphism that permit tentatively classifying them as having been intruded prior to the folding of the Devonian rocks; intruded during the folding of those rocks; and intruded after that folding was completed.

The region has been glaciated, and glacial deposits overlie rocks of all the earlier groups.

TABLE OF FORMATIONS

Era	Period or Epoch	Group or formation, and thickness in feet	Lithology
Cenozoic	Pleistocene	——	Glacial drift
Palæozoic	Devonian	Chetwynd granite	Granite
		Completion of orogeny	
			Derivative dyke rocks
		——	Porphyritic biotite granite; injection gneiss
		——	Hornblende-biotite granodiorite
		Baggs Hill granite	Pink and grey granite

Era	Period or Epoch	Group or formation, and thickness in feet	Lithology
Palæozoic—*Conc.*	Devonian—*Conc.*	Roti granite	Gneissic biotite-hornblende granite, granite porphyry
		——	Diorite, quartz diorite, gabbro, peridotite, amphibolite, serpentine
		Beginning of orogeny	
		——	Fine granite-gneiss, granulite
		Dolman gneiss	Orthogneiss, paragneiss
		——	Quartz porphyry
		Intrusive contact	
		La Poile group 13,000	Rhyolite, trachyte, tuff, minor shale, arkose, conglomerate
		Unconformity	
		——	Schist, paragneiss, conglomerate, minor volcanic rocks
	Lower or early Middle Devonian	Bay du Nord group 10,000	Slate, argillaceous quartzite, greywacke, grit, conglomerate, minor limestone
Precambrian or Palæozoic	Pre-Devonian	Northern granite	Granite, granite-gneiss
		Intrusive contact	
		Keepings gneiss	Granite-gneiss, hornblende gneiss, amphibolite, banded paragneiss

PRE-DEVONIAN COMPLEX

Keepings Gneiss

The name Keepings gneiss is used by the writer for a group of orthogneisses and paragneisses associated with other coarse metamorphic rock types, and believed to be, collectively, the oldest rocks in the area.

Rocks of this group occur on both sides of Morg Keepings Brook, near the north boundary of the area, and underlie about 9 square miles. Surrounded as they are by younger intrusions, their age must be inferred. They are considered to be the oldest rock group in the area, and possibly Precambrian in age.

The predominant rock type is granite-gneiss, which varies considerably from place to place. The bands and foliation are contorted, and at some places more than one disturbance and period of injection were noted. The gneiss is commonly granitic in composition, but in places it is much contaminated by sedimentary material. Banded grey or greenish paragneiss, siliceous gneiss, hornblende gneiss, and amphibolite were also noted. The amphibolite is spectacular in hand specimen, and commonly consists of hornblende crystals an inch or two long, with garnet and quartz discernible as smaller grains.

The contact between the Keepings gneiss and the Northern granite batholith is difficult to observe because of the general similarity of the gneiss to the sheared phases of the batholith. The relative abundance of amphibole was used to differentiate these rocks, and this method proved fairly satisfactory. The granite is very low or lacking in amphibole, whereas the gneiss has bronze-coloured to greenish black amphibole as a prominent constituent in most hand specimens.

The Keepings gneiss is considered pre-Devonian because of its uniformly high degree of metamorphism, generally coarse texture, and difference in structural trend from the Devonian rocks.

Northern Granite

The term 'Northern granite' is applied to the intrusive rocks that occur on three sides of the area underlain by Keepings gneiss, and which are believed to be younger than the gneiss and generally older than the earliest Devonian rocks in the area. The rocks are very poorly exposed, and this, as well as the natural difficulties of the terrain in the extreme north of the area, prevented an extensive study of these rocks. It is probable that some of the rocks included in this map-unit are younger than pre-Devonian.

The rocks range from coarse, pink, undeformed leucogranite to fine, pink and greyish, sheared granite and granite-gneiss. In places the contact with the Keepings gneiss is not well defined, and it is possible that further work will indicate that at least two intrusions are represented.

A body of unsheared pink leucogranite in the extreme northeast corner of the map-area extends north into adjacent unmapped areas. Exposures are not plentiful enough to enable the rock to be mapped separately, or to determine its relation to the sheared phases. Two thin sections were studied. Neither showed evidence of cataclastic deformation, even the quartz being devoid of strain shadows. Both of the thin sections are of sodic granite, albite-oligoclase being considerably in excess of potash feldspar. The latter is largely included in coarse microperthite, which is approximately half albite-oligoclase. The only primary ferromagnesian mineral is hornblende. These petrographic characteristics are unlike those of comparable rocks among the Devonian intrusions farther south. It is possible that this unsheared granite is part of the main mass of the Northern granite, much of which is gneissic, as the central part of a large body of competent rock, such as granite, may be undeformed, whereas the margins of the same body may be intensely sheared.

DEVONIAN STRATA

Three groups of strata, including both sedimentary and volcanic rock types, have been recognized in the map-area. That which is believed to be the oldest, the Bay du Nord group, carries Devonian fossils. A group of schists and gneisses is nowhere in contact with rocks of the Bay du Nord group, but is believed, on very broad and inconclusive structural grounds, to be younger. The schists and gneisses are, however, in contact with rocks of the La Poile group, largely of volcanic origin, and are believed, on structural grounds, to be older than the La Poile rocks.

Bay du Nord Group

'Bay du Nord' is a name proposed for a group of sedimentary rocks, largely clastic in origin, and bearing fossils of Devonian age. North Bay[1], the northern arm of La Poile Bay, after which the group is named, lies entirely within rocks of the group.

Rocks of the Bay du Nord group occur in two main belts, which may be considered to join at their eastern extremities. The southern belt extends northeasterly from the head of La Poile Bay across the area and is the south limb of an anticline. The north limb of the anticline extends slightly north of east from a point on the west side of the area about 10 miles north of the head of North Bay. In the western part of the map-area, the anticlinal limbs are separated by an intrusion of porphyritic biotite granite. The lowermost beds of the group, exposed along the anticlinal axis, are intimately injected by this granite, and the zone of injection is indicated separately on the map. To the north, Bay du Nord rocks are bounded by dioritic intrusions, and to the south by the Baggs Hill granite and by intrusive gneisses.

The thickness of the Bay du Nord group is estimated to be 10,000 feet, not including that part injected by granite. If this latter were included, the total would be nearer 15,000 feet. The group consists almost entirely of clastic sedimentary rocks. Slate, and its equivalents (phyllite and mica schist), predominate. The slate is grey to bluish black, and contains carbonaceous material. A banded variety is common, with alternating siliceous and argillaceous layers, the latter being darker. Individual bands are generally less than an inch thick, and resemble varves. Metamorphic flow cleavage and fracture cleavage have been developed, and both of these and bedding are well displayed in some areas.

Argillaceous quartzite and greywacke are abundant, and thin conglomerate beds are widespread but uncommon. One conglomerate zone, however, 1,500 feet thick and about 3 miles long, occurs in the northern belt, where it is followed for 2 miles above Morg Keepings Brook by La Poile River. This conglomerate carries limestone pebbles, which were not observed in the other conglomerates of the area. The only fossils found came from black slate of this conglomerate zone. A few thin beds of crystalline limestone occur in the northern belt; limestone was found in the southern belt only on the Strickland claims.

Volcanic rocks have not been identified but may be represented by diorite and shonkinite gneiss and schist, and by amphibolite.

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[1] *See* footnote 2, page 2.

Fossil plants were found in black slate within a narrow zone exposed on La Poile River between the mouths of Morg Keepings Brook and Fox Hole Brook. The fossils are impressions and graphitic residues. A collection was sent to Professor Erling Dorf of Princeton University, who wrote: "All the spiny stems belong to the species *Drepanophycus spinaeformis* Göppert (=*Arthrostigma gracile* Dawson) without any doubt. Your discovery is only the fourth known occurrence in North America—the others being Gaspe, northern New Brunswick, and northern Ontario . . . . Outside of North America, this widespread species is apparently known only in the Lower Devonian (Scotland, Norway, Germany, and China). In North America it is also known in the Lower Devonian (Ontario), but its occurrence in Gaspe and New Brunswick is in beds originally referred to the Lower Devonian and recently called lower Middle Devonian. It is safe to say, then, that your plant-bearing beds are of Early Devonian to early Medial Devonian age"[1].

Knowlton points out that the species *Arthrostigma gracile* is among the oldest known land plants (13, pp. 51-60). This indicates that the Bay du Nord group originated as a terrestrial deposit or was laid down in a lake or estuary of the sea. In view of the occurrence of varve-like bands and abundant carbonaceous material, and because marine fossils are apparently lacking, a lacustrine origin of the sediments is considered most probable.

The middle and greater part of the Bay du Nord group lies in the 'biotite zone' of metamorphism as recognized in the Scottish Highlands by Harker (10, pp. 215-218). The grade of metamorphism increases near the igneous intrusions at the top and bottom of the section, and also northeastward along the strike. Slate and greywacke grade into grey schist and gneiss. Garnet, indicating a higher grade of metamorphism, occurs at numerous places in this zone, and to the northeast much hornblende is present. The highest grade of metamorphism is found at the east end of the northern belt, where coarse, garnetiferous mica and hornblende schists abound.

Although metasomatic replacement has played a small part in the general metamorphism, considerable material has been introduced locally, as indicated by the occurrence of silicified and sericitized lenses containing metallic minerals. The general features of these altered zones are considered here, and their economic aspects on pages 41 and 50. The altered rocks range from quartz-sericite schist to massive quartzite and sericite schist. They weather buff or white, and generally have the rusty appearance of gossan. The lenses range in thickness from a foot to 500 feet, and some of them may be traced more than a mile. The lenses invariably trend parallel with the strike of the enclosing strata and, apparently, selectively replace favoured beds.

The factors controlling the locus of silicification and sericitization are obscure. The altered lenses are distributed throughout the upland east of North Bay and La Poile River Valley and thus have a wide stratigraphic range, and it is, moreover, evident that quite different rock types have been replaced.

[1] This was written prior to publication, by Dorf and Cooper, of a description of these fossils and of their enclosing rocks. This paper has been added to the bibliography and is item 5.—*Ed.*

Schist and Gneiss

For convenience in description, those stratified rocks that do not fall readily into either the Bay du Nord or the La Poile groups are treated hereunder. Regional structural relationships suggest that they lie between these two latter groups. The schists and gneisses show certain similarities to rocks of one or the other group, but in other ways are dissimilar. These similarities and differences are best shown if the two main areas of these rocks are considered separately.

NORTHEAST ARM AND EASTWARD

This northern of the two areas of schist and gneiss extends eastward across the map-area from the head of Northeast Arm, and lies on the north side of the Bay d'Est[1] fault, a structural feature of considerable magnitude.

Rocks in the northern area of this group are predominantly of sedimentary origin, and consist of stretched conglomerate, greywacke, arkose, banded micaceous schist, staurolite schist, and dense, fine-grained, black and white gneiss, termed 'salt and pepper gneiss' for lack of a better name. The last-named rock is common and is believed to be of sedimentary origin, as what seems to be original bedding is discernible. Rocks of volcanic origin were noted, and in other cases such an origin was suspected.

Conglomerate beds have been shown separately on the map, where possible. Much of the conglomerate is coarse and ill sorted. The rock consists mostly of a fine matrix containing 1- or 2-inch pebbles of quartz and other rocks, together with scattered cobbles of granite and felsite. The latter are stretched in some cases into cigar-like proportions. Except at Dolman Head, the largest boulder observed was about 1 foot in diameter originally. Pebbles of both sedimentary and igneous origin are found. Evidently the sediments were derived from a deeply eroded land, as pebbles of abyssal igneous rocks are common and those of gneiss and schist are foliated in random directions, showing that their metamorphism was pre-Devonian.

At Dolman Head, an unusual phase of the conglomerate is exposed. The rock is pink weathering, stretched conglomerate, generally so indurated that it breaks through the boulders as readily as around them. The most common boulders are buff to pink felsite, but granite and sedimentary rocks are not rare. The last mentioned range from coarse grit to banded slate, and resemble members of the Bay du Nord group. The rock is extremely coarse textured. Boulders 3 feet long are common, and one slab of slaty rock is more than 10 feet long. Such coarse material has, however, accumulated only locally, boulders being smaller as the conglomerate is traced eastward.

The variations in texture, sandy matrix, and diversity of rock types represented in the fragments suggest that the conglomerate is formed from a stream deposit. The occurrence of slate and grit boulders suggests that the Bay du Nord group, as well as older igneous and metamorphic rocks, was being eroded at the time the conglomerate was laid down.

In Northeast Arm, 1,400 feet of quartzite, arkose, and greywacke overlie the conglomerate of Dolman Head. The best section is found along

[1] Bay d'Est is local usage for Northeast Arm and the name is retained as applied to the fault named for it.

Rattling Brook and thence along the shore to Birchey Head. Gneissic arkose and greywacke are the most common rock types. These rocks consist largely of feldspar, quartz, and biotite, the feldspar in some cases composing nearly half of the rock. A little apatite, sphene, and epidote were seen in thin sections. Crushing and recrystallization have obscured the original textures. Poikiloblastic crystals of feldspar and green hornblende have developed locally.

Zones of fine-banded quartzite occur within the coarse clastic rocks. The thickest of these forms the shore for ½ mile on either side of Birchey Head. This rock consists of fine granular quartz, with much biotite and lesser amounts of apatite, epidote, and zircon. Weathered parts of the rock have the 'salt and pepper' appearance characteristic of many of the rocks in this schist and gneiss group.

Although some of the schists are indistinguishable from members of the Bay du Nord group, generally they exhibit a higher grade of metamorphism. Some of the argillaceous layers have been converted to staurolite schist. Fine-grained biotite-garnet schist carries porphyroblasts of staurolite more than an inch long, many of which are cruciform twins. Small quartz veins cutting this rock contain kyanite; and pink andalusite is developed in adjacent schists. Staurolite, andalusite, and kyanite were not observed in rocks of the Bay du Nord group, and are taken to indicate a higher grade of metamorphism. The Dolman gneiss, intruded as a flat sheet between the Bay du Nord rocks and the schists and gneisses, presumably would have altered the overlying schists and gneisses more than the underlying Bay du Nord rocks.

Dark grey and greenish pyroclastic rocks have been found at the tip of Birchey Head. They contain veins of calcite and pink feldspar. On the eastern side of the headland, where weathering has clarified the pyroclastic texture, the rock is a volcanic breccia, with fragments up to a foot long. The abundance of secondary chlorite, epidote, and calcite renders identification difficult, but the rock appears to be at least as basic as andesite and is possibly basaltic. Where less altered, these rocks consist of hornblende metacrysts and lesser sphene, apatite, epidote, and biotite. The hornblende is partly altered to chlorite and calcite, and contains irregular masses of chlorite ½ inch across.

ROTI BAY TO CINQ CERF

This area of schist and gneiss is about ¾ mile wide and 9 miles long, and extends north of east from Roti Bay. It is bounded by the La Poile group on the northwest and by igneous intrusions on the other three sides. The rocks are believed to be older than those of the La Poile group, although it is possible that they should be included in that group because of many points of lithological similarity. The separation is made because of the dissimilarities, and because of the possibility of a slight angular unconformity between them.

In general, this belt consists of greenstone, greywacke, tuff, conglomerate, chert, and possibly rhyolite lava flows. Intruding these rocks are many basic dykes and a few small stocks of diabase and rhyolite. These minor intrusions, few of which could be mapped, were not found cutting

the La Poile rocks. Many have been metamorphosed to schist and may be confused with the rocks they cut; others follow the bedding, and thus add to the difficulties of recognition.

In Cinq Cerf Valley, the rocks are largely green schist, with intercalated beds of greywacke, phyllite, and acidic tuff. Although contemporaneous volcanism is indicated, lava flows have not been definitely identified. The greywacke is a hard grey to greenish rock superficially resembling some of the dyke rocks. In the field, its sedimentary origin is revealed by more or less well defined stratification. Microscopically the rock has been partly granulated and recrystallized, but the original sedimentary texture has not been completely obliterated. Quartz is prominent and shows the original shape of the grains. Other minerals are feldspar, clinozoisite, and chlorite. Near Cinq Cerf Brook the rocks are sheared and partly replaced by pyrite, epidote, or calcite. To the west, grain size increases considerably. Near Grand Bruit, conglomerate beds are common, but pinch out farther north against a zone of banded chert and rhyolite, which in turn grades farther west to hackly greenstone, with occasional beds of tuff.

The conglomerates in this belt appear to be terrestrial stream deposits, as are those on Dolman Head. The rock fragments are generally subangular, and range from small pebbles to boulders about a foot long. The material of the conglomerate is poorly sorted and includes much fine-grained matrix. The observed rock fragments in the conglomerate include vein quartz, granite, syenite, chert, feldspar, and kaolinized rock. No boulders of conglomerate or banded sediment were found.

Small bodies of rhyolite associated with chert and tuff are probably lava flows although they are similar lithologically to the younger quartz porphyry. The rock forms massive, white weathering outcrops. On the fresh surface, scattered grains of quartz and feldspar are seen in an aphanitic, grey matrix. This latter is a fine, felted aggregate of feldspar and quartz, with a little disseminated chlorite and epidote. The phenocrysts are albite, quartz, chloritized biotite, magnetite, apatite, and zircon. Only the quartz and albite can be seen megascopically. The quartz phenocrysts are partly resorbed and embayed by the matrix. Because these rounded quartz grains weather in relief, the rock in outcrop may be mistaken for one of clastic origin.

COASTAL BELT

A third belt of schists and gneisses is exposed on scattered islands and headlands between Roti and Cinq Cerf Bays, and is separated from the Roti-Cinq Cerf belt by later intrusions.

The rocks consist of complex orthogneiss and paragneiss, which were apparently formed by the injection and metamorphism of the rocks just described. Many dykes cut these rocks, and have been metamorphosed with them. In places, dyke rock comprises more than half of the exposed rock. As the dykes are generally parallel with each other they lend the rock a pseudo-stratification, which may be mistaken for primary bedded structure.

Metamorphosed conglomerate is exposed at several places near Sandbank Point, as is gritty and arkosic quartzite. Farther east, there are intermediate to fine-grained grey schists and gneisses, the banding and

mineral composition of which indicate that they were originally tuffs and greywackes. The minerals of these rocks are quartz, feldspar, biotite, muscovite, and iron oxides, with lesser amounts of zircon, apatite, and a colourless, isotropic mineral, probably garnet. Some amphibolites were observed, which may have been derived from mafic tuffs or intrusives.

La Poile Group

GENERAL STATEMENT

"La Poile" is a name proposed by the writer for a group of sedimentary and volcanic rocks believed to be younger than those of the schist and gneiss group.

Rocks of this group are exposed on the peninsula between Northeast Arm and Roti Bay, and extend northeast to where they are cut off, respectively, by the Bay d'Est fault on the north, and by the Chetwynd granite on the east.

Lithologically, the rocks of the group fall into three divisions, which are also mainly stratigraphic. Rocks of the conglomerate division are, wherever found, the oldest rocks of the group. Overlying rocks of the conglomerate division are those of a dominantly sedimentary division, but in which minor amounts of volcanic rocks are found. The largest part of the group is composed of rocks of the youngest, dominantly volcanic division, which, in turn, includes some sedimentary beds.

Rocks of the La Poile group lie in a tightly compressed, partly overturned syncline plunging northeast. Accepting this structure, the group is about 13,000 feet thick, with the top not exposed.

BASAL CONGLOMERATE

At the base of the group is a conspicuous conglomerate zone, which locally is 900 feet thick. The best exposures are in the valley of Cinq Cerf Brook where it forms a hogback ridge parallel with the stream and waterfalls in Cinq Cerf and Georges Brooks. The beds dip from 80 to 53 degrees southeast, but overturning is indicated by regional structural relations and by gradation in pebble size within beds.

At the base of the conglomerate division is a quartz conglomerate with pebbles 2 inches or less in diameter. Overlying the quartz conglomerate, and separating it from the main body of conglomerate, are thin beds of purple slate and grit. The remainder, and main part of the division, is composed of poorly sorted conglomerate (*See* Plate III A). Small pebbles lie beside boulders several feet long in a schistose matrix. The detritus of the conglomerate includes a variety of rock types, the most numerous of which are granite and related igneous rocks. There are also boulders of older quartz conglomerate, chert, greywacke, buff weathering schist, and grey banded schist. The scarcity of quartz pebbles is noteworthy in view of the prevalence of quartz in the finer conglomerate at the base of the division.

This conglomerate is cut off by the Chetwynd granite to the east. To the southwest, it has been traced as far as Gull Pond, a distance of 6 miles. The basal quartz conglomerate and a quartz porphyry sill within it end

about a mile east of Gull Pond. The main conglomerate member, although of reduced thickness, has been traced as far as the east side of Gull Pond, but not to the west side, although rocks of the sedimentary division to the immediate north cross Gull Pond with an apparently unchanged trend. The wedging out of the sill and conglomerate may be due to an east-west fault, although no other evidence of such a fault was observed. Between Gull Pond and the head of Roti Bay, members of the sedimentary division are in contact with rocks of the schist and gneiss group, with no intervening conglomerate.

On Roti Point and Gull Island, conglomerate also occurs, and apparenly belongs to this same division, as it is associated with distinctive purplish slate, as were the conglomerates of Cinq Cerf Valley. The detritus of the Roti Point conglomerate is also similar to that of those of Cinq Cerf Valley, with the addition of numerous rhyolite boulders. This conglomerate extends inland less than a mile to where it is in faulted contact with schist and gneiss.

SEDIMENTARY DIVISION

Rocks of the conglomerate division are overlain by arkosic grit and slate, which, although composed partly of pyroclastic material, in general is considered to be of sedimentary origin, and will be referred to as the Sedimentary division of the La Poile group.

These sedimentary rocks extend along the southern side of the belt of La Poile rocks, from Little Roti Bay to where the belt is cut off by the Chetwynd granite. Between Little Roti Bay and Gull Pond, rocks of the sedimentary division are the lowest exposed La Poile rocks. On Roti Point and east of Gull Pond, they are underlain to the south by members of the conglomerate division. On the north, the sedimentary rocks are succeeded by rocks of the volcanic division. The contact between these latter two divisions is arbitrary and could not be mapped.

The thickness of the sedimentary division varies considerably along strike, being 2,400 feet on the Grand Bruit Brooks but only 1,000 feet east of Georges Brook.

Lithologically, the rocks are rather well bedded, grey to greenish, and range from fine slate, with rare cherty phases, to grits having a grain size up to $\frac{1}{10}$ inch. At many places in the eastern part of the belt, fragments of pyroclastic origin as much as a foot long occur sparsely in the rock. Quartz fragments nearly 1 inch long were observed at several places, and in one place a well-rounded vein quartz pebble 2 inches in diameter was noted.

Thin sections of the grit show it to consist of angular fragments of quartz, alkalic feldspar, and very fine mineral aggregates in a groundmass composed of epidote, a little chlorite and calcite, and varying amounts of interstitial quartz. A few small fragments of zircon and possibly some ilmenite are also present. Although most of the fragments are of a single mineral, some lithic fragments containing parts of several crystals were noted.

Although the rocks of this division are mainly sedimentary, the lithological features, both megascopic and microscopic, have shown that much of the material of the sediments is of volcanic origin. A close relation-

ship to volcanic conditions of deposition is further emphasized on Grand Bruit Brook, where, as already mentioned, the thickness of rocks in the division is more than double the computed thickness elsewhere. This added material is largely lava flows and tuffs, intercalated with the sedimentary beds.

VOLCANIC DIVISION

The volcanic division of the La Poile group is more than 10,000 feet thick, and forms the peninsula between Roti Bay and Northeast Arm. To the northeast it is cut off by the Bay d'Est fault and the Chetwynd granite. The rocks of the division are largely volcanic, with lesser amounts of clastic sedimentary rocks, and chert.

Volcanic Rocks

The observed volcanic rocks of this division, whether of extrusive or of pyroclastic origin, are generally acidic in composition. Most of them have the composition of either a rhyolite or a trachyte. Pyroclastic rocks are abundant, and range from fine tuffs to breccias containing blocks several feet in diameter.

The rhyolite, on a fresh surface, is pale grey or brown, commonly with a greenish cast. It weathers white or buff. The matrix is aphanitic, but phenocrysts of quartz and feldspar are readily discernible in the hand specimen. Measured flows vary in thickness from 20 to 410 feet. Flow-banding and amygdaloidal structures are rather rare but were observed. Amygdules consist of calcite, quartz, and epidote. Some pyroclastic rock types are indistinguishable from lava flows in the field.

Thin sections of the rhyolite display phenocrysts of quartz, plagioclase, orthoclase, and biotite, with some zircon, apatite, and titaniferous magnetite, in a fine matrix, probably devitrified glass in many cases. The phenocrysts are euhedral or subhedral, those of quartz being noticeably rounded and embayed by resorption. The plagioclase varies from andesine (An_{42}) to albite in different phases of the rock. The variation in plagioclase composition within a single rock may be considerable, as both progressive and oscillatory zoning of the feldspars were noted. Although the quartz-bearing forms are usually rhyolitic, locally with an increase of andesine, they become dacitic. As quartz decreases, the rock grades into trachyte.

The rhyolite is commonly altered, with biotite replaced by chlorite and epidote, which retain the shape and inclusions of the biotite. Orthoclase is sericitized and carbonatized. Plagioclase shows similar but less intense alteration. Titaniferous magnetite is partly altered to leucoxene.

The trachyte is similar in appearance to the rhyolite, but is lacking or deficient in quartz. The matrix is aphanitic and usually grey. Phenocrysts of sodic plagioclase up to $\frac{1}{8}$ inch long are visible megascopically. Thin sections reveal smaller phenocrysts of biotite, titaniferous magnetite, apatite, and zircon. The matrix is fine grained and rich in feldspars.

In general the alteration of the trachyte is similar to that of the rhyolitic rocks.

Sedimentary Rocks

Relatively thin beds of sedimentary rocks are sparsely intercalated with the volcanic rocks. Grit and arkose similar to those in the lower, sedimentary division are most abundant. Grey slate beds up to 350 feet thick have been noted at a few localities. Banded mudstone, greywacke, green schist, and chert comprise the remainder of these rocks. The chert may easily be confused with fresh rhyolite or trachyte, but usually can be distinguished by bedded structures and irregular cloud-like markings, and by lack of phenocrysts. Chert is more abundant west of Roti Brook where it is found associated with clastic sedimentary beds and intercalated with volcanic rocks.

DEVONIAN INTRUSIVE ROCKS

General Statement

With the exception of the Northern granite all the intrusive rocks of the area are believed to be of Devonian age, and to have been intruded before, during, and after that orogeny that folded the rocks of the Bay du Nord and La Poile groups. This orogeny is probably the Acadian Revolution.

These Devonian intrusive rocks range in composition from peridotite to granite, in grain size from fine granulite to coarse porphyritic granite, and in degree of metamorphism from gneiss to unaltered granite.

On the basis of metamorphism and, to a certain extent, of structural relations, the Devonian intrusions have been divided into three groups: those intruded before the Acadian(?) Revolution; those intruded during this orogeny; and those intruded after the close of that period of disturbance. The quartz porphyry, Dolman gneiss, and fine granulite comprise the earliest of these groups, and the Chetwynd granite, the latest. The other intrusions are believed to have taken place during folding, and comprise the intermediate group.

Analogies With Intrusive Rocks of New Hampshire

The Devonian intrusive rocks of La Poile area have many features in common with those of central New Hampshire as worked out by Billings (1), Williams (21), and Chapman (3) (*See* Table I). The Oliverian Magma series in New Hampshire was intruded after the deposition of the Lower Devonian Littleton formation and before the Acadian disturbance of late Devonian time. Bodies of this magmatic group occur as sills and concordant sheets, whereas the larger bodies are domes, with a concordant roof generally dipping outward in all directions. Although no floor has been observed, Chapman considers them laccoliths (3, p. 155). They range in composition from quartz diorite to granite, but do not have sharp contacts. Chapman believes that assimilation and replacement have been important in the origin of the various phases (3, pp. 166-170).

The suggested correlatives of the Oliverian Magma series in this area are the quartz porphyry, Dolman gneiss, and pink granulite. The quartz porphyry is probably wholly or in part contemporaneous with the lava

flows of the La Poile group, which it resembles lithologically. Sills of it were intruded at shallow depths and later were folded with the enclosing layers. The Dolman gneiss is a more deeply seated concordant intrusion of acidic composition. It was probably intruded as a flat-lying lenticular mass, which domed the rocks above it, and was later tilted. Apart from analogy with the Oliverian domes of New Hampshire, this explanation is suggested by the higher grade of metamorphism southeast of the body, which is assumed to be the roof, and by evident dynamic metamorphism within the gneiss itself, which would be caused by the strains of tilting. Granoblastic textures, as well as concordance, gradational contacts, and replacement or assimilation of inclusions are features both of the Dolman gneiss and of the Oliverian rocks.

The youngest of the pre-folding intrusive bodies are folded sills of pink granulite having the composition of alaskite. The sills are younger than the Dolman gneiss, but have a granoblastic texture and well-developed schistosity. There are no analogous rocks in New Hampshire.

The New Hampshire Magma series is a typical sub-alkaline group that includes diorite, quartz diorite, granodiorite, quartz monzonite, and granite. Biotite is the only primary ferromagnesian mineral present in any quantity, and muscovite is rather characteristic. Magmas of this series were intruded in part contemporaneously with the folding and in part after it was completed. The order of intrusion proceeded from basic to acidic but comprised two cycles, the first, ranging from diorite to granite, being contemporaneous with the folding, and the second, ranging from tonalite (quartz diorite) to granite, being later than the folding.

The suggested correlatives of the New Hampshire Magma series in the La Poile area also comprise a typical sub-alkaline series. The basic parts of the Newfoundland series are more fully developed. Primary hornblende is abundant in the older members, and muscovite is very scarce except in the younger rocks. Like the New Hampshire series, the rocks are in part contemporaneous with the folding and in part younger. Likewise, two cycles of basic to acidic rocks are recognizable, but the major part of both cycles is contemporaneous with the folding in La Poile area. The post-folding Chetwynd granite and the Scrag granite of New Hampshire are quite similar in composition. The other post-folding intrusions of New Hampshire seem, however, to lack correlatives in Newfoundland. The porphyritic biotite granite, which comprises the largest batholithic bodies in the La Poile area, is similar to porphyritic phases of the Kinsman quartz monzonite, which is known as the Meredith granite in parts of New Hampshire.

In the following pages, the intrusive rocks are described in detail. The order is that of apparent age, except that dykes are described together.

TABLE I

Comparison between La Poile-Cinq Cerf and Central New Hampshire Intrusions

	La Poile-Cinq Cerf area		Central New Hampshire (after Billings, Williams, and Chapman)		
Devonian	After folding	*Chetwynd pink granite	New Hampshire Magma Series	After folding	Scrag granite Pond Hill granite Moody Ledge granite French Pond granite Sugar Hill quartz monzonite Remick tonalite
	Contemporaneous with folding	Injection phase of porphyritic biotite granite *Porphyritic biotite granite *Granodiorite Baggs Hill granite *Roti granite Quartz-bearing diorite *Diorite-gabbro-peridotite		Contemporaneous with folding	Priest Hill granite Kinsman quartz monzonite (=Meredith granite) Bethlehem gneiss (Basic dykes and sills) Moulton diorite
	Before folding	Pink granulite Dolman gneiss Quartz porphyry		Before folding	Oliverian Magma Series Quartz diorite, granodiorite, quartz monzonite, granite
Pre-Devonian		Northern granite, granite-gneiss	Highlandcroft Magma Series (Late Ordovician?) Diorite, quartz diorite, granodiorite, quartz monzonite		

INTRUSIONS PRIOR TO ACADIAN (?) REVOLUTION

QUARTZ PORPHYRY

Quartz porhpyry occurs as a large, generally concordant body wrapping around the main synclinal axis in the La Poile group; as two, attenuated, almost concordant sheets near the base of the La Poile group; and as small isolated bodies intruding the schist and gneiss near Grand Bruit.

The rocks are similar in composition to the rhyolite lava flows of the La Poile group, but are coarser grained. They are considered to be intrusive sills of the rhyolite magma. Crosscutting intrusive contacts are rare, but were observed at one place, on the largest body. The most southerly sheet crosses the bedding at a small angle, as it occurs above the quartz conglomerate at the east end and below it farther west.

* The sequence of these units is shown by structural relationships. The position of others in the column is inferred from mineral composition and degree of metamorphism.

In the hand specimen, phenocrysts of pink orthoclase, plagioclase, quartz, and biotite are visible in an aphanitic groundmass. Phenocrysts occur up to 1 inch long, but usually are about ⅛ inch. In thin section, the groundmass is seen to be holocrystalline and composed of feldspar, quartz, and dark minerals. The alteration of the rock is similar to that of the lavas of the La Poile group. A little pyrite was introduced.

The small bodies of this rock near Grand Bruit are very similar to the rhyolite lavas lithologically, and may have been volcanic necks.

DOLMAN GNEISS

The name 'Dolman' is proposed by the writer for a body of orthogneiss and paragneiss, largely of intrusive origin and extending north of east from Dolman Cove. The body is lenticular, with the longer axis roughly parallel with the regional structure.

The rock is grey to pink feldspathic gneiss, which has undergone much dynamic metamorphism. Intrusive relations with the surrounding rocks were observed at several places, and small intrusive bodies of similar gneiss were noted in the adjacent paraschists. It is not, however, a single intrusive body. Several intrusions, and possibly some replaced sediments, are included in this map-unit. A phase of the rock at one place may be quite different from that at another, but internal contacts appear to be gradational.

The most common rock type is medium-grained, grey to pink gneiss, which weathers in smooth rounded forms. The minerals are those found in granite. Quartz, alkalic feldspar, and biotite are essential minerals, and apatite, sphene, magnetite, zircon, tourmaline, muscovite, and garnet are present in smaller amounts. Crushing and recrystallization have developed augen texture, planar foliation, and linear structures visible both in the field and in thin section. The microscopic texture is unusual, inasmuch as the augen are commonly subangular rather than lenticular, and some of them are embayed by the fine, granular matrix. This may signify that the original rock was a porphyry, the phenocrysts of which are only partly crushed by metamorphism. This conclusion is supported by the occurrence of local phases containing nearly euhedral phenocrysts of potash feldspar, which may be more than 1 inch long. They are considered to be primary features rather than metacrysts, as biotite precedes potash feldspar in the order of recrystallization, and yet in these rocks shows no tendency to form metacrysts. Furthermore, within one exposure, the rock was seen to grade from the quartz porphyry just described to normal gneiss.

In places the gneiss is fine textured and dark grey on the fresh surface, and contains flattened augen of dark minerals, which allow the rock to break readily parallel with the foliation. This phase is most abundant near the boundaries, and is probably altered sedimentary rock.

GRANULITE

The youngest of the pre-orogenic intrusions is a fine-grained granite-gneiss or granulite, which intrudes the Dolman gneiss and rocks of the Schist and Gneiss group. It has not been noted south of the Bay d'Est fault.

The rock is pink, hard, and fine textured, usually forming massive outcrops. Fine, schistose foliation is commonly discernible, and thin sections show that it is a sheared and recrystallized rock composed of quartz, feldspar, and mica, with accessory apatite, magnetite, zircon, and tourmaline. The texture is that of a *flaser*-gneiss. A mosaic of quartz and alkalic feldspar, both less than 0·1 mm. across, contains tiny scales of biotite and muscovite, with their long axes parallel. Porphyroblastic and poikiloblastic garnet crystals were noted, as was poikiloblastic muscovite.

The granulite is considered to have been intruded prior to the folding of the Devonian strata, because it shows the results of considerable dynamic metamorphism and because of its structural pattern, which can best be interpreted as folded sills. It is quite possible that it was intruded contemporaneously with the folding, and the textures, thus, are protoclastic rather than cataclastic. This possibility might explain why normal igneous textures were not observed. Granite-pegmatite dykes are found near the granulite bodies, and are believed to have been derived from the granulite, yet are themselves uncrushed.

Intrusions Contemporaneous With Acadian(?) Revolution

The intrusive rocks just described, because they have undergone post-intrusive folding, are believed to have been emplaced before most of the orogenic disturbance of the Devonian strata. In the series about to be described are intrusions, all of which have undergone varying degrees of metamorphism, but which show no clear evidence of having been folded They are believed to have been emplaced during the Devonian orogeny.

ULTRABASIC, BASIC, AND INTERMEDIATE ROCKS

In the southern part of the area, gabbro, diorite, and, at one locality, peridotite appear to be phases of single intrusive bodies, and are indicated as a single map-unit. In the northern part of the area a body of diorite, quartz diorite, and quartz-hornblende gabbro is indicated separately on the map.

Peridotite

Peridotite is known only as a border phase of the diorite stock near Roti Point. Bodies up to 100 feet wide have been found near the northern contact and near the long wedge of earlier rock that divides the stock. Hand specimens are either black or green and usually display a poikilitic texture. The black variety originally contained very little if any feldspar and has been altered to serpentine and carbonate. The green variety contained a little feldspar, in which epidote, chlorite, magnetite, clinozoisite, actinolite, and quartz have developed. Olivene originally made up 25 to 50 per cent of the rock, and in the black variety has been completely transformed to serpentine, secondary magnetite, and carbonate, with a typical ribbon structure. The abundance of magnetite suggests that the olivine was rich in iron. The serpentine pseudomorphs are encased in poiklitic crystals of brownish, deuteric(?) amphibole (pargasite). On alteration, the latter has changed to chlorite and carbonate.

Gabbro and Diorite

Gabbro and diorite occur as small stocks and bodies in the southern half of the area, intruding rocks of Bay du Nord and later age. Because the gabbros and the diorites are commonly indistinguishable in the field, and because study of thin sections from a single body indicates that they grade into one another, they are more conveniently described together.

Most of the large stock near Roti Point is dark grey, medium-textured diorite. Near the border it is a relatively fine xenomorphic-granular rock, whereas in the central part it is coarser, with some hornblende crystals more than 1 inch across. Rocks of the border phase consist essentially of green hornblende and andesine, with some quartz and a little apatite. The hornblende is partly replaced by chlorite, and the plagioclase by epidote and sericite. Rocks of the coarse phase near the centre consist of poikilitic hornblende crystals with inclusions of plagioclase, pyroxene, and a nearly isotropic brown mineral, probably chlorite, which evidently replaced some ferromagnesian mineral. A little late quartz is also present. The hornblende is pale olive-brown, similar to that observed in the peridotite. The feldspar crystals are zoned from andesine-labradorite at the centre to a sodic variety at the edges. A distinct oscillatory zoning affects the borders of many grains. This may indicate a lack of equilibrium during crystallization, such as would result from rapid cooling at relatively shallow depth.

The diorite stock near Roti Point is cut off by the younger Roti granite, but continues on Bass Island and southern Barasway Island. Thin sections of altered diorite from these islands display abundant secondary amphibole, together with intermediate plagioclase, epidote, chlorite, sericite, and leucoxene.

The small body forming Sandbank Point is dark hornblende gabbro resembling the fine-textured phases of the Roti Point stock. The hornblende commonly contains opaque, rod-shaped inclusions, which form a triangular grid pattern near the centres of the grains. These suggest a replacement origin for the hornblende, but may be exsolution features. The plagioclase is labradorite, approximately An_{55}.

The stocks, which are scattered over some miles to the northeast of Dolman Cove, have been altered to greenstone schist at most places, but sufficient unaltered phases were seen to suggest that they were originally similar to those along the coast. All the thin sections examined are of diorite. The plagioclase is andesine (An_{48}) and commonly euhedral. Hornblende and a little quartz fill the interstices between the plagioclase crystals. Pegmatitic phases, with large poikilitic hornblende crystals, have also been found. These rocks are older than the Baggs Hill granite, and the latter may be responsible for their usual alteration to green schist. The altered phases have not been studied microscopically, but hand specimens indicate that chlorite is a common alteration product. Metacrysts of garnet and tourmaline have been developed locally.

Northern Quartz-bearing Diorite

Quartz-bearing diorite forms a long, narrow body separating the Bay du Nord group from the pre-Devonian rocks in the north of the area. Although it is only in faulted contact with rocks of the Bay du Nord group, there is little doubt of its Devonian age. The rock is fine grained, even textured, and varies from dark bluish grey to medium grey, with a greenish or brownish cast. In thin section, the rock is seen to have hypidiomorphic-granular texture, with green hornblende and plagioclase as the most common constituents. The plagioclase is usually andesine (An_{45}), but in some specimens is oligoclase. The rock is called quartz-bearing diorite because quartz is always an accessory mineral and commonly is abundant enough to make the rock a quartz diorite. The quartz is interstitial, and is commonly accompanied by potash feldspar. Of the four thin sections studied, two were diorite and two were quartz diorite.

Pink, feldspathic veins and small granite dykes are quite common in these rocks, and quartz diorite-pegmatite was observed at a few places. The latter is composed of hornblende, oligoclase (An_{13}), and quartz, with considerable accessory apatite, sphene, and opaque minerals.

Quartz-hornblende gabbro occurs as a prong of the diorite west of Fox Hole Brook, and is younger than the Keepings gneiss. In thin section, the rock contains abundant labradorite, green hornblende, and quartz, with accessory epidote, magnetite, and pyrite. The quartz has replaced the other minerals, and may have been introduced by later intrusions.

ROTI GRANITE

'Roti' is a convenient name for the granite intruded after the diorite-peridotite stock near Roti Point and before intrusion of the granodiorite. A stock of similar-looking rock in the northern part of the area is correlated with it. Although the main body of this granite is faulted against other intrusions throughout most of its length, their relative ages are definitely established. The Roti granite cuts off the diorite-peridotite stock in Roti Bay and is intruded by the granodiorite near Bettys Pond. At this latter place the granodiorite was chilled against the Roti granite and formed apophyses within it. Also, the Roti granite is much more altered, both texturally and mineralogically, and is cut by many more dykes than are the other Devonian granites.

The rock is usually a medium-textured, grey granite, with a pinkish tint. A common but by no means universal characteristic is the presence of blue, milky quartz. Some pink granite and both grey and pinkish granite-porphyry were noted. Thin sections of the more common, unfoliated rocks reveal plagioclase, together with orthoclase, quartz, and green hornblende. Chlorite-epidote pseudomorphs of what was apparently biotite were observed in each section. The feldspars have been largely sericitized. The common accessory minerals are apatite, zircon, and some opaque minerals.

North of Grand Bruit, there is a leucocratic phase of the granite that contains microcline instead of orthoclase. It is characterized by late intergrowths of quartz, albite, and microcline. They consist of deuteric perthite around grain boundaries, and interstitial micropegmatite. The

accessory minerals and the type of alteration are the same as in the rock just described, but the alteration is slightly less pronounced. Transitional rocks indicate that it is part of the Roti granite, although it may be younger than most of that intrusion.

BAGGS HILL GRANITE

'Baggs Hill' is a convenient name for the granite occurring as a small stock on Baggs Hill and as two larger bodies to the northeast. The two latter intrusive bodies, although joined at the eastern side of the area, will be described separately. All three bodies, although not identical in appearance and characteristics, have many features in common, and are unlike other granites in the area.

Baggs Hill Stock

The Baggs Hill stock is composed of fine-grained, grey granite, with quartz, albite, potash feldspar, and biotite as the essential minerals, together with zircon and sphene. Micrographic intergrowths are common. Both perthite and antiperthite were observed, and some thin sections are 20 to 40 per cent micropegmatite. The rock is finer grained than most granites, with a grain size of 1 or 2 mm. The associated dykes are commonly porphyritic, and consist of albite, microcline, and quartz phenocrysts in a fine matrix of quartz and feldspar much of which is intergrown in the form of micropegmatite.

The Baggs Hill stock appears to represent the final stage of the first cycle of Devonian intrusions. The abundance of micropegmatite, the sodic plagioclase, and the scarcity of dark minerals are taken to indicate a late stage of differentiation, and yet the rock is unlike the Chetwynd granite, which is the final member of the younger series. If micropegmatite is formed by the crystallization of a eutectic (or cotectic), as many petrologists believe, the occurrence of much micropegmatite signifies a magma near eutectic composition such as would form at a late stage of differentiation.

Rocky Ridge Stock

Compared with the rock on Baggs Hill, the granite of the large, Rocky Ridge stock is lighter in colour and coarser in grain. Quartz, alkalic feldspar, and biotite are essential minerals and occur with zircon and opaque minerals. In some respects the rock resembles the Chetwynd granite, but it has undergone more shearing. Metamorphic foliation was noted at many places within the body and even apparently unaltered rocks show mortar structure in thin sections. As similar metamorphic effects were not observed in the Baggs Hill stock, it is suggested that the Baggs Hill stock may be somewhat younger.

Eight Mile Hill Prong

The long prong extending from the Rocky Ridge stock and forming Eight Mile Hill is in many respects peculiar. Locally it resembles rocks of the Rocky Ridge stock, whereas at other places it grades into altered

cherty and foliated rocks, the igneous origin of which would be questionable if it were not for the field relationships. The only thin section examined is of hornblende granite containing much accessory magnetite and a little apatite and zircon. The hornblende has similar properties to that found in the gabbro and diorite. Texturally the rock sectioned is an augen gneiss.

GRANODIORITE

Granodiorite occurs on the coast between Roti and Couteau Bays and in the central western part of the area. The rock is a grey, generally fresh rock having granitoid or gneissic texture. It is younger than the Roti granite but is intruded by apophyses of the porphyritic biotite granite. Shearing movements set up when the latter was emplaced have formed metamorphic foliation in the granodiorite as much as three-quarters of a mile from their contacts. The foliation is essentially parallel with primary flow structure in both rocks.

Because the granodiorite outcrops on islands and headlands, it is impossible to define the bodies closely, but there appear to be two bodies. The larger one underlies Cinq Cerf Bay and probably includes the granodiorite on Norman Rock and the southern part of Three Islands. This body is intersected by the Chetwynd pink granite to the east. The other body extends from Jenny Buffet Island through Grand Bruit to about half a mile east of Sandbank Point, and probably includes the granodiorite exposed in the northern part of Three Islands. The western of these two bodies is more metamorphosed both dynamically and mineralogically than is the eastern. It also contains more dykes. The two bodies are separated by rocks of the Schist and Gneiss group, but may be co-extensive beneath the sea. It is suggested that the western body is the older, although they both were emplaced during the same stage of the intrusive cycle.

The name granodiorite does not necessarily imply narrow quantitative limits for the various minerals. Actually the rock varies from quartz diorite to quartz monzonite. Mafic minerals, hornblende and biotite, make up 5 to 40 per cent of the rock. The percentage of quartz varies almost as much. The feldspars include andesine or calcic oligoclase and potash feldspar. The plagioclase is zoned, oscillatory zoning being commonly superimposed on that of the progressive type. The primary accessory minerals include opaque minerals, sphene, apatite, and zircon. In this rock, unlike in the Roti granite, sphene is abundant.

PORPHYRITIC BIOTITE GRANITE

The porphyritic biotite granite forms two batholiths. The La Poile batholith lies along the western side of the area. Traced northward, it ends in a series of tongues near Bunker Hill Brook. Farther north its place is taken by numerous smaller injections of genetically related but petrographically different granite. So far as could be judged by passing along shore in a small boat, this batholith extends without much variation as far west of the area as Garia Bay. The other batholith, the Grand Bruit batholith, forms the outer islands from Roti Bay eastward. It reaches the mainland east of Couteau Head and forms the outer part of Grand

Bruit Peninsula. Its eastern boundary is unknown but lies east of the area. The two batholiths probably converge beneath the sea to the southwest of Ireland Island and form a single body.

The rock of both batholiths is medium-grained biotite granite, characterized by pink microcline phenocrysts 1 inch to 1½ inches long, with smaller phenocrysts of oligoclase-andesine. Sphene, apatite, and zircon are prominent accessory minerals. At about the time of final solidification, perthite and a little micropegmatite were formed.

Most of the granite shows well-developed platy flow structure by lenticular inclusions and euhedral phenocrysts. Crushed and foliated phases are found in apophyses and close to contacts. They are best exposed along the west side of Couteau Bay, where the granite is sheared and foliated for half a mile from the contact. The foliation correlates with that in the adjacent granodiorite and is thought to date from the time of emplacement. The northward extending fingers of the La Poile batholith are also sheared and foliated.

Within the crushed zones the rocks are considerably altered. Penninite, epidote, and sericite, with calcite and pyrite, are the secondary minerals formed. Fault zones are partly silicified and in places contain a little tourmaline, pyrrhotite, and magnetite. A good example of silicification may be observed on the north shore of Little Bay, a short distance east of the village, where a shear zone 55 feet wide, striking north 40 degrees west and dipping 76 degrees southwest, cuts the granite. Along the southwest side, where the movement was most intense, the granite is completely replaced by quartz, except for small, scattered, relict fragments. To the northeast, the zone ends in ramifying quartz veins. The rock contains vugs lined with quartz crystals, but is lacking in tourmaline, magnetite, or sulphide minerals.

Granite-pegmatite

Granite-pegmatite dykes are associated with the porphyritic biotite granite near the north end of the La Poile batholith and along the north contact of the Grand Bruit batholith. They occur within the batholiths and also in the wall-rock. Most of the dykes are parallel with the batholith contact. The dykes on Harbour Island, Three Islands, Norman Rock, Western Head, and Cinq Cerf Islands are particularly worth noting. The one on Norman Rock is 36 feet thick, the others less than 15 feet.

The pegmatites contain orthoclase, microcline, albite, and quartz as most abundant minerals. These are commonly intergrown to form graphic granite (quartz and potash feldspar) and micro-perthite (potash feldspar and albite). Where pegmatites cut gabbro or other ferromagnesian rocks, as they do on Harbour Island, biotite becomes a prominent constituent, evidently resulting from contamination of the pegmatite magma. Accessory minerals thus far found in the pegmatites include magnetite, iron tourmaline (schorlite), garnet (almandite-spessartite), allanite, beryl, sphene, and pyrite. These minerals are confined to certain parts of the dykes and are commonly associated with one another. A replacement origin may be established for some occurrences. The *magnetite* is found within fine granular quartz that replaces potash feldspar. Elsewhere it is associated with more or less albitized potash feldspar, and chloritized biotite. Although

a little of it is a primary pegmatite constituent, most of the magnetite is thought to be hydrothermal, roughly contemporaneous with thin quartz-magnetite and quartz-magnetite-pyrite veins in the vicinity. The *garnet* is brown to deep red. It occurs in well-formed trapezohedra even where found within sheared feldspar and other minerals. The *tourmaline* is black. It is ordinarily in knots of small crystals, which locally at least have replaced feldspar. *Allanite* is in roughly equidimensional grains and acicular crystals, which are recognized by their black colour and pitchy lustre, and by the presence of cracked and slightly rusted haloes around them. This last characteristic of allanite is generally attributed to radioactive emanations from the mineral. Small euhedral crystals of *sphene* were found associated with allanite at several places. *Beryl* was found only in the pegmatite dyke on Western Head. Several crystals were found there, the largest about three-quarters of an inch in diameter.

Aplite and Alaskite

Associated with both batholiths is pink aplite and a mineralogically similar but coarser textured rock here called alaskite. They occur in lenticular dykes from a few inches to 300 feet thick. Most of the thin dykes are aplite, but there is little relationship between texture and dyke width, some of the smaller dykes being coarser than the larger ones. Both aplite and alaskite are commonly more or less granulated by late movements within the batholith.

The typical rock is pink and nearly devoid of dark minerals. Thin sections show much microcline and quartz, with fairly abundant albite. There is generally a little biotite and muscovite as well as scattered grains of sphene, zircon, apatite, and opaque minerals. Intergrowths except deuteric perthite are rare. Although the typical rock is distinctive, some dykes and local phases of other dykes resemble the Chetwynd granite because of the presence of a few per cent of biotite. This suggests a genetic relationship between them.

Injection Phase

Around the end of the La Poile batholith, numerous granite sheets and *lit-par-lit* injections are found in the Bay du Nord group. Most of them are too small to be mapped individually. The injected area as well as the larger sheets are shown on the map. Although different lithologically from the main body of the batholith, the injections are described here because of close genetic affinities with the batholith. It is suggested that they were formed by squeezing off residual magma at various stages during the solidification of the batholith. The injections are nearly all concordant, but a few crosscutting bodies indicate more than one episode of intrusion. The reason that injections are lacking near the batholith contact at most places seems to be that they require special structural conditions to form. Where the batholith contact parallels the strike of the wall-rock, the contact is simple and *lit-par-lit* injections have not taken place. Where the contact swings across the strike, *lit-par-lit* injections appear. Thus the concordant contact is simple and straight, the discordant contact jagged, with outlying sheets and injection gneisses (*See* Plate III B). Probably the injected area is underlain by an extension of the porphyritic granite in depth and thus is

part of the roof of the batholith. The possibility that it might represent the floor, in the way that Grout has interpreted similar relationships at the east end of the Saganaga granite of Minnesota (8), is unacceptable. The petrography of the *lit-par-lit* bodies shows them to be injections from the granite, rather than feeders to it. At one place a dyke of the *lit-par-lit* phase was found cutting the porphyritic granite, showing that here the margin of the batholith was solid at the time of *lit-par-lit* injection.

At most places, the injected granite is readily distinguished from that in the batholith proper by somewhat finer texture, lack of phenocrysts, relative scarcity of dark minerals, and occurrence of muscovite in addition to biotite. Locally it grades to rock similar to that in the batholith. It is commonly sheared and apparently contaminated by the intruded sedimentary beds. It is a matter of personal judgment whether some rocks are classified as contaminated granite or granitized sediment.

Thin sections of uncontaminated and unsheared phases show quartz, plagioclase, microcline, biotite, and muscovite as the essential minerals, with accessory apatite, zircon, and iron ores. Myrmekite is one of the last constituents to crystallize, and replaces the microcline. The plagioclase is oligoclase of a more sodic variety than that found as phenocrysts in the porphyritic biotite granite. This and the relative scarcity of biotite are explained by the filtering out of these early formed constituents on injection. The presence of muscovite also suggests that the injections are filtered residual magma. The facts are incompatible with the idea that the injections were feeders.

Intrusions Subsequent to Acadian(?) Revolution

With the possible exception of some of the dyke rocks whose parent magma is not definitely known, the Chetwynd granite is the only intrusion believed to have been emplaced after all orogeny had ceased.

CHETWYND GRANITE

The Chetwynd granite forms a few large bodies near the eastern boundary of the map-area, and a small body north of Bay du Nord. These bodies appear to have been emplaced quietly after all folding had ceased. The surrounding rock is relatively undisturbed and dykelets are common. Inclusions are rare and flow structure is not apparent.

The typical granite of the eastern part of the area is a medium-grained mixture of potash feldspar and quartz, with a little plagioclase and biotite. Most of the plagioclase crystallized early and is zoned. Much of the potash feldspar is perthitic. Accessory minerals include sphene, zircon, apatite, magnetite, and pyrite. The rock may be distinguished from the other granites by its light pink to reddish colour, its scarcity of dark minerals, and its unmodified granitoid texture. The potash feldspar is generally tabular and somewhat larger than the other minerals. Fine-grained granite was observed near the borders and in dykes. At many places the chilled rock has a porphyritic texture, with phenocrysts of potash feldspar and plagioclase.

The rock of the small body north of Bay du Nord contains much pale pink albite, and muscovite instead of the biotite found in the eastern bodies. Euhedral garnets are scattered throughout the rock.

Dykes and Sills

Dykes have been found in nearly every part of the area. They are particularly abundant along the southern coast east of Roti Bay, where they comprise more than half of the exposed rock in places. The dykes of this belt trend approximately parallel with the granite contacts and, therefore, intersecting dykes are not common. The average dip of the dykes is about 75 degrees, most of them dipping southeast toward the Grand Bruit batholith. In the North Bay region the minor intrusions are usually sills. The rocks range in composition from nearly black amphibolite to light-coloured felsite and rhyolite. Many are fine-grained equivalents of the larger intrusive bodies, or are composed of aplitic rocks related to them. Others may be classified as either older or younger than the porphyritic biotite granite. The older dykes include altered basic, intermediate, and acidic types that proved impractical to map or describe in detail. Dykes younger than the porphyritic biotite granite are relatively unaltered diabase and rhyolite. In the following descriptions, the rocks are classified by composition, without regard to age.

DIABASE AND DIABASE-PORPHYRY

Dykes of diabase and diabase-porphyry are uncommon and most of them intrude the porphyritic biotite granite in bodies from 1 foot to 30 feet wide. Both intergranular and ophitic textures were noted in these rocks. Plagioclase, which comprises 50 to 60 per cent of the rock, is zoned from labradorite at the crystal centres to albite or oligoclase at the margins. Pyroxene comprises about 30 per cent of the rock, and the remainder consists of titaniferous-magnetite, apatite, deep brown hornblende, biotite, and a little interstitial quartz.

The pre-porphyritic biotite granite dykes are in part older and in part younger than the granodiorite. Intruding rocks of the Schist and Gneiss group are schisted diabase porphyry dykes that have been folded with the gneiss. The most common of these is a black porphyry that occurs as non-persistent lenses. They are intruded by the granodiorite, which also contains xenoliths of them. It is possible that they are satellitic intrusions from the gabbro. Many other dykes cut the granodiorite but do not cut the adjacent porphyritic biotite granite. These are dark grey or greenish on fresh surfaces, and range in texture from aphanitic to medium grained and from porphyritic to non-porphyritic. These rocks also vary among themselves in colour and character of the weathered surface.

GRANITE-PORPHYRY

Granite-porphyry occurs as one large dyke 60 to 90 feet wide and more than ½ mile long near Culotte Cove, and as several smaller dykes. It is generally foliated and characterized by pink feldspar on the weathered surface. The foliation is parallel with the dyke walls; occurs even where foliation is lacking in the wall-rock; and truncates any foliation in the adjacent rocks. Dykes either lack foliation altogether or are equally foliated from wall to wall. These facts, together with the macroscopic and the microscopic characters of the foliation itself, suggest that it is not

common flow structure, but probably developed under regional stress. The dykes are younger than the foliation that they cut. Before most of them had fully solidified, regional stresses were again applied. The dykes were zones of weakness, and an independent foliation developed in them.

The granite-porphyry is closely related to the porphyritic biotite granite. Thin sections show augen of plagioclase and microcline in a granoblastic matrix of feldspar, quartz, mica, and accessory minerals. The mica (both biotite and muscovite) is concentrated in flat lenses and sheets that wrap around the augen and accent the foliation. Zircon, apatite, sphene, and opaque minerals are common accessory minerals.

RHYOLITE AND RHYOLITE-PORPHYRY

The youngest dykes of the area are pink to brick-red rhyolite-porphyry. They range from 1 foot to approximately 100 feet wide and may be traced for long distances. A few have been found near the Chetwynd shaft, but most of them occur in east-west fractures between Roti and Couteau Bays. One dyke in this belt was traced for more than 5 miles. The rhyolite is similar to the Chetwynd granite in colour and proportions of essential minerals, and it is thought that the two are nearly contemporaneous. The rhyolite is generally porphyritic; phenocrysts are quartz and potash feldspar, with a lesser amount of plagioclase and biotite. The matrix is aphanitic. Thin sections indicate that it consists of potash feldspar and quartz, with a little muscovite and other minerals. Feldspathic spherulites are common in the smaller dykes, and some micropegmatite is always present, in some instances comprising as much as two-thirds of the rock. Quite commonly the matrix contains small lenses of granular quartz, feldspar, and muscovite, which appear to be pegmatitic residues.

PLEISTOCENE AND RECENT

Glacial Geology

The entire area was glaciated during the Wisconsin stage of Pleistocene time. This conclusion is based on the widespread occurrence of fresh, erratic stones and striæ, and is in accord with the recent conclusion of MacClintock and Twenhofel that Newfoundland was completely glaciated during the Wisconsin (14).

More than a hundred observations of the ice-flow direction, as revealed by striæ, have been made and many are plotted on the map. Such should be a guide in any attempts to prospect for the source of minerals observed in the drift. The average direction from all the observations is south 4½ degrees west, the greatest departure from the mean being 30 degrees in each direction. As may be seen, these departures are quite sytematic, and the striæ are nearly parallel in one area but contrast with those a few miles distant. Thus the direction of flow was a few degrees east of south in Roti Bay but south 15 to 25 degrees west in Cinq Cerf Bay. The reason for the converging flow of the two currents is probably the spreading of the ice bodies in La Poile Valley and Cinq Cerf Valley, respectively, when the lower coastal lands were reached. It is possible, however, that ice

flowed from two glacial centres, one lying northeast of the map-area and the other northwest. Not enough striæ are preserved west of La Poile Bay to check this hypothesis. Of possible significance in this connection is the fact that an erratic boulder of fossiliferous limestone was found near Barasway Brook on the west side of La Poile Bay. Similar limestones occur near Port au Port but are not known in central Newfoundland.

La Poile Bay is a Y-shaped composite fiord gouged out along the lower courses of La Poile River and its old tributary, East Bay Brook. These valleys have been broadened and deepened to form a forking trough with precipitous sides 650 to 1,300 feet high. The north and northeastern ends of the trough are above water, whereas the southern end is completely submerged. Sounding data indicate that it ends abruptly several miles southwest of Ireland Island. The minor tributaries of La Poile River and East Bay Brook were not deepened by glacial erosion and in places are clogged with drift. They are now hanging valleys, and the streams plunge into the glaciated troughs in beautiful cascades and waterfalls.

The chief factor in instigating fiord formation was the soft rock at the bottom of La Poile Valley and that of East Bay Brook and not simply the valleys themselves. There is not the slightest suggestion of fiord formation in Cinq Cerf Bay, Couteau Bay, and most of the other bays of southern Newfoundland, which were well-developed valleys in pre-Glacial times, and which lie close to the direction of ice-flow but either lack soft rock floors or have their mouths dammed by glacier-resistant rock such as massive granite. Although the conclusion is inevitable that soft rock is the controlling factor in fiord formation in this part of southern Newfoundland, it does not follow that the same is true everywhere. In fact, the hardness of the rock seems to be an insignificant factor in the formation of many fiords.

The direction of ice movement within the La Poile fiord departs considerably from the general direction as revealed by striæ elsewhere in the area, and this fact gives a suggestion as to the way in which the fiord was formed. Such topographic features as the Highlands of Grand Bruit have affected the flow direction very slightly or none at all, suggesting that, at the maximum extent of the ice, the flow direction was very slightly affected by the subglacial contour of the land. During the fiord-forming stage, the ice in North Bay flowed south 18 degrees west and that in Northeast Arm south 59 degrees west, a local difference of 41 degrees in direction. Moreover, the Northeast Arm ice departed some 60 degrees from the direction of flow indicated by striæ to the south. These data strongly suggest that fiord formation was largely confined to the waxing and waning stages of the ice-sheet, when the ice-cap did not cover the coastal lands but drained outward as valley glaciers in the same way that the Greenland ice-sheet does today. The lack of fiord ice drainage via Cinq Cerf and Couteau Brooks may explain the ice stagnation in the northeast, which is discussed below.

Glacial drift is patchy and thin over the southern and greater part of the area. It is thickest in east-west valleys, where as much as 25 feet have been observed. The bedrock is thus concealed over considerable areas along the Northeast Arm-Cross Gulch lineament.

Drift is far more prominent in the northern part of the area. Drumlins occur as smooth-surfaced, oval hills elongated in the direction of ice flow and completely lacking in bedrock outcrops, in contrast with areas of abundant outcrops all around them. They are composed of drift, presumably till, and were evidently shaped beneath actively flowing ice.

Some drift features in the northern part of the map-area indicate that there the ice stagnated during melting. They include several eskers, as well as kames and kame terraces. The best esker is just north of Fox Hills; it is composed of fine gravel and is 25 to 30 feet high and about 2 miles long. It must have been laid down by a subglacial stream flowing between walls of ice either in a tunnel or at the bottom of a crevasse. As the esker ends against considerably higher land to the south, it is thought that the stream flowed northward to another subglacial stream occupying Cinq Cerf Valley. The kame terraces are found along the upper reaches of La Poile River (Billiards Brook), Fox Hole Brook, Morg Keepings Brook, and Deep Brook. They consist of gravel, and are high above the present streams. They were formed after the ice had melted from the upland but while it still remained in the valleys. The streams that deposited them flowed along the trough that must have formed between the ice and valley walls. When the ice melted away the gravels were left as terraces along the valley walls. Both eskers and kame terraces are formed only when the glaciers are more or less stagnant. These are the first features of this kind discovered in Newfoundland and the first indications of ice stagnation. It is impossible at present to outline the area thus affected.

CHAPTER IV

STRUCTURAL GEOLOGY

GENERAL FEATURES

The structural trend of the Devonian rocks, as shown by the strike of stratified rocks and the direction of elongation of igneous intrusions, is northeast in conformity with the trends in the greater Appalachians. The structure in the western and northern parts of the area is an anticline, here named the Gunflap anticline for the prominent Gunflap Hills located on its axis. In the southeastern part of the area is a syncline, which will be termed the La Poile syncline. Both these structures are complicated by igneous intrusions, faults, and small folds.

Little can be said of the structure of the pre-Devonian rocks in the northern part of the area. So far as studied, their structural trends are irregular and more nearly north than northeast. These rocks are truncated by the narrow, quartz-bearing diorite body, which parallels the trend of adjacent strata of the Bay du Nord group to the south.

The Gunflap anticline lies between the Dolman gneiss and the quartz-bearing diorite. The porphyritic biotite granite and the injection gneisses associated with it lie along the axis, and the Bay du Nord group forms the limbs.

The La Poile syncline lies south of the Bay d'Est fault, which runs through La Poile Bay and the valley of Northeast Arm to the eastern boundary of the map-area. Strata of the La Poile group lie in the syncline, and its southeastern limb is bordered by intrusive rocks. The axis plunges to the northeast and roughly bisects the peninsula between Northeast Arm and Cinq Cerf Bay, passing through Bevan Cove in La Poile Bay and a point 4½ miles due north of Cinq Cerf Barasway. The syncline is nearly symmetrical near La Poile Bay, but is sharply overturned to the northwest in the vicinity of Cinq Cerf Brook. It is cut off by the Bay d'Est fault, and neither it nor rocks of the La Poile group have been found northeast of this fault. The schists north of the fault are parallel with it, and vary as much as 40 degrees from trends in the La Poile syncline.

The Bay d'Est fault may be presumed to have a very large displacement as it has brought totally unlike rocks into juxtaposition. The direction and angle of dip of the fault plane, as well as the directions of relative movement, are unknown.

CLEAVAGE, SCHISTOSITY, AND LINEATION

Good examples of flow or slaty cleavage are to be found in slates exposed near North Bay. Their cleavage strikes northeast and dips southeast, and thus is parallel with the regional structure. Generally, the bedding coincides with the cleavage.

Schistosity, or platy foliation, is found in rocks of both igneous and sedimentary origin. Where both primary structures and schistosity are visible, the latter is generally parallel with the bedding of strata and with the flow banding of igneous rocks. At a few localities, however, in the schists and gneiss north of the Bay d'Est fault, well-defined schistosity crosses conglomerate and other sedimentary layers at a high angle, and would have effectively masked the folds if the beds had not been dissimilar lithologically.

Lineation, or linear parallelism of minerals in the plane of schistosity, has been observed in many parts of the region. The direction of plunge is usually within 30 or 40 degrees of an east-northeast direction. Near North Bay, such structures are well developed in the massive siliceous members in which the lineations trend very nearly north 65 degrees east and dip to the east at moderate angles. They generally parallel drag-fold axes, and are thought to mark a direction of localization of ore shoots on the Strickland claims.

The planar structures in the area are not all contemporaneous in origin. Some formed prior to the granite intrusions; others, of less significance, were developed after the emplacement of the Roti granite and the porphyritic biotite granite.

FOLDS

The main features of the major anticline and syncline of the map-area have already been described. These, as well as the smaller folds, have been determined with the aid of marker beds, drag-folds, fracture cleavage, and graded bedding.

The La Poile syncline is nearly upright at its southwestern end. Although the fold is nearly isoclinal, its presence is revealed by the strike and dip of the strata. Further evidence is the presence of sedimentary rocks and tuffs on both the northwest and southeast limbs, and the large quartz porphyry sill that roughly follows the axis. To the east, the fold is overturned toward the northwest, and dips give no indication of its presence. The synclinal structure might, indeed, be questioned if graded bedding at several places near Cinq Cerf Brook did not indicate that the tops of the beds are to the northwest although they dip 55 degrees in the opposite direction.

Small folds were observed near the Bay d'Est fault. Their axes parallel the fault and are, therefore, at an angle to the regional trend. They appear to be related genetically to the faulting. They are developed on both sides of the fault for a width of nearly a mile in the broad area of unclassified schists and gneisses north of the fault and in the bedded sediments and tuffs in the Bakers Brook area south of it. They are not evident in the massive volcanic rocks of the La Poile group, the large quartz porphyry sill, or the Dolman gneiss, presumably because these rocks were too competent to be folded.

There is considerable disturbance of strata adjacent to the porphyritic biotite granite. This is well displayed in the narrow belt of sedimentary rocks between Little Bay and Broad Cove, which strike toward the granite at high angles. At several places in the sea cliffs, isoclinal folds may be

seen involving scores of feet of strata. Drag-folding indicates the existence of a syncline in the upper part of Broad Cove, where the deformed belt is broadest. This minor folding dies out toward the north.

FAULTS AND FRACTURES

So far as known, the faults of the map-area are all steeply dipping and include both normal and reverse types. A fault exposed on the south shore of Roti Point brings the schist and conglomerate of the La Poile group into juxtaposition with the Roti granite. From there it trends northeasterly and passes across Little Roti Bay. Where exposed, the fault plane dips 80 degrees northwest. It is a reverse fault, as a large drag-fold and fracture cleavage both indicate that the northwest is the upthrow side. Considerable left-hand lateral movement occurred along the fault, as key formations on the upthrow side have been offset about 2,500 feet to the southwest.

A fault, marked by a shear zone 50 to 100 feet wide, forms the southern boundary of the Roti granite between Roti and Cinq Cerf Bays. It dips 67 degrees or more, generally toward the south. Drag-folds and fracture cleavage indicate that the downthrow side is to the south, and thus it is generally a normal fault. The fault fracture and the parallel fractures occupied by rhyolite dykes a short distance to the north are probably due to tensional fractures developed when the compression attending the intrusion of the Grand Bruit batholith was relaxed. Substantial movement occurred along the fault fracture; the other cracks were filled with rhyolite magma.

The Bay d'Est fault is the largest fault in the area, but less is known of it than of the other faults. Its course is well marked topographically as it runs up the valley of Northeast Arm and then follows a succession of east-west valleys cut by smaller brooks. Phillips Brook has a falls 75 feet high at the fault line. The brook then turns and follows the fault for nearly half a mile before resuming a southeast course. Nothing comparable to a fault plane was observed, as the rock near the fault line is sheared and crumpled.

The Bay d'Est fault is believed to have a steep dip as it maintains a fairly straight course over high land and low. Presumably it dips between 67 and 90 degrees as does the last-mentioned fault. The displacement must have been large as the stratified rocks on the two sides of the fault are totally different. Some igneous intrusions are common to both sides of the fault, but none of these cuts the plane itself. As the fault cuts the Chetwynd granite some fault movement took place after all the larger intrusive bodies were emplaced.

CHAPTER V

ECONOMIC GEOLOGY

INTRODUCTION AND SUMMARY

The La Poile-Cinq Cerf area is a potential source of various metallic minerals, feldspar, building stone, and hydro-electric power. The metals include lead, zinc, silver, copper, gold, iron, and arsenic. The building stone is granite. Up to the present, there has been no commercial development of any of these resources although they have been more or less prospected. The known resources are described and evaluated in the following pages. Their origin is discussed, and certain general guides to further prospecting are suggested.

In general, the metallic mineral possibilities are more promising than the others. Although both water power and building stone are adequate, lack of local demand and distance from markets retard development. The chief commercial interest in the area centres around two types of deposits at two localities. These are the Chetwynd gold-copper deposit at Cinq Cerf and the Strickland lead-zinc-silver deposit near North Bay. The former was discovered about 1902 and has been prospected intermittently since that time. The latter was discovered in the autumn of 1936, and was tested by trenching and drilling operations the following year. Both properties are now idle (July 1941). In addition to the two main deposits, small base-metal concentrations are known. They are of no value in themselves but show that mineralization is widespread and give some encouragement to more extensive search.

The metallic deposits are hydrothermal replacements and fissure fillings. Presumably the solutions were given off by one or more of the exposed intrusive rocks of the area, but criteria are lacking by which the mineralization may be dated precisely. The gold-copper deposit at Cinq Cerf is post-Roti granite and the silicification is pre-Chetwynd granite.

WATER POWER

The ideal natural water-power site is one where a large stream encounters a steep, high fall. These conditions are more or less fulfilled at several places in the area. The best natural site is the waterfall, 170 feet high, near the mouth of Broad Cove Brook, where 3,000 horse power is available. This site has been surveyed but is not the largest. A high falls 9 miles up Cinq Cerf Brook probably could produce more power.

INDUSTRIAL MINERALS

Feldspar and Associated Minerals

The granite-pegmatite dykes described earlier contain feldspar, mica, beryl, and garnet. Unfortunately, the possibility of commercial deposits is remote. Beryl and garnet are scarce, but might conceivably be sought

as gems. Although some of the garnet has an attractive red colour, all observed garnet was too flawed for this use. The mica is biotite, which is unsuited for electrical use and is not much in demand. Moreover, like beryl and garnet, it is of restricted occurrence in the dykes. Feldspar (mostly potash feldspar but including some soda feldspar) is invariably one of the chief constituents of the dykes, and it is possible that commercial deposits may be found. Under ordinary circumstances, a dyke of minimum width of 30 feet, which carries 60 per cent or more feldspar, is required.

Building Stone

The granites of the map-area are potential sources of building stone. Pink to light red leucogranite (Chetwynd granite), grey granite (granodiorite), and pink porphyritic granite (porphyritic biotite granite) have been observed. All of these outcrop at tidewater and might be developed for export. The porphyritic granite surrounds the excellent harbours at Little Bay and La Poile. Unfortunately, this and the other stones of the area seem to lack the special qualities (unusual beauty, ease of quarrying, etc.) necessary for successful competition in distant markets. They have been used locally to a slight extent in retaining walls and foundations. A quarry, now shut down, was open some years ago at Petites, 10 miles west of the map-area. The rock there is syenite, probably related to the porphyritic biotite granite. It is well jointed and admits of quarrying in slabs up to 25 feet. It was used as facings in the Court House at St. John's.

QUARTZ VEINS AND THEIR METALLIC MINERALS

Small quartz veins are common throughout the area, and are particularly abundant in rocks of the Bay du Nord group and in the quartz porphyry sills. Most of them are lacking in metallic minerals, and consist of more or less vuggy white quartz. Some contain a little calcite either as filling of cavities in the veins or as thin plates in the quartz. Where they cut mafic rocks, as they do in the gneiss areas near the southern coast, they contain euhedral epidote crystals up to ½ inch in diameter encrusted in places by tiny actinolite needles. Epidote is abundant in some veins. The totally barren veins grade into types containing various metallic minerals. Some of these veins, though of little potential value in themselves, are described below as they throw some light on the general nature of mineralization in the area.

Veins Within and Near the Batholiths

Small, high-temperature quartz veins cut porphyritic biotite granite, granodiorite, and the adjacent older rocks. They contain a little tourmaline, magnetite, pyrite (or pyrrhotite), and in a few cases chalcopyrite. Some are filled fissures and others are replacements along shear zones. They are thought to be closely related to the pegmatites, as vein minerals and late pegmatite minerals are practically identical, and quartz veins and pegmatites have approximately the same distribution. The veins may thus provide a link between the batholiths and the early specularite-tourmaline-pyrite mineralization of the Chetwynd lode.

Pyrrhotite-bearing Veins Near Dolman Cove

At several places near Dolman Cove, there are high-temperature veins that contain pyrrhotite and traces of chalcopyrite and arsenopyrite. The best example is near the head of the cove. This vein occurs along a sheared and crumpled zone in a greenish grey schist member of the Bay du Nord group, and is 5 feet thick. Selected samples were tested for gold, with negative results, by Mr. E. P. Conroy of the Newfoundland Government laboratory.

Arsenopyrite-bearing Veins and Replacements

Arsenopyrite is associated with quartz veins in the Rocky Ridge granite stock and in the Bay du Nord group. The best example is a mile southeast of Rocky Ridge, where small showings are numerous within an oval area 4,000 feet long. The granite is fractured in this area and contains quartz veins up to 10 feet wide. The more prominent of these strike north 10 degrees east roughly parallel with the long axis of the mineralized area. The arsenopyrite occurs in the quartz veins and as a replacement of granite near them. The thicker veins are mostly barren; the arsenopyrite is most abundant near their margins and in small veins and stringers in the granite. The arsenopyrite is in part fine-granular and in part in euhedral crystals ¼ inch long. Generally, it is the only metallic mineral in the veins, but at one place pyrite and a little chalcopyrite were found lining vugs in the quartz.

Arsenopyrite also occurs near North Bay. Commonly, the arsenopyrite occurs without other metallic minerals as an impregnation of slate or schist within a few inches or feet of quartz veins. The quartz itself is generally barren but may contain pyrite or pyrrhotite. The mineralization is most intense along the vein contact, and grades into barren schist within a few feet. The arsenopyrite is present as separate, commonly euhedral grains, which have replaced the schist. Flakes of dark mica, resembling biotite but having the relatively low index of refraction of phlogopite, occur in the schist and range from ⅛ to ¼ inch in diameter.

The arsenopyrite seems to occupy a transitional position between high-temperature veins and the lead-zinc-silver deposits. It is a late product in a high-temperature vein in Dolman Cove, and is one of the earliest metallic minerals on the Newfoundland Mining Syndicate's claim on Carrot Brook. The deposits are of no possible value as a source of arsenic. Mr. E. P. Conroy, of the Newfoundland Government laboratory, has assayed grab samples from six widely separated occurrences. Three from the North Bay area showed traces of gold, and three from the Rocky Ridge stock showed a trace, 0·02, and 0·04 ounce of gold a ton respectively.

Quartz-Pyrite Veins

In the northern part of the map-area, quartz-pyrite veins are associated with faults. They are fillings of fault fissures or of minor fractures branching from the fault. Such veins on Moose Brook are clean white quartz, with varying amounts of pyrite. No sulphide minerals other than pyrite

were observed. A much larger vein on Fault Brook is much weathered, and the quartz is rusted and cavernous. Leached cavities and solid cakes of limonite an inch or two thick show that there was considerable sulphide originally. At one place, a little pyrite was found, and it is probable that pyrite was the abundant sulphide. However, an occurrence of malachite in the gossan indicates that at least a little copper is present.

DISSEMINATED PYRITE

Both igneous and sedimentary rocks in the area contain local disseminations of pyrite at places accompanied by a little chalcopyrite. These were investigated carefully, and grab samples from eight representative occurrences were assayed for gold with negative results. Excepting the pyrite occurrence in the Chetwynd lode, the largest concentrations of pyrite were found just south of Northeast Arm for a mile or two west of Bakers Brook, along the southern shore from Barasway Island eastward to Cinq Cerf, and in the area of Keepings gneiss.

In Northeast Arm green schist and felsic pyroclastic rocks have been mineralized, more particularly where they have been sheared. This is best illustrated half-way between Bakers Spit and Friar Head, where the effects of mineralization centre about a sheared and crumpled zone in green schist. Pyrite and a little chalcopyrite have impregnated the schist across several feet, and thin layers of the schist have been selectively replaced. Small quartz veins in the shear zone contain a little pyrite and chalcopyrite.

The pyrite along the southern shore is disseminated in lenses having maximum dimensions of 15 by 150 feet and average dimensions of about 1 foot by 10 feet. The lenses occur in greenstone or dark-coloured dykes and are generally oriented parallel with the gneissic foliation.

In the Keepings gneiss area, pyrite disseminations are found in granite, siliceous rock that is presumed to have been sandstone originally, amphibolite, and other basic amphibole-bearing gneisses evidently derived from igneous rocks. The largest and most persistent are in gneisses carrying bronze-coloured amphibole as a prominent constituent.

LEAD-ZINC-SILVER AND COPPER MINERALIZATION

General Features

DISTRIBUTION

Deposits of lead, zinc, and copper sulphides, with gold and silver, are found in those members of the Bay du Nord group that have undergone extensive silicification and sericitization from the nearby intrusions of Baggs Hill granite. The general area in which these deposits occur extends southwesterly from the main mass, and smaller masses, of Baggs Hill granite to North Bay and Dolman Cove.

CHARACTER OF DEPOSITS

The deposits are mesothermal replacements of favoured layers in the Bay du Nord group now more or less silicified and sericitized. The metallic minerals are disseminated through the rock or occur as veinlets along fracture surfaces or favoured layers. The known deposits are patchy and, on the average, low in metals. The Strickland deposit is much the best, and is the only one known that may be of commercial value.

There are two types of deposit, one characterized by abundant sphalerite and galena, the other by chalcopyrite. Assays of the first type indicate a lead-zinc-silver ore, with a small amount of copper and gold, whereas those of the second type show a copper ore with a little gold and silver. The two are described together as there are some transitions between them and they occur close to one another on the Strickland property.

Strickland Prospects

HISTORY AND DEVELOPMENT

These deposits were discovered by Alex Strickland in the autumn of 1936. They were the first deposits of this type to be discovered and are the most promising of the known deposits in the district. All development is confined to a single mineralized zone 3,500 feet long, at the northern end of which is the so-called lead-zinc-silver prospect, and at the south end the copper prospect. The geology of this zone and development work are shown on Figure 1. Seventeen trenches cross the mineralized zone, and ten holes have been drilled from points 200 to 250 feet from the vein on the hanging-wall side. These holes dip 45 degrees and are approximately perpendicular to the bedding. They intersect the mineralized zone and are from 231 to 283 feet long. The prospecting was done during the summer of 1937 by Ventures Limited of Toronto, with whom Mr. Strickland and his associates had a co-operative agreement. Ventures Limited has since relinquished its share in the claims and they have reverted to the original owners. The property has been idle from that time until the time of writing (July 1941).

GEOLOGY OF THE DEPOSITS

The field relationships, as determined from outcrops, prospect trenches, and drill cores, is illustrated on Figures 1 and 2, the latter showing enlarged detail of part of Figure 1. As may be seen from these figures, the structure is simple, and the mineralized zones follow closely the bedding direction, which, with a few minor irregularities, strikes north 32 degrees east and dips 54 degrees southeast. At five places near the deposits, linear structures and small drag-folds plunge close to north 65 degrees east and dip 15 to 35 degrees. The northern 2,000 feet of the mineralized zone, which contains all the lead-zinc-silver deposits, follows a topographic depression bordered on the two sides by rocky, quartzite ridges (*See* Plate IV).

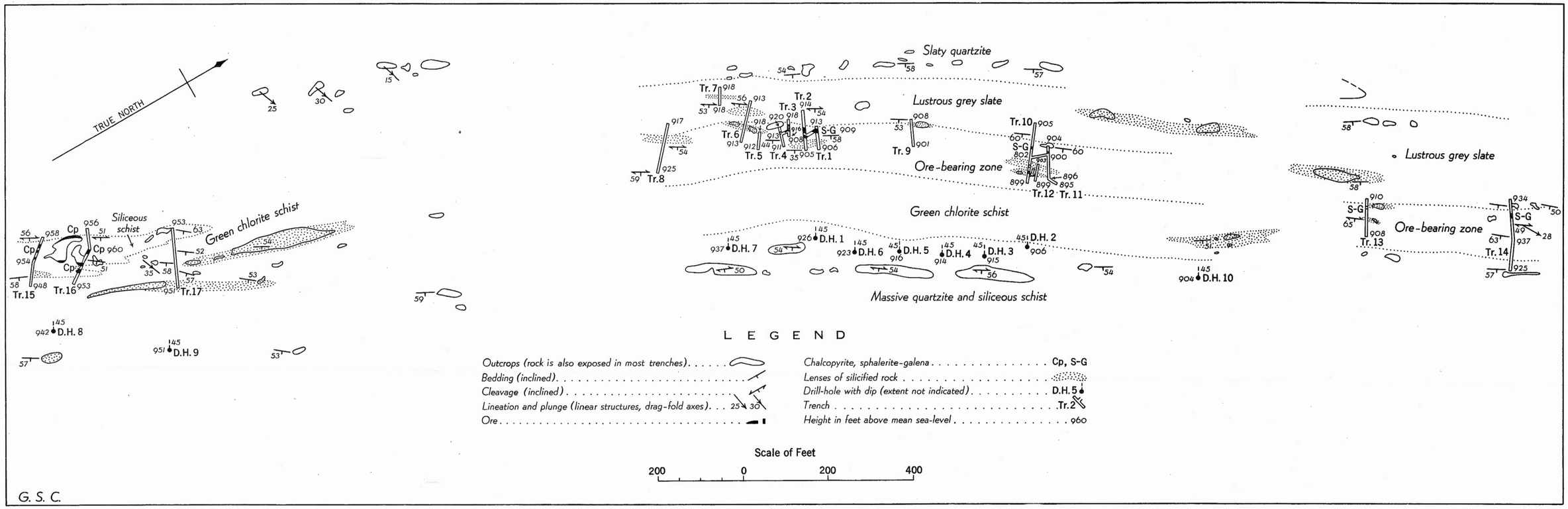

Figure 1. Outcrops and prospect trenches on Strickland claims.

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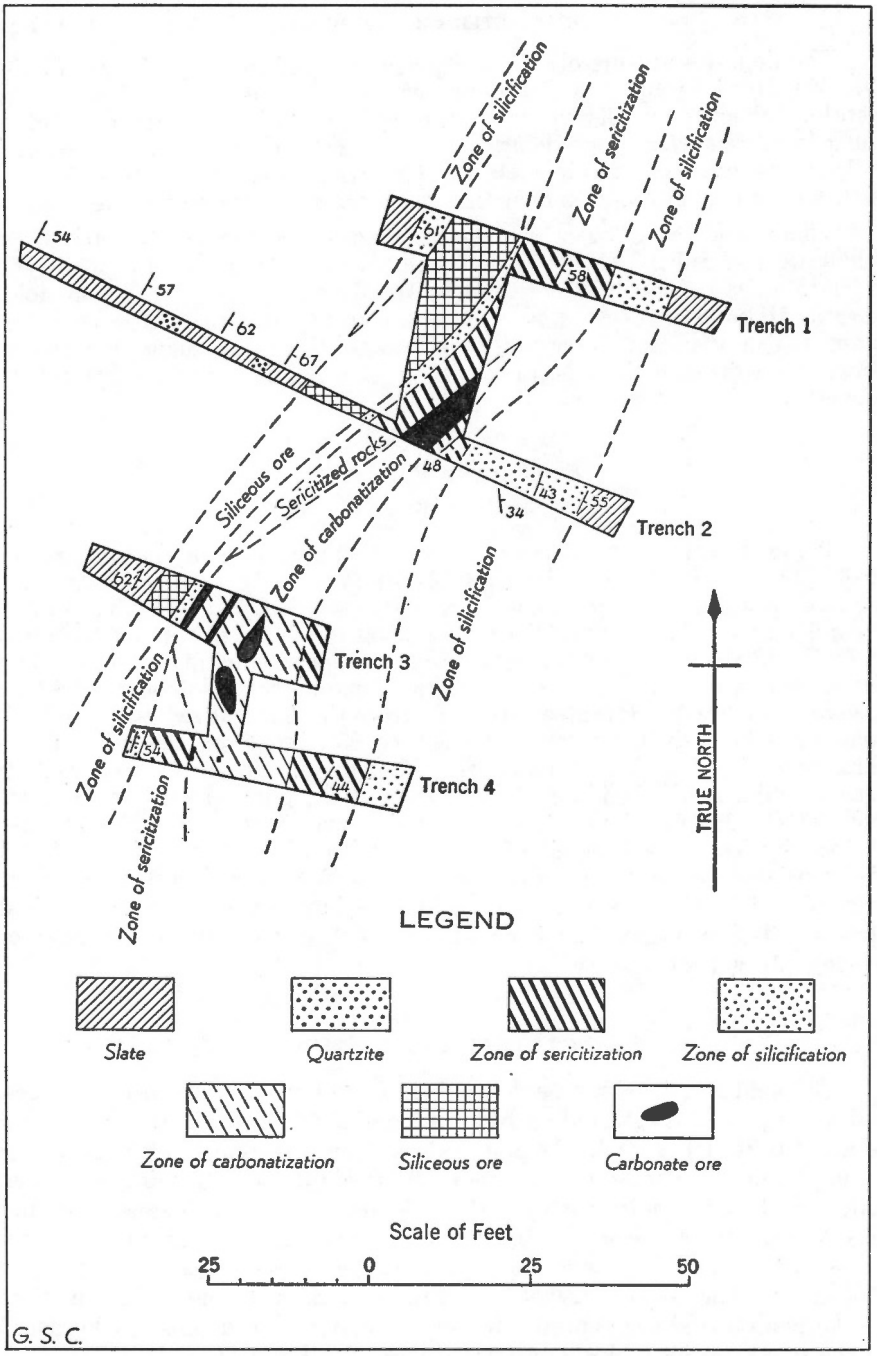


Figure 2. Detail of trenches 1 to 4 on Strickland claims.

The rock underlying the northern 2,000 feet of the ore-bearing depression is divisible into three units. The lowest unit consists of dark lustrous slate, which is commonly banded by thin siliceous layers. It is similar to banded slates exposed along Carrot Brook. A little disseminated pyrite, pyrrhotite, and chalcopyrite are the only metallic minerals present. Above this is a zone 30 to 70 feet thick characterized by silicification, sericitization, and a little carbonate rock. The sphalerite and galena are found in this zone, which, for convenience, is called the ore-bearing zone although most of it is below ore grade. Those parts that are of ore grade are indicated on Figure 1. The thickest ore shoot exposed by trenching is 10½ feet (trench 1), and by drilling is 5 feet (hole 3). The thickest ore shoots in the drill-holes were found at the base of the ore-bearing zone. Above this zone, is 100 to 130 feet of green chlorite schist, with greenish sericite, epidote, biotite, quartz, feldspar, and in places a little calcite. Disseminated pyrrhotite, pyrite, and chalcopyrite are common, comprising up to 5 per cent of the rock by volume over a few feet in thickness. A few paper-thin stringers of sphalerite and galena observed at one place represent the only zinc and lead minerals seen in this zone.

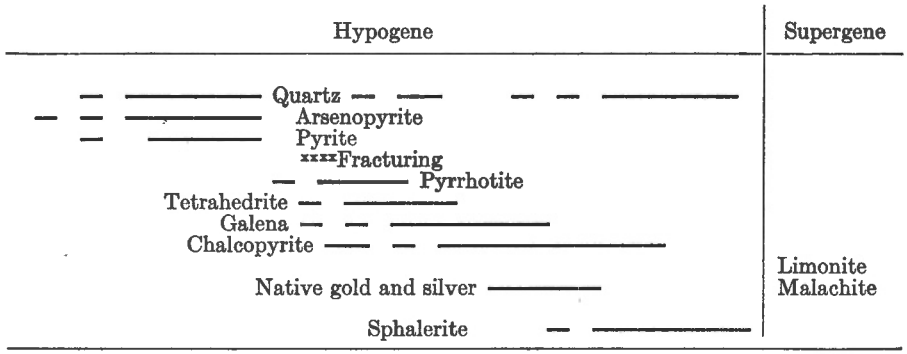
The threefold division described above is not recognizable near the copper prospect. At the southern end of the property the rock is greenish schist, associated with some siliceous schist and sericitic quartzite. Chalcopyrite, with pyrite, pyrrhotite, and at some places a little sphalerite and galena, occurs as veinlets and disseminations in the siliceous schist. A rude banding is discernible at some places because of the selective replacement of certain layers.

The lead-zinc-silver ores are of two general types, which may be distinguished on the basis of the gangue minerals as siliceous ore and carbonate ore. The first contains considerable gangue in the form of fine-grained granular quartz and sericite. The ore minerals are disseminated or occur as veinlets, and commonly have a rudely banded structure. The carbonate ore occurs as small, lenticular masses of nearly solid sulphides separated by nearly or quite barren calcite. The relationship between the two ore types is shown on Figure 2.

The mineralogy and paragenesis, as determined by Mr. A. P. Beavan from his miscroscopic study of the ore, are summarized in the following table.

TABLE II

Paragenesis of the Ore Minerals, Strickland Claims



NOTE. The symbol ×××× indicates the relative time at which fracturing and shearing occurred.

Pyrite occurs in most of the polished specimens examined. It is euhedral to subhedral, and observed occurrences were invariably fractured to some extent. Arsenopyrite occurs in typical euhedral crystals and also as small, thin, lath-shaped grains. Fracturing of the arsenopyrite is particularly well shown by these thin laths. Where pyrite and arsenopyrite are in contact, which is only in a few places, the latter shows euhedral outlines against the former. There is no evidence of replacement of one by the other. The arsenopyrite is interpreted as contemporaneous with, or in part earlier than, the pyrite.

Some quartz was probably deposited with these sulphides, or at any rate, at an early stage in the sequence of mineralization. Irregular to rounded areas of glassy quartz occur in the ore. They are crossed by a few fractures in which pyrite, arsenopyrite, and other sulphides occur, but in contrast with the surrounding materials they are almost free of sulphides.

The renewal of movement in the ore zone that caused fracturing of the early quartz, pyrite, and arsenopyrite evidently coincided with a change in the nature of the material deposited from the hydrothermal solutions. All the remaining hypogene minerals of the ore are obviously later than this fracturing. As they are rather intimately associated, they may be described together.

The sulphides of this later group are sphalerite, galena, pyrrhotite, chalcopyrite, and tetrahedrite, in order of their abundance. Of these, sphalerite of a dark brown colour is the most abundant, and is always accompanied by at least a little galena. Pyrrhotite occurs in appreciable amount in three polished sections, and in traces in another. Tetrahedrite is closely associated with galena, but occurs in only two polished sections, in both of which pyrrhotite is abundant, as well as galena. Chalcopyrite is sparingly present in several specimens but is plentiful only in those from the copper prospect, where it is the only abundant sulphide.

The chalcopyrite in one polished section contains three small grains of a mineral that appears to be native gold rich in silver. In another section it contains an unidentified, pink, isotropic mineral, which is slightly harder than the chalcopyrite.

EXPOSED THICKNESS AND TENOR OF ORE SHOOTS

The outcrop of material considered to be of ore grade is indicated on Figures 1 and 2. The greatest thickness is that of the siliceous ore shoot in trench 1, which is 10½ feet. The thickness of the other shoots may be inferred by comparing their outcrop width with that shown for this shoot, the exposed width being approximately proportional to the thickness of ore except in trench 14 where an ore band only 1 foot thick appears as a relatively wide band because it occurs along the crumpled axis of a small anticline. All the ore exposed at the surface, except the carbonate ore in trenches 2, 3, and 4 (*See* Figure 2), is siliceous ore or simple replacement of the schist. There are, however, mineable thicknesses of fairly high-grade carbonate ore in four of the cores, namely, 5 feet in hole 6, 3¼ feet in hole 4, 5 feet in hole 3, and 4 feet in hole 2. The sulphide content of these was estimated to be 15 to 30 per cent by volume. The siliceous ore in the cores is lower in grade than this and apparently lower in grade that that exposed in the trenches. The sulphide content of the siliceous ore appears to make up less than 10 per cent by volume.

The available assays of the Strickland orebodies are compiled in Table III. Assays 1 and 2 are of siliceous ore and mineralized schist. Assay 1 is thought to be representative of the siliceous ore of trenches 1, 2, and 3, and is probably of higher grade than that from the other trenches. Assays 3 and 4 are of massive sulphide lenses, here termed carbonate ore. They are not representative of a mineable thickness, because the highly weathered condition of the carbonate zones made it impossible to secure such a channel sample. A higher proportion of silver to lead and zinc seems to be characteristic of the carbonate ore when compared with the siliceous ore. Assay 5 shows the gold content of one of the rare pyrite veins in the ore. In the whole deposit, there is very little of this material. Assays 6 to 9 show the tenor of the chalcopyrite deposits at the southern end of the mineralized belt. Considerable material of this general grade is exposed at the surface and in core from drill-hole No. 9, but not in bodies large enough for commercial development.

TABLE III

Assays of Strickland Orebodies

	Zinc	Lead	Copper	Silver	Gold
	Per cent	Per cent	Per cent	Ounces a long ton	Ounces a long ton
1	7·60	6·71	0·44	7·62	0·05
2	1·72	2·63	.....	3·05	0·01
3	20·75	22·35	0·31	33·00	0·02
4	19·76	12·56	.....	30·511	0·065
5	.....	.....	.....	.....	0·20
6	*Nil*	*Nil*	3·62	6·12	0·04
7	.....	.....	1·60	.....	0·01
8	.....	.....	3·26	.....	trace
9	.....	.....	3·87	.....	*Nil*

1. Channel sample of siliceous ore vein 4 feet thick in trench 3. J. R. Cooper, collector; E. P. Conroy, analyst.
2. Grab sample from northern part of claim. Quoted from Claude Howse (11, p. 5).
3. Channel sample of a lens of massive carbonate ore 1 foot thick from trench 3. J. R. Cooper, collector; E. P. Conroy, analyst.
4. Chip sample across vein (evidently carbonate ore) at main prospect. Quoted from Claude Howse (12, p. 4).
5. Grab sample of high-grade pyrite ore from trench 1 to determine gold content. J. R. Cooper, collector; E. P. Conroy, analyst.
6. Channel sample of chalcopyrite ore 6 feet thick from richest part of trench 16. J. R. Cooper, collector; E. P. Conroy, analyst.
7. Channel sample of chalcopyrite ore 4½ feet thick from trench 15. J. R. Cooper, collector; E. P. Conroy, analyst.

8 and 9. Grab samples from the copper prospect described as "high grade". Quoted from Claude Howse (11, p. 4).

STRUCTURE OF THE ORE SHOOTS

The structure of any mineral deposit is of paramount importance in its development. The discussion that follows is an attempt to solve some of the structural problems of the Strickland ores. The ideas advanced are necessarily hypothetical, but they help to explain a number of otherwise puzzling features.

The prospecting trenches show a persistent lead-zinc-silver mineralized zone from trench 4 to trench 14, a distance of 1,700 feet. All holes drilled into this zone reveal that it continues in depth approximately parallel with the stratification planes of the adjacent rock. The intensity of mineralization decreases toward the north. The best ore showings are at the surface near the southern end of the zone (trench 1), south of which the lead-zinc-silver mineralization dies out rapidly so that, so far as known, the ground between trench 4 and the copper prospect, 1,650 feet south, is totally barren of metallic minerals. Parts, but not all, of the mineralized ground appear to be of high enough grade and sufficient thickness to mine, the chief problem being whether any of the workable shoots are large enough to mine profitably.

The shoots pinch rapidly along strike and down the dip. This fact is clearly brought out by the shoot of siliceous ore in trench 1. It is 10½ feet thick in trench 1, 8⅓ feet in trench 2, and 4 feet in trench 3, a total distance of only 75 feet, and it disappears a short distance farther south. It also pinches in depth, as drill-hole 1, which intersects the mineralized zone less than 200 feet beneath the surface, penetrated only sparsely disseminated ore minerals, nothing that could be classed as ore. The band of carbonate rock exposed in trenches 3 and 4 also pinches rapidly, for it is only 5 feet thick where it crosses trench 2 and ends before it reaches trench 1.

The ore shoots are thought to have a northeast or east-northeast plunge. The best evidence for this is at the copper prospect. There drill-hole No. 8, which is drilled opposite a good ore showing, penetrates no ore whereas drill-hole No. 9, which is 270 feet northeast along the strike and opposite a totally barren trench, shows as much chalcopyrite as in the surface exposures opposite drill-hole No. 8. Relationships to the north suggest that the lead-zinc-silver shoots have the same structure. Drill-hole No. 1, which is opposite the best showing (trench No. 1), encounters less ore minerals than any of the holes farther north. Drill-hole No. 7, which is south of trench No. 1, lacks sphalerite and galena, although it cuts intensely sericitized rock in the ore-bearing zone.

The known distribution of ores becomes understandable if it is assumed that ore deposition has been controlled by the linear structure, which is strong and persistent in the region. Drag-fold axes are everywhere parallel with the linear structure, and it is probable that they, rather than the linear structure itself, are the controlling factor, as in trench 14 the ore minerals are confined to the crumpled axis of a small anticline. On this hypothesis, the ore shoots are flattened cylinders or cigar-shaped lenses trending north 65 to 70 degrees east and dipping about 25 degrees northeast. A simple calculation reveals that the ore shoot in trench No. 1 would project between drill-holes Nos. 5 and 6, both of which show ore and associated carbonate rocks. The ore in drill-holes Nos. 2, 3, and 4 may represent an extension or another shoot, which has not been located at the surface.

There is little indication that the size of ore shoots increases with depth, as the drill-holes in this region are only 100 feet apart and any large increase in the size of the orebodies with depth would have been revealed by them.

ORIGIN

As has been pointed out, the Strickland deposits, are mesothermal replacements of a favoured zone of the Bay du Nord group. It is thought that the ore-forming solutions were given off by the Baggs Hill granite, which the ore-bearing strata intersect at depth. The solutions are believed to have risen along the bedding planes and zones of shearing or brecciation. The chief control of ore deposition in this case appears to have been the presence of the rock layers that were easily replaced. There is little evidence of dynamic movement along the ore zone, the rock being 'tight' and unfractured. The solutions rising along fractures and bedding planes encountered the thin limestone bed and easily replaced green schist, and deposited their dissolved metals in this favourable environment. Their upward course appears to have been guided by drag-folds as available data suggest that the ore shoots are elongated in the direction of the drag-fold axes.

Newfoundland Mining Syndicate's Claims

LOCATION

The claims of the Newfoundland Mining Syndicate are in two localities, one about half a mile east of Bay du Nord on Carrot Brook, the other on Big Pond Brook, a tributary of La Poile River.

HISTORY AND DEVELOPMENT

The Newfoundland Mining Syndicate of St. John's was formed soon after the Strickland discovery to prospect for further deposits in the area. The syndicate was active during the summers of 1937 and 1940, after which prospecting was discontinued as all of the showings were small and unpromising. The best centre around Carrot Brook, where small concentrations of sphalerite-galena and arsenopyrite were found. The development work consisted of digging pits and trenches on likely looking outcrops. The main operation was a deep trench southward from the bed of Carrot Brook in an attempt to trace several, thin, lead-zinc veins exposed in the bed of the brook. The trench encountered thick glacial till and was abandoned before reaching bedrock; its sides have now collapsed. In 1940, prospecting centred northeast of the Strickland claim and in the Morg Keepings Brook region. The only claim staked was the base-metal showing on Big Pond Brook.

LEAD-ZINC PROSPECTS

The lead-zinc deposits near Carrot Brook occur along shear zones in white weathering silicified rock or lustrous quartz-sericite schist. The best showing south of the stream is near the west end of a long prospect trench at the valley rim. Here the rock is sheared and contains quartz veins across 6 feet. Low-grade mineral disseminations occur in this zone, the best being near, but not in, quartz veins. It is too low in grade to be of value. In the bed of the brook there are two showings about 125 feet apart in silicified rock, the lowest silicified lens in this area. At the lower showing, some quartz veinlets cut sheared schist and are bordered for about a foot on either side by very low-grade disseminated sulphide minerals. The upper showing, on which most of the development work was done, is in highly silicified rock, which contains two sulphide veins 3 feet apart. The maximum width of either is 6 inches, but some disseminated sulphide occurs between them. The lower vein extends only 4 feet. The hanging-wall of the upper and more persistent vein is a shear plane consisting of a slaty sericitic gouge 2 to 8 inches thick. Lesser shears run out from this in several directions and have localized smaller sulphide veins.

COPPER PROSPECT SOUTH OF CARROT BROOK

This prospect lies ⅓ mile south of Carrot Brook, in white weathering silicified rock, which commonly contains tiny crystals of biotite. One blue-grey zone 4 feet thick is sheared and a little chalcopyrite occurs along the shear plane. The mineralized zone is up to 8 inches wide.

BIG POND PROSPECT

Two copper showings in the vicinity of Big Pond lie about 1,000 feet north of the lake on Big Pond Brook. Both occur in silicified rock and may be traced some distance parallel with the strike of the enclosing beds. Both metallic minerals and wall-rock alteration resemble those already described near North Bay. The showings were discovered and investigated in 1939. The Newfoundland Mining Syndicate staked the deposit the following year and did a little development work. Although several of their trenches were examined, the area was not restudied in detail. Apparently nothing of value was discovered.

The best of the two showings is in the bed of Big Pond Brook. The silicified zone is 50 feet thick but contains unreplaced lenses of chlorite schist with garnet metacrysts. Brecciation is evident at some places and there are more or less vuggy quartz veins. The tiny quartz crystals within the vugs are rounded and etched, a feature not observed near North Bay but common on the Chetwynd claim at Cinq Cerf. The metallic minerals are disseminated and make up less than 5 per cent of the rock. They have been leached out of most of the surface outcrops, which, however, are not more rusted or porous than many other outcrops of the area. The least-leached material is found in the bed of the stream. Chalcopyrite is the most abundant metallic mineral. With it are found tetrahedrite, pyrrhotite, and late marcasite. In a silicified layer ¼ mile west and another ½ mile south, millerite crystals were found in vugs. The quartz in the vug is coated with albite, which in turn is coated by needle-like crystals of millerite.

The other showing is on the strike of the brook prospect, 3,600 feet to the southwest. The mineralization is similar, except that a little sphalerite and galena were found with the copper minerals. Here, as at the other showing, metallic minerals are scarce. It is evident from inspection that the deposits are too small and too low grade to be valuable for their base-metal content.

CINQ CERF GOLD-COPPER AREA

General Features

INTRODUCTION

The Cinq Cerf gold-copper area is a regional term used to include those prospects and mineral occurrences in and near the valley of Cinq Cerf Brook, most of which lie within 3 miles of Cinq Cerf Bay. The most important of these prospects are the two Chetwynd deposits, on Cinq Cerf Brook about 2 miles north of Cinq Cerf Bay, and the Woodmans Droke prospect, 3 miles southwest of the Chetwynd deposits. Plate II is a view of the Chetwynd property.

The following description is intended to supplement that of Snelgrove in 1935 (18, pp. 11-16), to which the reader is referred particularly for the history, development, and available assays for the district. The following paragraphs are concerned with new information gathered during the present study. Mr. Greig's metallographic study of specimens secured from outcrops, mine dumps, and trenches has cleared up many puzzling problems of the mineralogy and paragenesis. The discovery of fourteen specimens with macroscopic gold near the Chetwynd shaft give for the first time critical data regarding the position of gold in the mineral succession. The broad regional studies in the area have served to define the mineralized area and to locate a few additional prospects. A detailed account of these results is given in the following pages.

The only development work performed in the area since 1935 is the trenching of the Woodmans Droke prospect and the drilling of eight diamond drill-holes by Toronto interests in 1937. Four holes were drilled at the Woodmans Droke prospect, three were drilled near the Narrows of Cinq Cerf Brook, and one at the Hope Brook prospect.

As it was reported locally that visible gold was once found on the small island in Cinq Cerf Brook opposite the Chetwynd shaft, and as a specimen collected from a quartz vein there by Dr. Snelgrove showed microscopic gold, it was thought desirable to thoroughly test the rock of this island for gold. Two channel samples and one grab sample were assayed for gold, but each showed only a trace.

MINERALIZED AREA

The deposits lie in a narrow and nearly straight belt trending north 53 degrees east between the Woodmans Droke prospect and the Chetwynd granite, a distance of 4⅓ miles. The trend of this belt varies slightly from that of the stratified rocks in which it occurs. The northeastern 2¼ miles of the belt, which contains the only deposits of any promise, is a silicified and otherwise altered shear zone that extends roughly parallel with Cinq Cerf Brook and easterly beyond it to the Chetwynd granite. This zone is easily traced by brown or buff weathering hillocks of silicified rock. The width of the zone of silicification increases toward the northeast. About 1 mile southwest of the Chetwynd shafts, the zone is indicated by small lenses of silicified rock arranged *en échelon* over a width of a few feet. At Chetwynd shaft, the width of alteration is 600 feet, individual silicified lenses being 20 to 100 feet thick and several hundred feet long. Near the Chetwynd granite, silicification is evident across a width of 1,000 feet. The Chetwynd granite cuts off the belt, and no sign of it was found beyond the granite.

TYPES OF MINERAL DEPOSITS

In general, there are four types of mineral deposits in the Cinq Cerf gold-copper area: (1) mesothermal quartz veins carrying pyrite, chalcopyrite, sphalerite, and galena, represented by the Woodmans Droke

prospect and by occurrences in Georges Brook; (2) hypothermal quartz-specularite-tourmaline mineralization, with more or less pyrite, found at the Iron Hat prospect and at a point ¼ mile northeast of it; (3) disseminated pyrite mineralization, represented by the Hope Brook prospect; (4) epithermal copper ores, mainly of hypogene bornite, with some free gold as well as supergene chalcocite and covellite. The last type, which is represented at the Chetwynd main shaft and at the Chetwynd Copper shaft, is the only one of promise. Mineralization of this type has followed that of types 2 and 3, and has been superimposed on them locally. That of type 1 has no apparent connection with the others.

Woodmans Droke Prospect

Woodmans Droke prospect is about ½ mile west of Cinq Cerf Brook, about ½ mile from its mouth in Cinq Cerf Bay.

Sulphides—pyrite, chalcopyrite, sphalerite, and galena—occur in coarse, glassy quartz veins that cut a sheared quartz porphyry sill. A trench 440 feet long crosses the sill and some adjacent grit and conglomerate beds, and a cross-trench 250 feet long with short side extensions follows the mineralized part of the sill. Elsewhere the sill contains numerous quartz veins, but they are mostly barren of metallic minerals.

Individual sulphide-bearing veins lack persistence, and except for their content of sulphides are indistinguishable from small, barren quartz veins that characterize the quartz porphyry in many parts of the area. The sulphides occur sporadically, generally where the quartz veins are fractured and more or less vuggy. The abundance of barren quartz as compared with the small, scattered sulphide occurrences in it gives little encouragement for the discovery of commercial deposits.

Iron Hat Prospect

The so-called Iron Hat prospect is 400 feet southeast of the Chetwynd main shaft, and on the same property. The prospect has been known for many years and has been explored by shallow surface cuts. A similar type of deposit was found during the present investigation ¼ mile northeast. The Iron Hat deposit seems to be only a few square yards in extent, but the new discovery has been traced at intervals for about 100 yards along strike. In this distance it varies in width from several inches to several feet. As the two deposits are similar they are described together.

The deposits consist of disseminated specularite, tourmaline, and pyrite(?), generally associated with small quartz veins. The tourmaline is fine grained, and the specularite occurs either as microscopic scales or macroscopic plates, which are locally as much as 2 inches across. No pyrite was found in the deposits, but its original presence is indicated by cubic cavities in quartz, tourmaline, and specularite. Small plates of barite encrust the quartz crystals lining small vugs.

Mr. Greig has studied polished specimens from both localities. The specimen from the Iron Hat contained fine platy specularite in coarsely crystalline quartz. The specularite is either interstitial to, or contemporaneous with, the quartz. Evidently the quartz began to crystallize first, and crystallization continued, together with the specularite. At the other deposit, specularite is associated with tourmaline in porous, platy masses, and also occurs as platy masses in vein quartz, and as finely disseminated microscopic plates in the tourmaline. At both localities supergene limonite is present.

Hope Brook Prospect

The Hope Brook prospect was first described by Snelgrove in 1934 (18, p. 15). Since that time a diamond drill-hole has been put down on the outcrop, but the results of the drilling are not available. The deposit consists of pyrite disseminated in silicified rock and appears to be representative of the early quartz-pyrite stage of mineralization recognized at the Chetwynd shaft.

Chetwynd Main Shaft

The Chetwynd Main shaft is on the south bank of Cinq Cerf Brook about 2½ miles from its mouth. The mineral deposit there is partly a replacement of highly silicified rock and partly fracture fillings in silicified and pyrophyllitized zones. The original rock type is indeterminable because of the high degree of secondary alteration. The silicified rock is fine textured, but contains at many places large residual grains of bluish milky quartz, which suggest derivation from an acidic intrusion or from one of the coarse-textured tuffs. Although the underground workings are flooded and not accessible, relationships observed in the trenches and in specimens from the mine dump clearly indicate an earlier quartz-pyrite mineralization and a later gold-copper stage. Fracturing took place between the two stages of mineralization. In general there are two types of mineralized rock occurring in close association with one another:

(1) *Sulphide Replacement Deposits.* This material consists of disseminated fine to fairly coarse-grained sulphide replacements of highly silicified rock along shear and fracture zones. A rough banding of the sulphides is noticeable in places. The hypogene minerals are pyrite, tennantite, bornite, and two unidentified sulphide minerals. Pyrite is the most common sulphide. It varies from very finely disseminated aggregates to coarser euhedral grains, commonly contains small quartz inclusions, and is almost invariably fractured. Apparent inclusions of bornite and tennantite were observed under the microscope in a few polished sections. These may indicate a second generation of pyrite, but, more probably, are bornite and tennantite replacements along paths that cannot be seen in that particular section. Coarse to fine, roughly banded or disseminated

tennantite has replaced the enclosing rock. The other sulphides—bornite and the two unidentified sulphides—usually occur as disseminated replacement minerals. Commonly the pyrite is euhedral toward the interstitial but locally embaying copper sulphides. Fractures in the pyrite are commonly filled with quartz or copper sulphides. Very minute specks of a white mineral, probably hematite, are disseminated in the silicified rock. This suggests a connection with the specularite-tourmaline deposits, the nearest of which, at the Iron Hat, is only 400 feet away.

(2) *Vein Fillings.* Small veins and stringers resulting largely from fracture filling are common. The metallic minerals are pyrite, bornite, gold, and two unidentified sulphides. Quartz is the main non-metallic mineral, but late pyrophyllite, fluorite, and barite are found in some veins. Quartz was introduced at first during early silicification of the shear zone and later, after the fracturing of pyrite. The late quartz is commonly euhedral and shows comb structure on the walls of the stringers. Within small vugs, the pyramidal faces of the quartz crystals are rounded as though the quartz was out of equilibrium with later solutions and had been partly dissolved. These later solutions would be those responsible for the pyrophyllite, fluorite, and barite. Pyrite occurs in the quartz stringers as small fractured grains or as relatively large fractured crystals. Tennantite is rare in the stringers, presumably because it was one of the early sulphides of the second generation, and thus was disseminated in the wall-rock and replaced bands in the silicified material, none being available when deposition of the vein material began. Bornite is common in the stringers and is always interstitial to the quartz. The two unidentified sulphide minerals occur in minor amounts in the quartz stringers. Native gold has been observed in about a score of specimens, and, with one possible exception, is definitely later than the quartz and copper sulphides.

Chetwynd Copper Shafts

The two shallow shafts known as the Chetwynd Copper shafts are 500 feet northeast of the main shaft. The shafts are flooded and inaccessible. From the dumps it appears that the one nearer the brook penetrated rock similar to that at the main shaft but less intensely mineralized. The other shaft was sunk in the hanging-wall slate as the silicified rock encountered in the first shaft was found to be almost impenetrable. All the minerals found at the Main shaft have been found at the Copper shafts, and their paragenetic relationships are in general the same. The only differences are that primary chalcopyrite is more abundant at the Copper shafts and that hematite there occurs in isolated pseudomorphs after magnetite.

Economic Possibilities of the Cinq Cerf Area

The Chetwynd gold-copper showings represent the only known deposits of possible value in the Cinq Cerf area. The mineralized zone is nearly

40 feet wide at the Main shaft, and presumably continues at least as far as the Copper shafts, a distance of 500 feet. The mineralized zone at the Copper shafts is similar to that at the Main shaft but apparently of lower grade and thickness. Assays from the district are not particularly encouraging. In a series of 5-foot channel samples taken continuously along the 40-foot trench just northeast of the Main shaft by Dr. A. K. Snelgrove (18), only four showed measurable amounts of gold. These are adjacent to one another and on strike with the shaft. They show that for a width of 20 feet in the trench the gold content ranges from 0·05 to 0·125 ounce a ton, with a maximum copper content of 1·09 per cent across a width of 5 feet. These results, however, may not be truly representative of the deposit, for it is known that copper has been leached from near the surface, and it is possible that gold has also been leached. Dr. Snelgrove quotes local miners as reporting lenses of bornite and other sulphides several feet in thickness near the bottom of the Main shaft (18, p. 14). Although no evidence of such sulphide masses was seen on the dump, it seems safe to conclude that the copper content is greater below ground. This is based in part on the testimony of miners and in part on the presence of supergene chalcocite and covellite in material from the dump.

Data are lacking as to the probability of gold leaching and enrichment. Following the discovery of visible gold at the Main shaft, an attempt was made to find detrital gold by panning gravels secured from potholes in the bed of Cinq Cerf Brook below the shaft. Although the potholes seemed to be ideal to catch any gold that was in the brook, and although an abundant heavy mineral concentrate consisting largely of magnetite, specularite, and garnet was secured, no gold was detected. Thus it may mean that gold is being leached from outcrops and is, therefore, not being supplied to the stream or it may mean that there is insufficient gold in the deposit to have got into the stream bed in the geologically short time since the last glaciation. There is, of course, a third possibility, that there is a little gold in the stream bed but that none happened to be caught in those particular places that were panned.

The only reliable way to appraise the Chetwynd deposit is by subsurface exploration. In view of the width and apparent length of the mineralized zone, the owners would be justified in testing it by diamond drill. There is a possibility that enough material exists of sufficiently high grade to warrant opening a small mine. It is well to point out, however, that a mine at this place would encounter difficulties. The orebody, if such exists, is very close to Cinq Cerf Brook, and ground water is likely to be a serious mining problem in view of the fractured nature of the rock. It is understood that difficulty with underground water was the chief reason for abandoning the Chetwynd Main shaft.

There is a possibility, also, that additional deposits of the same type may be found in the general area. In the silicified and otherwise altered zone extending from the Chetwynd Main shaft to the Chetwynd granite,

there are local, leached, spongy outcrops indicative of the former occurrence of sulphide minerals. However, it is impossible to tell from these outcrops whether the sulphides were valueless early pyrite, as in the Hope Brook prospect, or valuable gold and copper-bearing sulphides of the later mineralization.

Both barite and spherulitic pyrophyllites have been observed in the area northeast of the Chetwynd Main shaft. As these minerals are among the latest group at the Chetwynd shaft, they suggest that the other, associated gold-copper minerals may also be present. This can only be determined by underground exploration.

BASE-METAL VEINS IN THE NORTHERN PART OF THE MAP-AREA

Evidence of low-grade, base-metal deposition is widespread in the northern part of the map-area, as indicated by mineralized boulders or float found along every large stream flowing south. Float containing pyrite, chalcopyrite, sphalerite, and galena was found along Deep Brook, Morg Keepings Brook, Fox Hole Brook, and La Poile River. It came from the north, most probably from the area of Keepings gneiss, although possibly from still farther north. Rocks of various types have been mineralized to a varying degree, with quartzite and siliceous gneiss carrying the best showings of ore minerals.

In order to have some idea of the general grade of the material and to compare it with the Strickland ores, a mineralized specimen was analysed, with the following results (E. P. Conroy):

Silver	—0·87	ounce per short ton
Gold	—0·01	" " " "
Copper	—0·56	per cent
Lead	—0·13	" "
Zinc	—5·86	" "

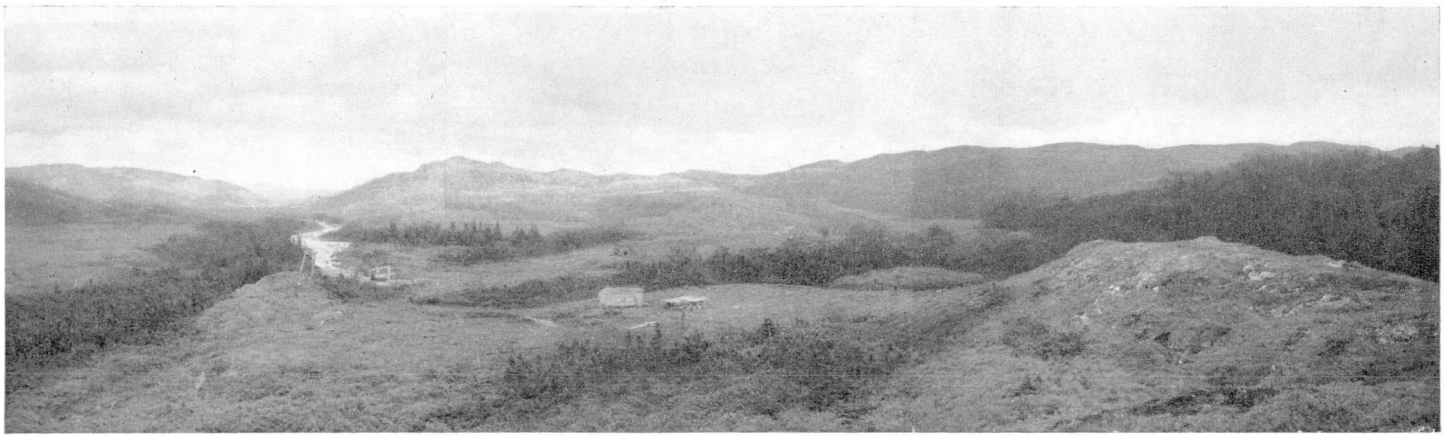
This piece was fairly typical of the mineralized float and consisted of easily seen sphalerite, chalcopyrite, and pyrite in a gangue of glassy granular quartz. It is of lower grade but relatively richer in zinc than the Strickland ores.

Apparently the float of the northern area comes from many small deposits rather than a few large ones. This conclusion is reached because of the wide distribution of the float, the gradation from mineralized to unmineralized rock in single boulders, and the small size of observed bedrock deposits.

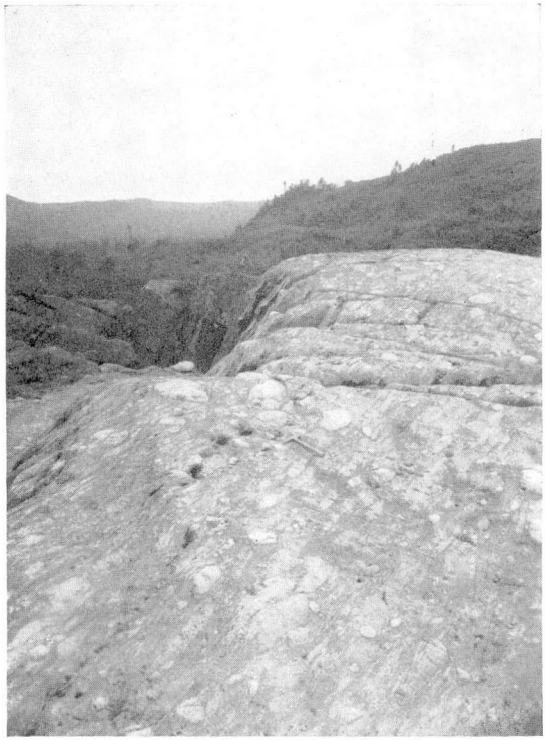
About 2 miles up Morg Keepings Brook from the mouth, a small vein carrying lead, zinc, and copper minerals was found in granite carrying inclusions of banded gneiss. The vein is only 7 inches wide and 7 feet long but is faulted off at one end.

Two small veins were found near the forks of Fox Hole Brook, one in granite and the other in an altered diorite rock. The mineralization was localized along epidotized and chloritized shear zones and is represented by lenses of calcite a few feet long carrying disseminated magnetite and chalcopyrite. Magnetite is more abundant than chalcopyrite. Other deposits of the same general type occur farther north, judging from float found in the east branch of Fox Hole Brook.

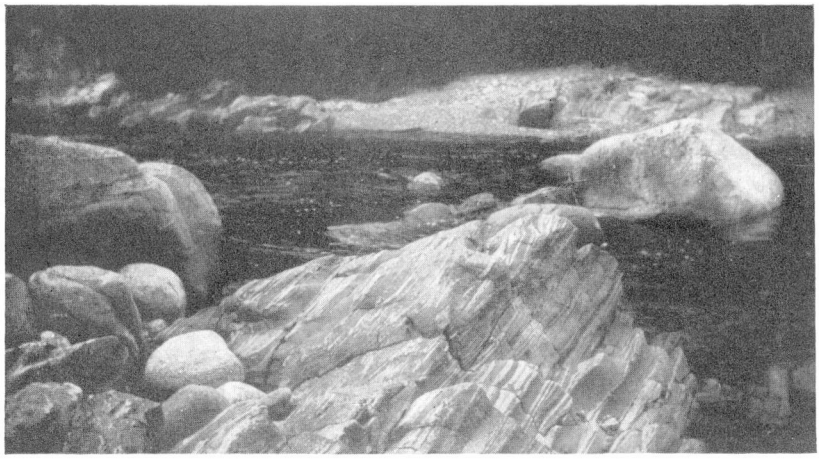
PLATE II



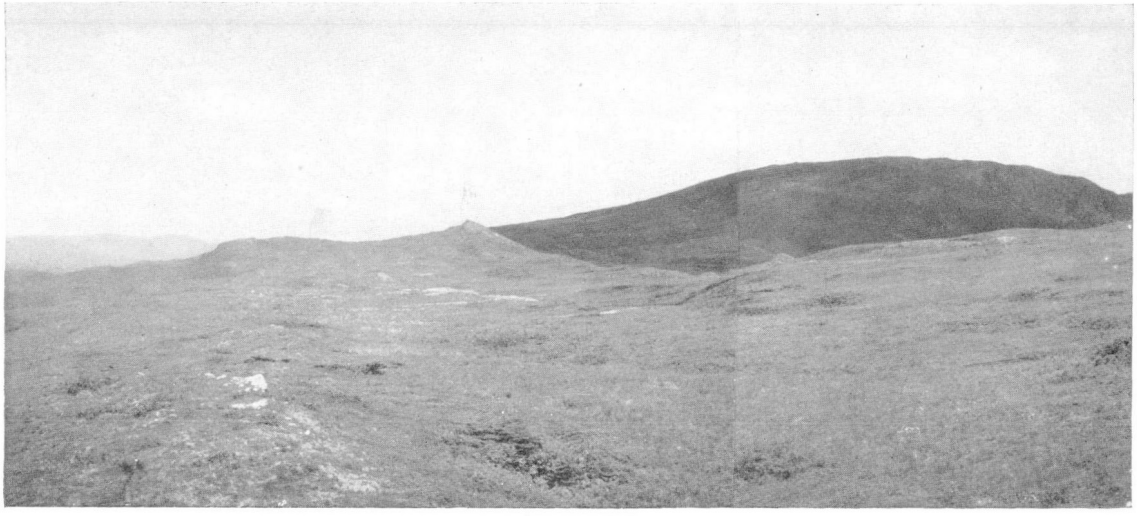
Panorama looking northeast along the main mineralized zone at the Chetwynd prospect, Cinq Cerf. Main shaft is beside brook to left of centre. Rocky knoll in right foreground is a silicified lens; others may be seen in the middle distance. (Page 49.)



A. La Poile conglomerate near the falls of Cinq Cerf Brook. (Page 15.)



B. Injection gneiss in Bunker Hill Brook. (Page 28.)



Ore-bearing depression at Strickland claims, looking northeast. Lead-zinc-silver prospect trenches show as light patches in the middle distance. Baggs Hill in right background. (Page 41.)

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