GEOLOGICAL
SURVEY
OF
CANADA

DEPARTMENT OF MINES
AND. TECHNICAL SURVEYS

MEMOIR 321

GISBORNE LAKE AND TERRENCEVILLE MAP-AREAS, NEWFOUNDLAND

(1 M/15 and 10)

D. A. Bradley

Price, $1.00

1962

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TERRENCEVILLE MAP-AREAS,
NEWFOUNDLAND

2,000—1962—1975

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By

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PREFACE

The map-areas adjoining Fortune Bay in southern Newfoundland are in a key position to provide data on the geological and tectonic history of Newfoundland. Several studies for university theses were made in parts of the area before 1949, the year of Newfoundland's confederation with Canada, but were not published. The author began field investigations in the Gisborne Lake and Terrenceville areas in 1947 under the auspices of the Geological Survey of Newfoundland, and for two more seasons after confederation he continued his studies as a project for the Geological Survey of Canada.

This report is the first comprehensive published account of the complex geology and structure of part of the Fortune Bay area. It includes descriptions of the approximately 35,000 feet of volcanic and sedimentary rocks of Precambrian (?) to Late Devonian age, of three granitic batholiths of Silurian and/or Devonian age, of several major unconformities, fold complexes, and fault systems, and of a low-intensity regional metamorphism that occurred before Late Devonian time. It also includes brief descriptions of the Pleistocene deposits and a few mineral occurrences.

The report is illustrated by two coloured geological maps on a scale of 1 inch to 1 mile.

J. M. HARRISON,
Director, Geological Survey of Canada.

OTTAWA, June 13, 1960.

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GISBORNE LAKE AND TERRENCEVILLE MAP-AREAS, NEWFOUNDLAND

Abstract

The Gisborne Lake and Terrenceville map-areas, at the head of Fortune Bay in southeastern Newfoundland, are part of an extensive plateau that developed by post-Devonian peneplanation and was thoroughly glaciated during the Pleistocene epoch. The two areas are underlain by approximately 35,000 feet of folded Precambrian (?) to Upper Devonian volcanic and sedimentary rocks. Three granitic batholiths have been intruded into formations as young as Ordovician, and formations from Precambrian to Silurian (?) age have undergone low-intensity regional metamorphism.

The stratified rocks include conglomerate, greywacke conglomerate, sandstone, greywacke, siltstone, shale, slate, and interbedded lavas and pyroclastic rocks. An Upper Cambrian trilobite and Upper Devonian plant remains are the only fossils found to date in the map-areas.

The oldest batholith, at Cape Roger Mountain, is metamorphosed; the next oldest, Cross Hills batholith, contains a large proportion of basic xenoliths; and the youngest, the Ackley batholith, is characterized by roof pendants.

Four unconformities are recognized, one below the Lower Ordovician (?) rocks, two in Middle and Upper Ordovician (?) rocks, and one below the Silurian (?) rocks. A fifth unconformity may exist, unexposed, below the Upper Devonian rocks. Southeast of Fortune Bay the rocks are exposed in narrow, tight, overturned isoclinal and fan folds trending northeastward. North of the Bay, folds have the same orientation, but range from open to asymmetrical and overturned. The map-areas are broken by longitudinal reverse, transverse, and normal faults into elongate, northeasterly-trending blocks in which fold axes are parallel. At Terrenceville, Precambrian (?) rocks were thrust on Upper Devonian rocks. The head of Fortune Bay may be a Triassic graben.

The areas are structurally favourable for metallization, but no deposits of economic importance have yet been found.

Résumé

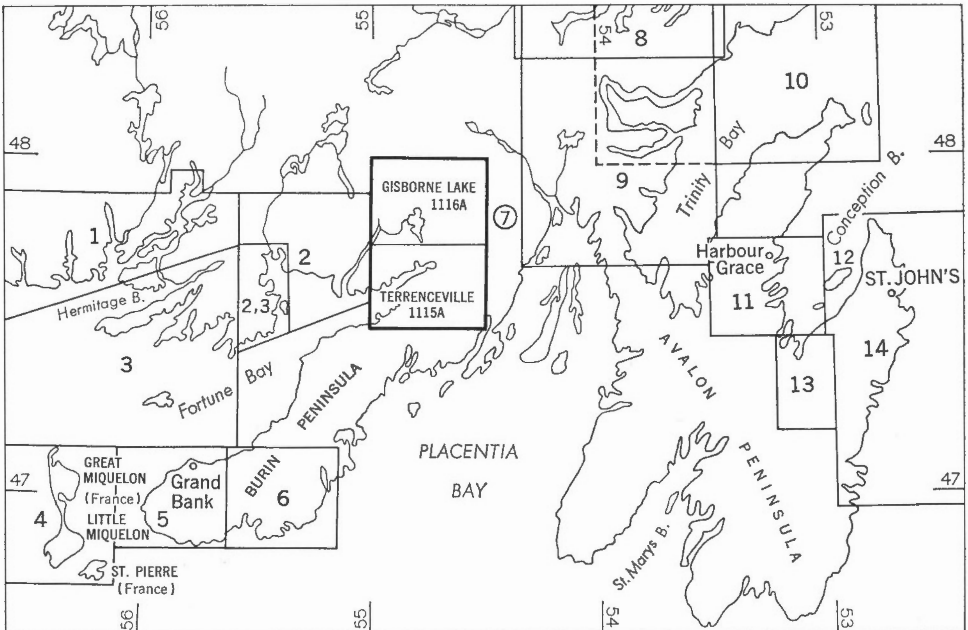
Les régions des cartes Gisborne Lake et Terrenceville, qui se trouvent à l'entrée de la baie Fortune, dans le Sud-Est de Terre-Neuve, font partie d'un vaste plateau façonné par la pénéplanation post-dévonienne que les glaces du Pléistocène ont recouvert sur toute son étendue. Le sous-sol de ces deux régions se compose d'une épaisseur d'environ 35,000 pieds de roches sédimentaires et volcaniques plissées dont l'âge varie entre le Précambrien (?) et le Dévonien supérieur. Trois batholites granitiques ont fait intrusion dans des formations aussi récentes que celles de l'Ordovicien, tandis que les formations dont l'âge se situe entre le Précambrien et le Silurien (?) ont été soumises à un métamorphisme régional de faible intensité.

Les roches stratifiées comprennent du conglomérat, du conglomérat à galets de grauwacke, du grès, de la grauwacke, du siltstone, du schiste, de l'ardoise, et des laves et roches pyroclastiques interstratifiées. Un trilobite du Cambrien supérieur et des débris de plante du Dévonien supérieur sont les seuls fossiles à avoir été trouvés dans les régions à l'étude.

Le batholite le plus ancien, soit celui du mont Cape Roger, a été métamorphisé, tandis qu'un autre d'origine moins ancienne, soit le batholite des collines Cross, contient une forte proportion de xénolithes basiques. Quant au batholite d'Ackley, le plus récent des trois, sa principale caractéristique est la présence de lambeaux de toits.

Quatre discordances sont reconnues dans la région à l'étude: une sous-jacente aux roches de l'Ordovicien inférieur (?), deux au sein des roches de l'Ordovicien moyen et supérieur (?), et une autre qui se trouve sous les roches siluriennes (?). Il se peut qu'il existe une cinquième discordance non encore mise à jour en dessous des roches du Dévonien supérieur. Au sud-est de la baie Fortune, les roches affleurent suivant des plis étroits, resserrés et déversés de types isoclinal et en éventail, orientés vers le nord-est. Au nord de la baie, les plis ont la même orientation, mais ils y sont ouverts, asymétriques et déversés. Les régions des cartes à l'étude sont coupées par des failles longitudinales inverses, transversales et normales, ce qui forme des blocs allongés, à direction nord-est, au sein desquels les axes des plis sont parallèles. A Terrenceville, des roches précambriennes (?) ont été poussées sur des roches du Dévonien supérieur. L'entrée de la baie Fortune pourrait être un graben triasique.

Du point de vue de la structure, ces régions sont propices à la métallisation, mais aucune découverte d'importance économique n'a encore été effectuée.



1. Baie d'Espoir, W. B. Jewell (1939)
2. Rencontre East, D. E. White (1939, 1940)
3. Hermitage Bay, Kemble Widmer (1951, unpublished)
4. St. Pierre et Miquelon, Aubert de la Rue (1932)
5. Grand Bank, N. C. Dale (1927) and T. N. Waltier (1948, unpublished)
6. St. Lawrence, R. E. Van Alstine (1944, 1948)
7. Hickeys Pond, A. L. Howland (1940)
8. Terra Nova, Kemble Widmer (1948, unpublished map, Newfoundland Geological Survey)
9. Area between Bonavista, Trinity, and Placentia Bays, A. O. Hayes (1948, part I) and E. R. Rose (1948, part II)
10. Bonavista, A. M. Christie (1950)
11. Harbour Grace, R. D. Hutchinson (1951)
12. Wabana, A. O. Hayes (1915, 1931)
13. Holyrood, W. D. McCartney (1954)
14. Torbay, E. R. Rose (1952)

Scale of Miles

0 25 50

GSC

Figure 1. *Index of geological mapping in southeastern Newfoundland (1954).*

Chapter I

INTRODUCTION

Location and Size of Area

The Gisborne Lake and Terrenceville map-areas lie on the south coast of Newfoundland at the head of Fortune Bay, and are bounded by latitudes 47°30′ and 48°00′ north and longitudes 54°30′ and 55°00′ west. They consist of two 30- by 15-minute map-areas, Gisborne Lake (1M/15) to the north and Terrenceville (1M/10) to the south, their combined areas being 850 square miles, of which about 50 square miles are underlain by a part of Fortune Bay.

Previous Work

Very little previous work has been done in the Gisborne Lake and Terrenceville areas. Reference is made, however, to localities within the area in the voluminous reports of the early geologists, Alexander Murray and J. P. Howley, of the Geological Survey of Newfoundland, whose work extends collectively from 1864 to 1909. D. E. White (1939)[1] mapped the adjacent Rencontre East area, which lay to the west and included a narrow strip of terrain contained in the present map-areas. W. H. Twenhofel (1947) described the physiographic features along the road from Terrenceville to the railway station at Goobies. Geologists representing a number of mining companies have done exploratory work within and on the borders of the area, and several topographic parties have made surveys relative to potential power installations and dam sites, but no published reports of their work are available.

The results of geological work done in nearby south-coast areas up to 1952 (Fig. 1) have been published by N. C. Dale (1927), Aubert de la Rue (1932), W. B. Jewell (1939), D. E. White (1939), A. L. Howland (1940), R. E. Van Alstine (1948), and E. R. Rose (1948).

Present Work

The field study of the Gisborne Lake and Terrenceville map-areas was proposed in 1947 by C. K. Howse, then Government Geologist of Newfoundland. The writer was engaged by the Geological Survey of Newfoundland during the summers of 1947 and 1948, and by the Geological Survey of Canada during the summers of 1949 and 1951, after Newfoundland became the tenth province of Canada.

[1]Dates in parentheses are those of References at end of report.

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The program was one of reconnaissance mapping, and locations were determined by pace and compass surveys. Traverses were generally made at intervals of 1 or 2 miles.

Acknowledgments

The author is grateful to Professors F. S. Turneaure, E. N. Goddard, L. B. Kellum, J. T. Wilson, and L. S. Ramsdell of the University of Michigan for their guidance, constructive criticism, and interest in discussing problems. Drs. E. W. Heinrich, L. I. Briggs, J. A. Dorr Jr. and J. H. Zumberge have also helped in certain aspects of the work.

In 1947 and 1948, during the writer's association with the Geological Survey of Newfoundland, Dr. A. K. Snelgrove of Michigan College of Mining and Technology, former Government Geologist of Newfoundland, visited the field party and offered valuable suggestions. Dr. Snelgrove, as a member of the writer's doctoral committee, has continued his interest in the progress of the field work. Thanks are due to C. K. Howse for suggesting the problem and providing the opportunity to begin this research. Dr. E. R. Rose aided the author in several conferences on the geology of the Swift Current area to the east. Drs. Kemble Widmer, D. E. White, T. N. Walthier, B. L. Smith, and R. E. Van Alstine have been helpful through discussions of the geology of the Fortune Bay region.

Dr. R. D. Hutchinson, formerly of the Geological Survey of Canada, identified late Upper Cambrian trilobites and brachiopods found by the writer in slates from Pin Hill Pond. Dr. W. A. Bell then Director of the Geological Survey of Canada, and Dr. C. A. Arnold of the University of Michigan concurred on an Upper Devonian age for plant fossils from sandstones at Terrenceville.

The writer was ably assisted in the field by Theodore Best in 1947; by John Campbell, R. H. Chapman, and A. J. Myers in 1948; and by H. D. Lilly and Donald Norris in 1949. J. S. Hickey of Terrenceville was indispensable as guide and boatman for three summers, and Patrick McCarthy of Terrenceville for one summer. Townspeople of Terrenceville, Grand Le Pierre, English Harbour East, and Bay L'Argent were most kind in offering hospitalities to the field parties.

General Character of Region

Accessibility

Terrenceville, a town in the north-central part of the Terrenceville map-area, can be reached by automobile via the Cabot Highway from St. John's (179 miles) or from Goobies (52 miles), the nearest railway station. The Marystown road joins the Terrenceville road 7 miles northeast of Terrenceville and partly follows the coastline southward along the Burin Peninsula. In the southern part of the area, a branch road leads from the Marystown road to the town of Bay L'Argent. The roads in the area are surfaced with gravel or crushed stone, and are suitable for automobiles and light trucks, except for short periods of heavy snow in winter or mud in spring.

Travel within the area is facilitated by a fine network of trails. Winter paths connect the frozen lakes and ponds. Summer paths, which run along the bedrock ridges and esker chains, are more circuitous but generally afford good walking. Trails follow the telephone line between neighbouring settlements, and each settlement has its own trail into what the inhabitants call the 'barrens', the upland surface of which the Terrenceville and Gisborne Lake areas are a part.

The government-operated coastal steamer that plies between Port aux Basques and Argentia makes stops the year round at English Harbour East, Terrenceville, Bay L'Argent, and several smaller settlements. Weekly mail boats pick up mail brought by truck from the railway to Terrenceville and distribute it to each settlement that has a post office, westward as far as English Harbour West and southwestward to Grand Bank. These boats generally carry a few passengers and provide a means of access to parts of the area.

Topography

The Gisborne Lake and Terrenceville areas are part of an extensive plateau that was thoroughly glaciated during the Pleistocene epoch. This upland surface is strikingly consistent and of great maturity. It has a gently rolling surface, is essentially treeless, and is dotted with countless ponds and peat bogs. Relief is slight over most of the area. A few isolated hills have steep slopes with a local relief of as much as 600 feet. Areas of bedrock as large as several square miles are exposed. Most of the topographic features trend northeast. Southward movement of the ice is indicated by striations on many bedrock surfaces. Glacial erratics are common.

Most of the area is a bedrock plateau 500 to 800 feet above sea-level, but a few monadnocks rise to 1,200 feet. The monadnock summits may represent an older peneplain surface and the general level of the plateau a younger surface that is being dissected by streams in the present cycle. The present streams have been rejuvenated by post-glacial uplift.

The topography is controlled to some extent by rock type and structure. For example, the granite that outcrops over much of the northern half of the area breaks down readily to form lowlands, and consequently contact zones and roof-pendant areas of volcanic and sedimentary rock project above the granite as resistant ridges. In the southern half of the area the volcanic rocks and an older granite form ridges whereas meta-volcanic and meta-sedimentary rocks form lowlands. The structure is moderately complex. Most of the structural features have a northeasterly trend, thus imposing a northeasterly grain on the ridges and valleys, streams and ponds.

The movement of the Pleistocene ice-sheet in this part of the island was south and southeast, essentially across the major structures. Many of the hills were rounded in the form of *roches moutonnées,* with vertical or nearly vertical, southward-facing slopes. Where the direction of glacial movement coincided with secondary northwest faults and joints and the strike of beds in structural noses, valleys were gouged out in the weaker rocks. These valleys have U-shaped profiles, oversteepened walls, talus slopes, and hanging tributary valleys.

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Glacial moraine occurs as a thin blanket in the lower areas. Eskers occur only over the northern granite area on the level parts of the erosion surfaces. Several drift ridges were noted northeast of Heffern Pond. Meltwater streams deposited gravel where they entered the sea, forming outwash deltas. With the melting of the ice, all but major drainage systems were buried by glacial drift, and much of the area was probably covered by innumerable ponds in unconnected depressions. Since then uplift has rejuvenated the streams that survived burial and has initiated and aided the slow development of the short streams connecting and draining the depressions. Short, rock-walled streams commonly connect the larger ponds.

Drainage

The streams in the area that drain the few lakes and the thousands of ponds and bogs are either dendritic or straight, as determined by rock structure. Four drainage divides separate the stream systems. Falls and rapids are common. Streams can be assigned to one of three classes by using length as the distinguishing feature.

The long streams have headwaters more than 30 miles from tidewater and flow in mature, broad, open valleys. These streams originate to the north in the granite areas and drain many interior ponds. The flow of water is considerable and the gradient is moderate: it is estimated to be about 40 feet per mile for the lower half of Long Harbour River. Rapids and pools are common, and falls are generally less than 5 feet. Where controlled by joints, the drainage pattern of the long streams in granite areas is dendritic or rectilinear; it is trellis-like in the folded sedimentary and volcanic rocks to the south. The largest stream of this class, Long Harbour River, drains Meta Pond (north of the area) and is joined by several tributaries: Tolt Brook, Pin Hill Brook, Beaver Brook, and Kane Brook. Long Harbour, the continuation of this river valley, is a spectacular fiord formed where the ice movement coincided with a preglacial valley. Southwest Brook, which drains Gisborne Lake (locally called Long Harbour Pond) and flows into Long Harbour 1 mile south of the river, was probably a tributary of the preglacial Long Harbour River. Two other streams of this class are Sandy Harbour River and the Dunns Brook-Paradise River system, Sandy Harbour River being the larger of the two. Both drain into Placentia Bay.

The intermediate streams have headwaters from 5 to 15 miles from tidewater and flow in youthful valleys that widen locally to as much as 1 mile. These streams drain several interior ponds and have a flow of water comparable to that of the longer streams. The gradient is from 50 to 100 feet per mile. Rapids, pools, and falls of 5 to 20 feet are common. The lower part of each stream is incised and graded to sea-level with a gentler gradient. The base of a falls with a drop of at least 50 feet commonly marks the beginning of the gentler gradient. The drainage pattern of the intermediate-sized streams is dendritic in granite areas and straight where the streams cross the folded sedimentary and volcanic rocks. The largest stream of this class is the Bay de l'Eau River, which drains Grandys Pond through Clam Brook and Georges Pond. The river is joined by the Eastern Feeder, the Middle Feeder, and the Western Feeder (south of the area) and empties into Bay de l'Eau, Placentia Bay. Other streams of this class are Grand Le Pierre Brook and Terrenceville Brook, which flow into Fortune Bay.

The short streams have headwaters less than 5 miles from Fortune Bay and flow in youthful valleys. Each of these streams drains one or more ponds and has a continuous but limited flow of water. The gradient ranges from about 10 feet to several hundred feet per mile. Rapids, pools, and incised lower parts with a gentler gradient are common in the larger streams of this class. Falls that drop precipitously into the bay characterize the smaller streams. A few streams drain individual ponds, their courses being little more than a series of waterfalls from the plateau 500 feet or more above. The courses of these short streams are straight and controlled by structure. The streams with the incised lower parts drain into landward-projecting arms of the sea. Such streams include: Ryle Barrisway Brook; Bottom Brook, east of Little Harbour East; Salmonier Brook, northeast of Little Bay East; Sugarloaf Brook, east of Bay L'Argent; and Black Duck Brook, which flows into Terrenceville Brook. The falls of the more precipitous streams are majestic when, after a torrential summer rain, the immediate run-off empties quickly into the bay. A few of the more precipitous streams are Harbour Brook, at Terrenceville, and the brooks flowing out of Little Lou Pond, north of English Harbour East, and Gull Pond, west of Pays Cove.

Four irregular drainage divides separate the stream systems of the area. Three are essentially parallel and trend northeast; the fourth trends north-northwest and joins with the northeast ends of the other three. From north to south, the parallel divides are: the Rocky Hills, the Southern Hills, and the Cape Roger Mountain ridge systems. The fourth divide is a chain of hills extending south-southeast from north of Pin Hill to south of Heffern Mountain. In the north, the stream flow off the Rocky Hills is to Fortune Bay via Long Harbour; in the south it is direct to Fortune Bay. Stream flow off the Southern Hills divide is to both Fortune and Placentia bays, whereas that off Cape Roger Mountain is to Placentia Bay. Stream flow off the east face of the north-northwest divide is to Placentia Bay, whereas the flow off the west face is to Fortune Bay in the north and to Placentia Bay in the south.

Gisborne Lake and Grandys Pond are the largest bodies of fresh water. The ponds in the northern half of the two map-areas are bordered by morainal deposits and are shallow, whereas most of those in the southern half are bordered by bedrock and are deeper.

Peat bogs are common on the large flat interstream surfaces of the barrens. Many gentle ridge slopes, a square mile or more in area, have hundreds of terraced bogs, each draining into a lower bog and separated by a small dam of mud and plant growth.

Sea-Coast

The sea-coast is rugged and walled with steep cliffs. Fortune Bay, a N60°E trending arm of the Gulf of St. Lawrence, extends more than half way across Terrenceville map-area. For almost 2 miles the southeasternmost part of this map-area borders the northern part of Paradise Sound on Placentia Bay. Long Harbour projects from Fortune Bay for several miles into the Terrenceville and Gisborne Lake map-areas.

Fortune Bay and other bays of Newfoundland appear to have been formed by the partial submergence of a dissected plateau (Dale, 1927, p. 415), as shown by the indented configuration of its shoreline, the distribution of its principal islands, and the dismemberment of its streams. The coast-lines of Fortune Bay, including Long Harbour and Paradise Sound, are dominated by rugged sea-cliffs that truncate the plateau surface at an elevation of about 500 feet. Fortune Bay, Long Harbour, and Paradise Sound are fiords.

The cliffs extend under water along much of the shoreline. At a few places, rock benches at sea-level have been cut by wave action. Cobble beaches a few feet in width occur in protected coves, and shingle beaches are common along the peninsulas of the Bay L'Argent area where weak sedimentary rocks are exposed to erosion. Sand and gravel beaches have formed where glacial outwash deposits are being dissected.

A magnificent bay-head bar, slightly more than a mile long, extends across the head of Fortune Bay from Terrenceville to within a hundred feet of the opposite shore. Bars, spits, and tombolos have been formed by the accumulation of sand and gravel in some of the larger harbours. Several square miles of grey sandy soil suitable for limited agricultural use are developed on the surfaces of glacio-fluvial terraces, and terraces near each settlement serve as hay grounds and pasture land.

Chapter II

GENERAL GEOLOGY

Gisborne Lake and Terrenceville map-areas are underlain by approximately 35,000 feet of folded, Precambrian to Upper Devonian, volcanic and sedimentary rocks. Formations as young as Ordovician have been intruded by three batholithic plutons, and pre-Upper Devonian formations have undergone low-grade regional metamorphism.

Table of Formations

Era	Period or Epoch	Formation (thickness in feet)	Lithology
Cenozoic	Pleistocene and Recent	Alluvium and beach deposits	Sand and gravel
		Glacial drift 0-75	Glacial drift; sand and gravel in eskers, drift ridges, and fluvioglacial terraces
		Unconformity	
Palæozoic	Late Devonian (?)	Ackley batholith	Coarse red biotite granite with minor local phases of porphyritic alaskite and aplite, cut by dykes and sills of granite, alaskite porphyry, aplite and lamprophyre; medium-grained grey biotite granite in the contaminated roof zone
		Intrusive contact	
	Middle or Late Devonian (?)	Cross Hills batholith	Biotite-hornblende granite, aplite, and quartz monzonite with tabular xenoliths of gabbro, diabase, and diorite; cut by unfoliated lamprophyre dykes
		Not in contact	
	Late Devonian	Terrenceville formation 1,000 + (base and top not exposed)	Brown and grey conglomerate and sandstone, grey-green shale, and red mudstone

Table of Formations (cont.)

Era	Period or Epoch	Formation (thickness in feet)	Lithology
Palæozoic (cont'd)		Not in contact	
	Silurian (?)	Cape Roger Mountain batholith	Foliated hornblende-biotite granite; minor local phases of aplite and diorite in stocks and sills; cut by aplite dykes and lamprophyre dykes that show the regional foliation; minor associated felsite porphyry sills
		Not in contact	
		Rencontre formation 200-4,000	Reworked acid volcanic rocks grading from basal red and purple volcanic conglomerate to red sandstone, siltstone, and minor red shale; one felsite flow. Red and green pebble-schist, phyllite, and slate overlying the Andersons Cove formation in some places may also be Rencontre formation
		Angular unconformity	
	Middle and/or Late Ordovician (?)	Andersons Cove formation 500-4,000	Greywacke conglomerate with acidic volcanic pebbles; green tuffaceous varved slates; meta-conglomerate; minor basalt with pillow structures
		Contact not observed	
		Belle Bay formation 6,000	Felsite, rhyolite porphyry and andesite porphyry flows, minor basalt flows, red agglomerate and tuff, minor intrusive felsite, red green, and purple bedded siltstones in several thick beds showing locally cross-laminations and diagenetic folds
		Angular unconformity	
	Early Ordovician (?)	Grand Le Pierre formation 1,000	Dense, brown, crystal-lithic tuff; minor felsite, greywacke, chert, and basalt. Probably includes some undifferentiated beds of the Nine Mile Hill formation
		Minor erosional unconformity	
	Late Cambrian (?)	Nine Mile Hill formation 3,500	Thermally metamorphosed sediments in the roof pendant; green slate, black- to grey-banded hornfels, quartzite, basalt, and greywacke conglomerate

Table of Formations (conc.)

Era	Period or Epoch	Formation (thickness in feet)	Lithology
		Not in contact	
Precambrian	Proterozoic (?)	Deer Park Pond formation 0-5,000	Schistose, porphyritic, yellow and green felsite and tuff, interbedded in the lower part with meta-basalt, and in the upper part with minor meta-greywacke
		Conformable contact (?)	
		Southern Hills formation 10,000	Greywacke conglomerate, and green schist derived from it in the lower part; red and purple felsite in the middle part; and red and purple felsite interbedded with greywacke and green schist, minor green phyllite, and meta-basalt in the upper part

Precambrian

Southern Hills Formation

Definition

The name 'Southern Hills formation' is proposed for a succession of greywacke conglomerate and green schist overlain by felsite flows and tuffs that are interbedded toward the top of the formation with greywacke, green schist, and meta-basalt flows. This succession is exposed in the cores of doubly plunging anticlines to the northeast and southwest of the Southern Hills. The formation is the oldest in the two map-areas and is probably of Precambrian age. Typical sections can be examined along the axial zone of the doubly plunging Southern Hills anticline either to the northeast, in the minor folds near Big Southeast Brook, or to the southwest, in the folds east of Bay L'Argent. Subdivisions of this formation shown on the geological map accompanying this report are lithologic rather than stratigraphic.

Distribution

The rocks of the Southern Hills formation outcrop in four northeasterly-trending anticlinal belts. The felsite forms high barren ridges (Pl. I A), the basalt forms ridges that maintain a little vegetation, and the sedimentary rocks underlie valleys that contain a little vegetation. The formation is best exposed along the Southern Hills anticline (Fig. 2) and along a parallel but smaller anticline along the south shore of Fortune Bay.

The formation is also exposed in two minor anticlines southeast of the Cape Roger Mountain batholith, each of which is at least 5 miles long and a mile wide. The Southern Hills formation is about 10,000 feet thick but the major anticlinal folds rarely expose more than 7,000 feet of strata and the minor folds to the southeast expose less than 2,500 feet. The formation does not extend north of Fortune Bay and only extends north of the Terrenceville thrust in a narrow belt a little more than 1 mile northeast of the Terrenceville-Marystown road intersection.

Lithology

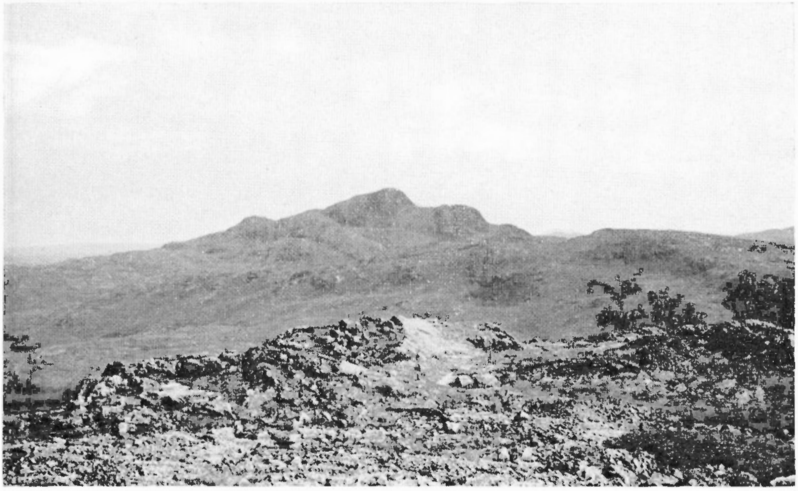
Greywacke conglomerate and green schist derived from it are the principal rock types in the lower part of the formation. Felsite flows and tuffs make up at least half the formation: they form the middle part and are interbedded in the upper part with greywacke (and green schist derived from it), green phyllite, and meta-basalt flows.

The beds of greywacke and greywacke conglomerate are lenticular. They reach a thickness of a few hundred feet and are persistent over several square miles. Felsite flows and tuffs are widespread. In places they reach a thickness of several thousand feet, but individual flows can be differentiated only locally. Tuffs are lenticular but useful in tracing certain structures. The basalt flows are rare but, although only 50 to 200 feet thick, are persistent and most helpful in delineating the fold pattern.

The *greywacke conglomerate* contains boulders, cobbles, and pebbles of red, purple, and green felsite and felsite porphyry, rock types probably derived from intraformational lavas. Although the boulders, cobbles, and pebbles are considerably stretched, most of them before deformation probably ranged from pea-size to 6 inches in diameter (Pl. I B). A few boulders have been observed that in their deformed condition average 12 inches in length and 4 inches in width; the largest noted was a boulder of purple felsite 4 feet long and 10 inches wide. Resistant boulders, cobbles, and pebbles project from the whitish-green, weathered surface of the conglomerate.

The *green schist* derived from the regional metamorphism of greywacke and greywacke conglomerate ranges from light to dark green, as does the green phyllite derived from finer sediments. These rocks are made up of abundant chlorite or biotite and minor amounts of sericite, together with clear quartz, orange orthoclase, and pebbles. The pebbles are altered to penny-sized masses of flaky sericite in a chlorite or biotite matrix.

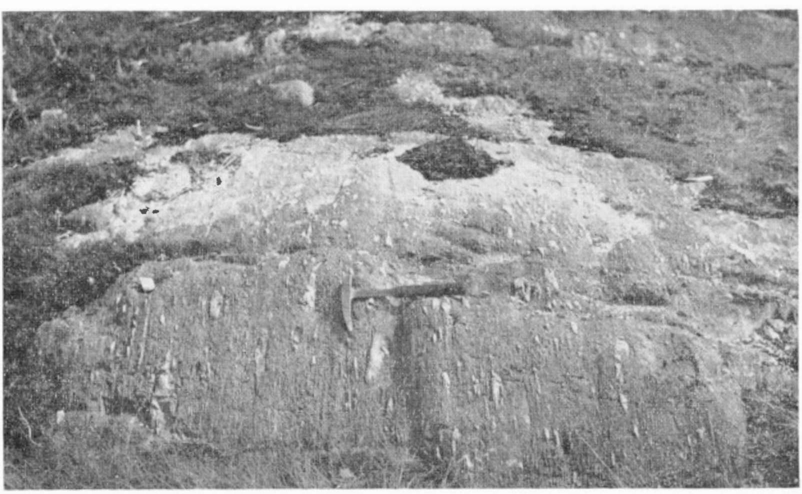
Several specimens of green schist containing deformed pebbles as much as ½ inch in length were examined in thin section. The schist ranges from a less schistose low-grade chlorite type to a more schistose low-middle-grade biotite type. The schist in general consists of fresh subangular grains of quartz, orthoclase, and andesine (An_{38}) averaging 0.3 mm. in diameter, in a matrix rich in either



D.A.B.

A. View looking northeast toward the Southern Hills. Felsite of the Southern Hills formation forms the ridges, and meta-conglomerate of the Andersons Cove formation underlies the lower area on the left.

Plate I



D.A.B.

B. Foliation and stretched pebbles in the greywacke conglomerate of the Southern Hills formation, southwest of Terrenceville.

D.A.B.

A. View looking northeast toward Grand Le Pierre Harbour. The narrow tidal opening (gut), bay mouth bar, barasway, and cliffs of glacial outwash are readily seen. The terrace on the outwash on the right is 42 feet above sea level.

Plate II

D.A.B.

B. Block stoping of diorite by granite in the Cross Hills batholith. The locality is 500 feet northwest of Grand Le Pierre River, due east of the Cross Hills.

chlorite or dark green biotite, and muscovite and epidote. Subangular fragments of fresh felsite, spherulitic felsite, trachyte, and altered diabase are generally larger than the clastic mineral grains.

A progression of metamorphism is shown in thin sections by the foliate minerals. In specimens of lower grade, chlorite predominates in the matrix, and epidote is scattered throughout in irregular patches. In specimens of higher grade, chlorite is present sparingly, and the matrix is partly recrystallized to dark green biotite flakes interlayered with minor amounts of muscovite. The biotite is fairly continuous in the matrix and imparts a parallelism to the rock. The epidote is recrystallized to elongate metacrysts as large as 0.2 mm. in length and to clusters strung out parallel with the biotite.

The recognition of bedding in the green schist and green phyllite is difficult because foliation and cleavage are strongly developed parallel with the axial plane of the folds. Deformed pebbles give the impression of bedding in field exposures, whereas the actual bedding may be perpendicular to this plane. Alternating pebbles and sand layers recognized in a few places exhibit crude bedding. The bedding is also indicated by detrital magnetite layers that have a black, wavy appearance and indicate the sedimentary origin of the green schist. On the crest of a few minor anticlines, the green schist has a rude, irregular blocky appearance controlled by many small fractures that are parallel with the bedding.

The *felsite flows* are of many colours: black, purple, red, brown, and orange in the more aphanitic, massive, quartzose types; green and yellow in the more easily sheared chloritic lavas. The weathered surface is of a lighter shade than the fresh surface because of the alteration of the feldspars to sericite and clay minerals. The felsites are composed principally of quartz and feldspar and contain only small amounts of ferromagnesian minerals. In porphyritic varieties the principal phenocrysts that can be recognized in hand specimens are clear quartz, orange orthoclase, and white plagioclase. Biotite, chlorite, muscovite, and epidote occur in minor amounts as phenocrysts; amphibole and pyroxene are rare or absent. Magnetite is an important accessory mineral and ranges in grain size from octahedra $\frac{1}{4}$ inch in diameter to finely disseminated particles.

The felsite flows show a number of textural variations and primary rock structures that generally occur together. A common variety is an aphanitic, tough felsite somewhat resembling volcanic glass, which has a greasy, vitreous lustre, breaks with a conchoidal fracture, and shatters and splinters like glass that has been hammered. In thin sections the glass-like felsite is seen to be devitrified. Flow-banded felsites are common, as are porphyritic and spherulitic facies. Some varieties have a medium-grained granular texture; others show quartz-feldspar layers and lenses. Jasper and hematite form nodules and irregular streaks in some of the felsite. Tuffaceous and agglomeratic zones are not common, but those examined contain many types of felsite pebbles, probably of local origin. In one place a bed of felsite showing contorted flow-banding was noted, and boulders of this rock were found in the overlying agglomerate.

Under the microscope the felsites are seen to be microcrystalline aggregates of quartz and feldspar grains less than 0.001 mm. in diameter with lenses of quartz as thick as 0.005 mm. In porphyritic varieties having quartz phenocrysts, orthoclase-plagioclase perthite is bordered by sericite in a quartz-orthoclase groundmass. Delicate magnetite grains 0.0005 mm. in diameter occur in clusters and streaks that emphasize layering. In some specimens quartz and feldspar are crystallized as spherulitic radial aggregates 0.02 mm. in diameter with quartz in the interstices. Subordinate minerals include chlorite, muscovite, sericite, green biotite, epidote, and magnetite. Blue riebeckite was observed in the microcrystalline groundmass of a specimen of felsite from Sugarloaf Peak, southeast of Bay L'Argent.

The felsites show little effect of regional metamorphism and are not as strongly foliated as the greywackes. They do, however, show the effects of dynamic deformation as indicated by flattened vesicules, spherulites, and stretched pebbles and, in the porphyritic varieties, by cracked and rotated phenocrysts. One hand specimen of felsite porphyry shows a phenocryst of feldspar that is cracked and rotated much like a loaf of sliced bread in which the slices have been allowed to slump one against another.

Meta-basalt flows range in thickness from 50 to 200 feet. One flow unit is mapped in the northeastern part of the Southern Hills anticline and two in the southwestern part. Megascopically, the meta-basalts are yellowish-green to dark green, and schistose yet tough and resistant, and are characterized by yellow epidote nodules that are probably metamorphosed amygdules. The meta-basalts are fine grained, some mineral grains being as large as 1 mm. and are slightly vesicular in places.

One tough, resistant variety of meta-basalt was found to contain an abundance of olivine, accompanied by labradorite, chlorite, and antigorite. A peculiar red mineral, visible megascopically, was identified under the microscope as iddingsite, an alteration product of olivine, on which it generally forms a red-brown rim. Epidote was present in small amounts.

Another variety of basalt, slightly vesicular megascopically, was seen in thin section to have a diabasic texture. Labradorite laths slightly altered to sericite were abundant, as were grains and flakes of augite and antigorite. Epidote was scattered throughout the groundmass and was present also in vugs. Some quartz was also present.

Age and Correlation

Van Alstine (1948, p. 8) correlated a thick volcanic series in the St. Lawrence area, about 60 miles southwest of Terrenceville, with the Harbour Main group of Conception Bay. His series in the St. Lawrence area consisted of rhyolite, trachyte, dacite, and minor andesite and basalt flows containing local interbedded sediments. These he regarded as of Precambrian age because they are overlain unconformably by fossiliferous Lower Cambrian rocks. This volcanic series and minor sedimentary strata are lithologically similar to the Southern Hills formation and lie along strike to the southwest.

In the area under consideration the unfossiliferous Southern Hills formation is overlain by the Middle to Upper Ordovician (?) Andersons Cove formation. Although the beds in both formations are nearly conformable, an unconformity is believed to exist between them because (1) the Andersons Cove beds are conglomeratic, (2) the Andersons Cove formation overlaps both the Southern Hills and the Deer Park Pond formation, (3) a thick volcanic accumulation such as the Southern Hills formation is atypical of Cambrian rocks in southeastern Newfoundland, and (4) the lithology, thickness, and stratigraphic position of the Southern Hills formation resemble those of the proven Precambrian rocks of the St. Lawrence area to the southwest.

The Southern Hills formation is therefore correlated lithologically with some of the Precambrian rocks in the St. Lawrence area and may also be a part of the Harbour Main group on the Avalon Peninsula.

Deer Park Pond Formation

Definition

The name 'Deer Park Pond formation' is proposed for a series of lavas and minor meta-greywacke in the southeastern part of the map-areas. Representative exposures occur along the Marystown road, and outcrops east of the road and west of Deer Park Pond are typical.

Distribution

The Deer Park Pond formation is exposed from the Bay L'Argent road northeast across the area at least to Sandy Harbour River. Outcrops are much less prominent than in areas underlain by the Southern Hills formation, and the formation underlies broad lowlands of the barrens, where it is commonly exposed in low, flat outcrops.

The Deer Park Pond formation thickens from a few hundred feet on the southeast flank of the Southern Hills anticline to 5,000 feet in the Black Mountain syncline (Fig. 2), southeast of the Cape Roger Mountain batholith. The formation is absent on the southwest nose and on the northwest flank of the Southern Hills anticline, but partly flanks a subsidiary anticline northeast of Ten Mile Pond.

Lithology

The Deer Park Pond formation has been subjected to low-grade, regional metamorphism. The principal rock types are yellow and green schistose felsites and tuffs. The felsites are commonly porphyritic and flow-banded, and the tuffs contain fragments of similar rock. Both facies are interbedded with meta-basalt in the lower part of the section and with minor meta-greywacke in the upper part.

The *felsites* are probably an intermediate-type lava ranging from dacite to andesite. They differ from the red and purple rhyolitic felsites in the Southern

Hills and Belle Bay formations by being characteristically more schistose and more basic. They commonly weather whitish with prominent bands ranging in width from several inches to a foot, but many of the rocks weather to yellow schistose slabs.

Schistose porphyritic varieties of the felsite contain phenocrysts as large as 2 mm. in length, of quartz, pink orthoclase, and yellow, platy, altered plagioclase. Subordinate biotite and sericite can be identified megascopically. In thin sections these felsites are seen to contain broken and dragged andesine (An_{32}), orthoclase, and quartz phenocrysts in a banded sericite-quartz-feldspar-chlorite matrix with calcite stringers. The quartz and feldspar phenocrysts are equally abundant and range in length from 1 to 2 mm. The quartz phenocrysts are embayed by minerals in the matrix, and the feldspar phenocrysts are partly replaced by calcite. Parallel stringy flakes of sericite make up most of the matrix and emphasize the flow-banding in the rock. Quartz, feldspar, and some chlorite are also present in the matrix.

The felsites have been converted in some places to quartz-feldspar-sericite phyllites, schists, or gneisses. These metamorphic rocks of light yellow-green colour contain quartz and feldspar porphyroblasts in a finer quartz-feldspar-sericite matrix. They are pearly white where kaolinized and brown where iron-stained. Cubes of pyrite are common locally.

The *meta-basalts* and *meta-greywackes* in the Deer Park Pond formation cannot be distinguished megascopically from the meta-basalt and meta-greywacke of the Southern Hills formation, but they can be assigned to their proper formation on the basis of the associated lava flows.

Rocks of the Deer Park Pond formation locally show drag-folding, crinkle foliation, and a weak pencil structure formed by the intersection of bedding and schistosity. Those that border the Cape Roger Mountain batholith and those in roof pendants are baked to tough, resistant, massive rocks that in places outwardly resemble granite.

Age and Correlation

The unfossiliferous Deer Park Pond formation is believed to be Precambrian in age for the reasons advanced for the Precambrian age of the Southern Hills formation, which the Deer Park Pond formation resembles lithologically and structurally. Both formations may be the northern extension of Precambrian volcanic rocks in the St. Lawrence area.

Cambrian (?)

Nine Mile Hill Formation

Definition

The name 'Nine Mile Hill formation' is proposed for a sequence of thermally metamorphosed rocks, including slate, hornfels, quartzite, basalt, and greywacke conglomerate, that occur as roof pendants in the Ackley and Cross Hills batholiths or at their margins. Typical exposures of the formation occur at Nine Mile Hill, Dunns Mountain, and Pin Hill.

Distribution

The Nine Mile Hill formation forms high ridges along a line of disconnected roof pendants exposed at Pin Hill, Dunns Mountain, Carrolls Hat, Little Nine Mile Hill, and Nine Mile Hill. The formation is also exposed in a band 5 miles wide that trends southwest from Nine Mile Hill for 15 miles to connect with the Rocky Hills. This band was intruded on the northwest by the Ackley batholith and on the southeast by the Cross Hills batholith. The greatest thickness of the formation is preserved in the Pin Hill area, where 3,500 feet of strata, including 1,500 feet of a stratigraphically low slate member, lie below the base of the overlying Belle Bay formation. The base of the Nine Mile Hill formation is not exposed.

Lithology

Green slates make up the lower part of the Nine Mile Hill formation. These are overlain by black- to grey-banded hornfels, white quartzite, and greywacke conglomerate, which make up the upper part, the greywacke conglomerate being most common near the top. A few basalt flows are present in the section.

The *green slates* in the lower part of the formation and the overlying hornfels occur in beds from ½ inch to 1 foot thick or more. Local crossbedding in the hornfels indicates a source area to the east or southeast.

The rocks in the middle of the formation originally ranged from black siltstone to white arkosic sandstone, but they have been thermally metamorphosed by the underlying granite to black and grey hornfels and white quartzite. The *hornfels,* as seen in thin section, has a grain size ranging from 0.01 to 0.05 mm. and consists of quartz, plagioclase, and red-brown biotite, the biotite generally having a parallel orientation. Quartz predominates among the clastic grains, but plagioclase and orthoclase are also plentiful. Biotite is the principal mineral in the matrix and is very abundant in some layers. Colourless poikiloblastic andalusite, yellow cordierite with abundant inclusions, and muscovite are common in several thin sections. Green tourmaline was identified in one thin section and detrital zircon in another. The *quartzite* is arkosic and poor in biotite, and is generally coarser-grained than the hornfels. Angular grains of quartz and feldspar 0.1 mm. in diameter are scattered in a finer quartz-sericite matrix. The feldspar is chiefly orthoclase, and has been partly replaced by sericite and muscovite.

The *greywacke conglomerate* in the Nine Mile Hill formation is only slightly foliated in contrast to the strongly foliated conglomerate of the Southern Hills formation. The exposure of conglomerate at the Southeast Bight Hills is typical. Dark green to purplish-green greywacke conglomerate contains rounded pebbles ½ to 1 inch in diameter and a few pebbles as long as 3 inches and as wide as 1 inch. The pebbles include the following rock types: felsite, felsite porphyry, flow-banded felsite, basalt, and black and grey siltstone. The acid volcanic pebbles are similar to the acid volcanic rocks of the Southern Hills formation, and the basalt and siltstone pebbles are similar to rock types in the lower part of the Nine Mile Hill formation. In addition to the pebbles, the conglomerate contains grains of clear quartz and white plagioclase in a groundmass of chlorite, epidote, magnetite, and locally green chert.

The examination of several conglomerate specimens under the miscroscope permitted the recognition of fragments of spherulitic felsite and trachyte, and indicated that the matrices are either of green chlorite with subordinate finely divided quartz and feldspar or of quartz and feldspar with subordinate chlorite. Epidote and magnetite are scattered through most of the thin sections.

The *basalt* flows of the Nine Mile Hill formation range in colour from black to dark green and from fine-grained, averaging 0.5 mm., to medium-grained, between 1 and 2 mm. Some of the fine-grained black basalts are difficult to distinguish from the black hornfels. The basalts, however, are sufficiently magnetic to affect a compass around Nine Mile Hill and in the western part of the Southeast Bight Hills. The basalts are neither vesicular nor amygdaloidal, but show crude flow banding.

As seen in thin sections, specimens of the finer-grained basalt flows show a diabasic texture, while the coarser-grained flows show a weak ophitic texture. In the former, the diabasic texture is produced by randomly oriented labradorite microlites (0.01 to 0.05 mm. long) with augite; grains of magnetite and quartz, and crystals of apatite all occur interstitially. Magnetite is abundant, but quartz is a minor constituent. The ophitic texture in the coarser basalt flows is formed by subhedral plates of labradorite (approximately 0.1 mm. long) embedded in anhedral augite, magnetite and apatite being accessory. In one thin section augite is partly replaced by green uralite, and brown biotite is in an early stage of formation. Olivine in crystals 0.05 mm. in length is an important constituent of some of the coarser basalts. In thin sections olivine is recognizably altered to antigorite and bright red iddingsite.

Age and Correlation

Fossils have been found in loose blocks of slate in glacial drift overlying outcrops of the stratigraphically low slate member of the Nine Mile Hill formation southeast of Pin Hill Pond. These fossil-bearing slate blocks are lithologically identical with the slate of the bedrock underneath. The material of the drift is characteristically local, and the size and angularity of the inherently weak slate blocks strongly suggest that they have not been transported far. Similar slates outcrop for 1 mile to the north-northwest of the fossil locality along the centre of the roof pendant; beyond this lies more than 10 miles of granite. As the ice in this region moved southward or southeastward it is almost certain that the fossiliferous slate blocks were derived from outcrops of the stratigraphically low slate member in the area to the north-northwest of Pin Hill Pond. Fossils collected from the slate blocks consisted of fragments of a trilobite and inarticulate brachiopods. The trilobite was identified by Dr. R. D. Hutchinson as *Beltella solitaria* Westergard. He considered it to be of late Upper Cambrian age, and noted that although it had not been reported from North America it is present in the *Orusia* zone of the Upper Cambrian series in Norway and Sweden.

The Nine Mile Hill formation can be tentatively correlated with part of the Youngs Cove group in the Rencontre East area (White, 1939, p. 53) on the basis of age, lithology, structure, and position in the geological column, as outlined in the three numbered paragraphs that follow.

(1) The Youngs Cove group consists of at least 2,000 feet of interbedded dark quartzites and slates (White, 1939, p. 54), comparable to the 3,500 feet of hornfels and green slate of the Nine Mile Hill formation.

(2) The Youngs Cove group contains fauna of two ages, one of early Middle Cambrian age, and one of Late Cambrian or Early Ordovician age. The fossiliferous (?), stratigraphically low, slate member of the Nine Mile Hill formation appears of comparable age.

(3) The Nine Mile Hill formation, like the Youngs Cove group east of Bay d'Est (White, 1939), is unconformably overlain by the Belle Bay volcanic formation at Southeast Bight Hills, and north of Nine Mile Hill at Pin Hill.

Ordovician (?)

Grand Le Pierre Formation

Definition

The name 'Grand Le Pierre formation' is proposed for a thin succession of crystal-lithic tuff, felsite, greywacke, chert, and basalt overlying the Nine Mile Hill formation east of Grand Le Pierre Harbour.

Distribution

The formation is exposed over a few square miles on both sides of Grand Le Pierre Harbour and in several small elongated areas northeast of Terrenceville. West of Grand Le Pierre the formation is exposed extensively in a bedrock plateau and is overlain unconformably by the Belle Bay formation along its western boundary. The Cross Hills batholith is intruded into and bounds the formation on the north. Northeast of Terrenceville a narrow band of the formation is bounded on the south by the Terrenceville thrust and on the north by the Cross Hills batholith. North of the Terrenceville-Marystown road intersection, the formation forms ridges in roof pendant blocks within the Cross Hills batholith and is bounded to the northeast by the Ackley batholith. The formation is about 1,000 feet thick.

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Lithology

The Grand Le Pierre formation is composed principally of a fine-grained, tan to green crystal-lithic tuff that is interbedded in the lower part with minor greywacke, chert, and basalt flows and in the upper part with minor felsite flows. The rocks of the formation are weakly foliated in places.

The *crystal-lithic tuff* is composed of quartz and feldspar crystals averaging 2 mm. in diameter, together with pebbles ranging from 3 to 13 mm. in diameter of coloured felsites and felsite porphyry. The tuff is tan to light green, silicified, and remarkably uniform. A thin section of green crystal-lithic tuff shows rounded quartz phenocrysts 0.1 mm. in diameter embayed by the matrix. Orthoclase and plagioclase phenocrysts and rock fragments are badly altered to sericite, kaolinite, and calcite, in a flow-banded matrix. The matrix makes up about half the rock and consists mostly of finely crystallized quartz and feldspar, with subordinate chlorite and sericite and minor sphene, apatite, and leucoxene. Quartz shards can be recognized, and pyrite cubes are common. The tuff passes stratigraphically upward into brown to red flow-banded felsite flows containing fewer rock and mineral fragments and more feldspar phenocrysts.

The *greywacke* in the lower part of the formation is a green, locally foliated, fairly coarse-grained rock containing detrital quartz and pebbles of green felsite and chert. Thin beds of tan to green chert 1 inch thick are interlayered with the greywacke, as are several *basalt flows,* each about 50 feet thick. The flows are dark green, chlorite-rich, and amygdaloidal.

Age

The Grand Le Pierre formation appears to conformably overlie black to grey hornfels in the upper part of the Upper Cambrian (?) Nine Mile Hill formation. The occurrence of pebbles of black hornfels (originally siltstone) in the crystal-lithic tuff of the Grand Le Pierre, however, indicates a minor erosional unconformity at the base of this formation. The unfossiliferous Grand Le Pierre, overlain unconformably by the Ordovician (?) Belle Bay volcanic formation, is tentatively assigned an early Ordovician age because it (1) apparently lies with erosional unconformity on Upper Cambrian (?) beds, (2) is overlain unconformably by Ordovician (?) volcanic rocks, and (3) consists of volcanic rocks generally not found in Cambrian rocks of Newfoundland but common in Ordovician assemblages.

Belle Bay Formation[1]

Definition

The name 'Belle Bay volcanics' was proposed by White (1939) for a thick volcanic sequence that is in the Rencontre East area and includes minor greenstone and clastic beds. In the author's area the formation consists of a thick,

[1]The term 'Belle Bay formation' is used here in place of 'Belle Bay volcanics' because of the mixed lithology of the unit, and to conform with modern stratigraphic terminology.

extensive series of lavas, agglomerate, and tuff with minor intrusive felsite interbedded with several thick bands of siltstone. A representative section of the formation is exposed in the Rocky Hills.

Distribution

The Belle Bay formation is exposed extensively along the north side of Fortune Bay, and south of the Ackley granite, within an east-northeast-trending belt that ranges from 4 to 8 miles in width. It is commonly a ridge-former and appears continuously on 500-foot cliffs for about 10 miles along the north shore of Fortune Bay from Grand Le Pierre Harbour to Femme Harbour. The abundance of isolated areas underlain by the formation results from structural disruptions that occurred during the intrusion of granitic batholiths, and from subsequent erosion. Such residual patches are found 2 miles north of Terrenceville, 2, 8, and 15 miles northwest of Dunns Pond, immediately south of Gisborne Lake, and in a cluster along the northern margin of the main body south and west of Gisborne Lake and at Youngs Hill and Snooks Tolt, southeast of Long Harbour. The Belle Bay formation is 6,000 feet thick in the Rocky Hills syncline and ranges in thickness from 1,000 to 3,000 feet in some of the smaller folds. Siltstone beds west of Grand Le Pierre Harbour range in thickness from 200 to 500 feet.

Lithology

Felsite, rhyolite porphyry, andesite porphyry, and minor intrusive felsite make up 65 per cent of the formation. Basalt flows make up another 5 per cent, red agglomerate and tuff 20 per cent, and siltstone beds the remaining 10 per cent. Almost the entire section outcrops along the north shore of Fortune Bay from Grand Le Pierre to Femme Harbour and dips gently southwest. There is some duplication by faulting and folding. The rocks of the formation show little effect of regional metamorphism, perhaps because of the predominance and massive nature of the felsites; the tuffs and basalt flows are foliated locally.

Many textural and structural varieties of *felsite* are found. A common type is aphanitic, probably a devitrified glass. Porphyritic felsite is also abundant. Flow-banded zones are locally mappable, as are spherulitic bands, beds of red nodular chert, and lenses of volcanic tuff or volcanic breccia. The felsites are red, brown, purple, and orange.

The recognition of separate flows in felsite sections is difficult, but in a few places brecciated flow tops can be identified. A spectacular brecciated flow top occurs at the entrance to Little Bay de l'Eau, where fragments as large as several inches in diameter from an earlier flow crust are visible in the disturbed zone of later flowage. Felsite showing contorted flow structure is common. In places felsite shows evidence of brecciation that was post-flowage and preconsolidation. At one locality specimens showing results of flowage were noted that broke along planes of flowage, so that paper-thin folds could be separated. One felsite flow had developed hexagonal joints and showed columns 5 feet in length on a cliff surface.

Representative specimens of the Belle Bay felsite examined in thin sections are made up of microcrystalline aggregates 0.008 mm. in diameter of quartz and feldspar. These aggregates contain some coarser quartz lenses 0.02 mm. thick and scattered quartz phenocrysts. Orthoclase and plagioclase phenocrysts 0.08 mm. in diameter are slightly altered to sericite and kaolinite. Biotite and muscovite phenocrysts are subordinate, and the matrix consists of minor quantities of chlorite, sericite, and epidote. Some felsite has a spherulitic texture, the individual spherulites measuring 0.04 mm. in diameter. In plain light, magnetite in finely divided particles and skeletal crystal growths is seen to emphasize primary structures such as spherulites, flow banding, and phenocryst boundaries. A red, bronzy mica in one of the porphyritic felsite flows was identified in thin section as iron-stained muscovite.

The *intrusive felsite* is red-orange and fine grained. White quartz, orange feldsspar, and patches of white kaolin can be recognized in hand specimens. As seen under the microscope, specimens of the felsite have a xenoblastic texture composed of grains 0.15 mm. in diameter. Quartz in myrmekitic intergrowths with acid plagioclase is a dominant constituent of the rock; orthoclase and acid plagioclase make up most of the rest. Patches of rock are completely converted to sericite. Magnetite is common; ferromagnesian minerals are rare.

Some of the felsite appears to have a trachytic texture, visible in hand specimens, with parallel plagioclase laths as large as 0.5 mm., indicating flow banding.

Red *agglomerate* and *tuff* are interstratified with felsite and basalt flows, but agglomerate and tuff also occur in local irregular masses that may originally have been volcanic vents. One possible vent is exposed for 4,000 feet along the coast, from the west side of Grand Le Pierre to Spudgel Cove. There a coarse, red volcanic agglomerate is interstratified locally with felsite flows and tuff, but elsewhere it is massive and structureless. Boulders in the agglomerate include all the types of volcanic rocks exposed in the Belle Bay formation. The boulders are well rounded, are commonly about a cubic foot in volume, and occur in a red, tuffaceous matrix. Large angular blocks are also present locally; the largest of these measures 12 feet by 5 feet as exposed and is composed of spherulitic felsite.

Several major flows of purple *rhyolite porphyry* and green *andesite porphyry* about the middle of the formation are exposed between Pays Cove and English Harbour East. These flows are thick and extensive and much coarser grained than the average porphyritic felsite. The rhyolite porphyry flow north of Bombards Island has a thickness of several hundred feet. In thin section the rhyolite porphyry is seen to be considerably altered. Phenocrysts, 2 to 3 mm. in length, of twinned orthoclase and plagioclase are altered to sericite and calcite. Large phenocrysts of quartz 5 mm. in diameter are broken and embayed by groundmass. Pyroxene, recognized by its octagonal outline, is altered to calcite, epidote, chlorite, magnetite, hematite, and limonite. The groundmass is microcrystalline and contains much quartz in grains 0.01 mm. in diameter.

Green andesite porphyry from a flow near Spudgel Cove contains andesine (An_{35}) in phenocrysts from 2 to 5 mm. long. These phenocrysts are partly kaolinized and are rimmed in places by calcite and chlorite. Plagioclase microlites of a second generation make up the groundmass. Phenocrysts of much-altered brown augite 0.01 mm. in diameter show rim and crack alteration to ilmenite and leucoxene. Apatite and magnetite are accessory minerals.

The *siltstone beds* in the Belle Bay formation described by White (1939) also occur in the author's two map-areas. At least three beds are present and these are separated by several hundred to 1,000 feet of acid lavas. The beds are from 200 to 500 feet thick and are composed of bedded siltstone, individual beds ranging in thickness from less than 1 foot to 5 feet and a few beds having a thickness of 30 feet or more. Individual beds are uniform in colour, lithology, and thickness. The siltstones are red, purple, and green.

Some of the layers of the siltstone beds are locally conglomeratic and have bands of inwashed volcanic materials. The beds on the cliff west of Spudgel Cove show graded bedding and diagenetic folds. A recumbent flat-*S* fold 50 feet long has its axial plane parallel with the local bedding. The fold is overlain by volcanic agglomerate and was perhaps caused by the sliding of agglomerate down a submarine slope. The beds west of English Harbour East more commonly show choppy cross-laminations. Fossil-like cavities are common at the Spudgel Cove exposure of the siltstones.

Diagenetic folds in the siltstone beds on the cliff west of Spudgel Cove are identical with intrastratal contortions in Silurian siltstone beds at Aberystwyth, Wales, that Rich (1950, p. 729) believed took place within the silt bed after the bed above had been laid down, as a result of flowage and slumping on a submarine slope.

Age and Correlation

The Belle Bay formation in the Gisborne Lake and Terrenceville map-areas rests unconformably on tuffs of the Lower Ordovician (?) Grand Le Pierre formation and on the Upper Cambrian (?) Nine Mile Hill formation. It, in turn, is overlain unconformably by the Silurian (?) Rencontre formation. No fossils have been found in the Belle Bay formation, although fossil-like cavities are common in the siltstone beds at Spudgel Cove. From the foregoing structural evidence, the writer believes the Belle Bay formation to be Middle and/or Upper Ordovician in age, as suggested by White (1939).

White (1939) used the name 'Long Harbour series' to refer to an unfossiliferous volcanic series made up of three formations exposed in the Long Harbour syncline at Long Harbour. These formations bore the names 'Belle Bay volcanics', 'Anderson Cove slates', and 'Mooring Cove volcanics'. He assigned a Middle and Upper Ordovician (?) age to this series because (1) lower Belle Bay volcanic rocks lie unconformably on the Youngs Cove group, whose age is between early Middle Cambrian and Late Cambrian or Early Ordovician and (2) the 'Long Harbour series' is folded and overlain unconformably by the

Rencontre formation of probable Silurian age. The Belle Bay formation and the Andersons Cove formation, in the Gisborne Lake and Terrenceville map-areas, are essentially the same units that White called the 'Belle Bay volcanics' and 'Anderson Cove slates', respectively. White's third unit, the 'Mooring Cove volcanics', does not occur, however, in the author's area.

Andersons Cove Formation

Definition

The name 'Andersons Cove formation' is proposed for a sequence of green, thinly laminated (varved?) tuffaceous slates with a thin conglomerate or coarse greywacke at the base. The name is a revision of the term 'Anderson Cove slates' suggested by White (1939) in an unpublished doctoral thesis. The type locality is at Andersons Cove on the west side of Long Harbour, where White first recognized this formation. The formation extends from the type locality into the western part of Terrenceville map-area for 2 to 3 miles, to where it is cut off by the Ackley batholith. Another section, nearly identical with White's, can be seen in the syncline at Bay L'Argent. In other parts of Terrenceville map-area, the Andersons Cove formation is composed predominantly of meta-conglomerate, the green, thinly laminated slates being limited in extent but important as a marker unit. Several pillow basalt flows also serve as marker beds in the basal and lower part of the formation. Near Long Harbour the formation conformably overlies the Belle Bay formation. South of Fortune Bay it rests on the Precambrian-aged Southern Hills and Deer Park Pond formations with an erosional disconformity.

Distribution

The belt of Andersons Cove rocks that is truncated by the Ackley batholith just east of Long Harbour is the only exposure of this formation north of Fortune Bay. South of the bay, the Andersons Cove formation is in fault contact with the Southern Hills formation on the northwest flank of the Southern Hills anticline. The Andersons Cove formation overlies the Southern Hills formation on both noses of the anticline, but it overlaps the Deer Park Pond formation on the southeast flank. The Andersons Cove formation is a prominent valley-former (Pl. I A). In the syncline near Bay L'Argent, slates overlie relatively unmetamorphosed conglomerate of the lower part of the formation and are exposed on peninsulas that are half as high as the nearby 500-foot cliffs of resistant Southern Hills formation.

Thinly laminated slate is present in the Andersons Cove formation at Bay L'Argent, south of Ryle Barrisway, along the Terrenceville road near Big Southeast Brook, along the road in the syncline southwest of the Paradise River bridge, and in other localities. In fault zones and local zones of tight folds, both the slate and the conglomerate are badly sheared. Pillowed basalts occur in this formation north of Southeast Bight Hills Pond, southwest of the Paradise River bridge and south of the Terrenceville road, southwest of Black Hill Pond, and in other localities. Basalt flows overlain by meta-conglomerate form the basal part of the formation in folds north and east of East Bay and from west of Big Southeast Pond to west and south of the Paradise River bridge.

The Andersons Cove formation has a thickness of 4,000 feet in the syncline near Bay L'Argent, where both the top and bottom are exposed. In the folds at Big Southeast Brook, on the northeast nose of the Southern Hills anticline, beds totalling 1,000 feet in thickness are present. The formation occurs over a wide area on both sides of Fortune Bay.

Lithology

At Andersons Cove, Long Harbour, the formation consists of more than 1,500 feet of fine-grained, olive-green, tuffaceous slates with a characteristic light-greenish-grey or cream-coloured weathered surface (White, 1939, p. 71). The formation is remarkably homogeneous except in the lower 100 feet, which is characterized by a thin conglomerate bed or by coarse greywacke at the base, by a greater percentage of greenish greywacke than the rest of the formation, and by several beds of purple slate.

In Terrenceville map-area the formation consists of greywacke conglomerate, green thinly laminated tuffaceous slates, meta-conglomerate, and basalt. The *greywacke conglomerate* in the syncline near Bay L'Argent is relatively unmetamorphosed and contains pebbles and boulders ranging from ¼ inch to 12 inches in diameter in a fine yellow-green matrix. The boulders are derived from the nearby Southern Hills formation and include red and purple felsite, felsite porphyry, greywacke, and basalt. The yellow-green matrix is fine-grained, tough, and homogeneous in texture and composition. A thin section of the matrix shows it to have an average grain size of 0.005 mm., and to consist 50 per cent of epidote and 50 per cent of angular quartz and plagioclase.

The green thinly laminated tuffaceous slates are lithologically similar to those described by White (1939, p. 71), who wrote:

> . . . Slaty cleavage, generally cutting across the stratification, is characteristic of the formation, except in the relatively flat-lying, undisturbed beds . . . near the axis of the syncline north of Andersons Cove, where primary structures are revealed. Here the rocks consist of very finely-laminated, "varved" layers varying from 1/16 to ½ inch thick, of fine-grained, olive-green material with minor, coarser, dark-green grains concentrated in certain bands; these "varved" layers are stratified within themselves and separated by very thin "pencil lines" of very fine-grained light greenish material.
>
> Evidence of diagenetic disturbance of the material before lithification is common; several polished specimens show cross-bedding, disturbed and disrupted bedding, and microfaults which are overlain by undisturbed bedding. The most conclusive specimen shows a small local overturned fold, which is slightly disrupted on its crest; a part of the crest has been removed, by local scouring, and is overlain with local unconformity by undisturbed laminae . . .
>
> Microscopically, the slates are seen to consist of a very fine-grained aggregate, the minerals of which cannot be determined definitely. Much or all of the material is probably of volcanic origin, although relict shard or bogen structure is not common.

> . . . The rocks are arkosic, with fresh feldspar particularly characteristic of the coarser greywackes, but also present in the finer-grained tuffs. Angular quartz grains are common, and some euhedral crystals of both feldspar and quartz are present. The euhedral crystals also suggest volcanic derivation of material . . .
> . . . The rocks may be either marine or lacustrine. The color, the sorting, and the thickness suggest a marine origin, though careful search in the unmetamorphosed area failed to reveal fossils . . .
> The "varved" structure is somewhat suggestive of a lacustrine origin, by comparison with varved glacial clays, which are lacustrine and rarely if ever marine . . .

The *meta-conglomerate* is similar to the green schist (derived from greywacke conglomerate and greywacke) in the Precambrian-aged Southern Hills formation. The pebbles average ½ to 1 inch in diameter. Few boulders were noted in the meta-conglomerate, whereas boulders are common in the unmetamorphosed conglomerate at Bay L'Argent. In thin sections the meta-conglomerate shows many sharp angular quartz grains as large as 1 mm. and a few grains of plagioclase in a pasty sericite matrix. Some quartz grains are replaced along boundaries by authigenic sericite. Muscovite and green biotite have formed in the matrix, which contains in addition minor amounts of calcite, magnetite, and sphene.

Amygdaloidal pillowed *basalt* from a ridge 1 mile west of the Paradise River bridge and ¼ mile south of the Terrenceville road is typical of basalt flows in this formation. The basalt contains red jasper, epidote, and chlorite filling amygdules that are generally less than 5 mm. in diameter. Volcanic bombs 3 to 6 inches long and pillow structures 1 foot to 2 feet long can be identified at this exposure. Under the microscope specimens of the basalt show a diabasic texture formed by labradorite laths, averaging 0.05 mm., and interstitial augite. The rock is altered, and green chlorite, sphene, and magnetite are present throughout. Coarse epidote and chlorite occur in oval lenses.

Age and Correlation

Assignment of a Middle and/or Late Ordovician (?) age to the unfossiliferous Andersons Cove formation is made principally on the basis of its occurrence above the Belle Bay formation in the Long Harbour syncline of the Rencontre East area (White, 1939). The formation is absent in the Rocky Hills syncline several miles to the southeast, where the Rencontre formation lies unconformably on the Belle Bay formation.

Conglomerate and thinly laminated slates exposed in the syncline at Bay L'Argent resemble the type Andersons Cove slates in the Long Harbour syncline, but it is nevertheless possible that the strata assigned to the Andersons Cove formation south of Fortune Bay are Precambrian or Cambrian in age.

Silurian (?)

Rencontre Formation

Definition

The Rencontre formation, as named by White (1939, 1940) and described by Twenhofel (1947), is in the Rencontre East area, but is also present in the Gisborne Lake and Terrenceville map-areas, where it consists of a series of red clastic sediments and one felsite flow. Metamorphosed strata tentatively assigned to the Rencontre formation are exposed at Boat Rocks[1] and in the synclinal folds that plunge northeast off the Southern Hills anticline.

Distribution

The Rencontre formation, including the strata of questionable relationship, occurs over a large part of the area on both sides of Fortune Bay. The principal exposure is in the Rocky Hills syncline near Femme Pond, where the 4,000 feet of red clastic sediments exposed lie with angular unconformity on the Belle Bay formation. The alternation of ridges and valleys near Femme Pond indicates, in a remarkable fashion, the structural arrangement of minor lithological units.

Red clastic beds of the Rencontre formation that are about 200 feet thick overlie the Andersons Cove formation on the Harbour Mille Peninsula on the south side of Fortune Bay. The red pebble-schists on Boat Rocks 1 mile to the south-southwest are tentatively assigned to the Rencontre formation.

About 200 feet of red clastic rocks of the Rencontre formation are in fault contact with the Grand Le Pierre formation at the Grass Grounds opposite the end of the Terrenceville bar and to the east along the head of Fortune Bay. It is not known what part of the formation is represented by these exposures. The same two formations are separated by the Terrenceville thrust on the north side of the Terrenceville River valley. South of this thrust, about 1,000 feet of the Rencontre formation are underlain by the Andersons Cove formation. On the uplands south of the Terrenceville road and northeast of Big Southeast Brook, red pebble-schists 2,000 feet thick are believed to be the metamorphic equivalent of the Rencontre formation and are tentatively so mapped. This pebble-schist overlies the Andersons Cove formation in the syncline extending northeast from Big Southeast Brook and in the syncline centering on Paradise River.

The red shales of the Rencontre formation and the red slates of the metamorphic equivalent could perhaps be used as marker beds within each of the two stratigraphic sections; neither the shales nor the slates are abundant, but both persist areally. The shale has been observed northwest of Femme Pond, on the southwest side of Harbour Mille Peninsula, and at the Grass Grounds across from Terrenceville; and the slate near Big Southeast Brook and on the ridge, east of Dunns Pond.

Lithology

According to White (1939, p. 77) the Rencontre formation is probably at least 3,500 feet thick, and can be divided lithologically into two members: a lower member consisting of basic greenstone flows interstratified with greywacke and red and purple shale, and an upper member consisting of coarse, hard, silica-cemented, light-purple arkosic greywacke, with some dark-grey impure quartzite at its base and top. The lower member of the formation has considerable lateral

[1]Boat Rocks is a small cluster of rocks that lie about 1½ miles northwest of Bay L'Argent village. They are not shown on the Terrenceville 1:50,000 topographic map issued in 1957.

variation. A coarse basal conglomerate about 20 feet thick is overlain by about 100 feet of red clastic rocks at Lally Cove and northwest of Isle à Glu in the Rencontre East area.

In the present map-areas only the clastic beds of the lower member occur. The basic greenstone flows and the upper member are missing. The lower part of the section, however, is similar to the sections at Lally Cove and northwest of Isle à Glu. The Rencontre formation of the author's area consists of one felsite flow and a series of reworked, acid-volcanic rocks that grade from basal red and purple volcanic conglomerate to red sandstone, red siltstone, and red shale.

The basal red *volcanic conglomerate* of the Rencontre formation in the area of Femme Pond is well exposed along the upper part of the cliff northwest of Northwest Arm. There it dips gently northwest and overlies acid flows of the Belle Bay formation from which detritus was derived. Boulders range from 6 inches to 2 feet in diameter and vary from subangular to subrounded. Some of the rock types present as boulders are of red and purple felsite, felsite porphyry, flow-banded felsite, and felsite from a brecciated flow top. The matrix is composed of similar pebbles ranging from 1 inch in diameter to sand size. Eroded agates of poor quality generally less than 1 inch in diameter are characteristic. Higher in the section, finer volcanic conglomerate is gradational with red sandstone (probably arkosic), brick-red siltstone, and minor red shale. Evidence that these clastic materials were water-lain is seen in the degree of pebble-rounding, the evenness of bedding, the lenticular zones of coarser material, and crossbedding. A red and purple felsite flow containing brecciated felsite fragments is exposed northeast of Femme Pond near the centre of the Rocky Hills syncline. The felsite is aphanitic and breaks with a glass-like fracture. On the northwest flank of the syncline the beds dip steeply southeast to the northeast of Femme Pond. There the conglomerate and sandstone are schistose and the shale has developed a weak slaty cleavage.

Red *volcanic sandstone* and red *shale,* locally with slaty cleavage, make up the 200-foot section of the Rencontre formation at the Grass Grounds across the bay from Terrenceville. Pea-sized pebbles of red felsite occur in 1-inch bands in the sandstone. The red sandstone, as seen under the microscope, is an arkosic greywacke with an average grain size of 0.05 mm. Quartz in euhedral crystals 0.1 mm. in diameter is common; smaller angular quartz grains are less abundant than the crystals. Plagioclase and acidic-rock fragments are badly altered to patches of kaolinite and sericite. Angular fragments of felsite are identified by shard structure. Basic-rock fragments are altered to patches of epidote, chlorite, and magnetite. Green biotite is scattered throughout a pasty matrix of quartz, sericite, and chlorite.

The metamorphosed strata tentatively assigned to the Rencontre formation consist of pebble-schist, phyllite, and slate, all of which are red and green and overlie the Andersons Cove formation with apparent conformity.

The red *pebble-schist* is exposed north of the Terrenceville road, where Lakelys Rock Brook cuts across the southern part of the metamorphic equivalent of the formation. It ranges in colour from red to lavender and contains foliated pebbles generally smaller than ½ inch long and ⅛ inch thick. Red and purple felsite pebbles are abundant and appear to give this rock its red to lavender colour. Quartz and white feldspar grains 1 mm. in diameter are less abundant than the pebbles. In thin sections the schist is seen to be strongly foliated and coarser but is otherwise nearly identical with the volcanic sandstone at the Grass Grounds near Terrenceville. One quartz grain invaded by matrix was similar to grains in the sandstone. Some acidic-rock fragments are conspicuous because they contain numerous small magnetic grains.

Age and Correlation

The unfossiliferous Rencontre formation was considered by White (1939, p. 91) to be either Silurian or Devonian in age. He believed the Rencontre formation was not older than Silurian because two marked orogenies and the tremendously thick volcanic series, the Belle Bay formation, separate it from Upper Cambrian (?) or Lower Ordovician (?) rocks. He further observed that if the age was Silurian, the major folding that followed its deposition was either Caledonian or Acadian, or both. Widmer (1950) considered the Rencontre formation as probably Silurian in age, on the basis of his studies of the formation as White's field assistant in the Rencontre East area, and also from his own work in the Hermitage Bay area to the west.

In the present map-areas the formation lies with angular unconformity on the Middle and/or Upper Ordovician (?) Belle Bay formation in the Rocky Hills syncline, with the Andersons Cove and the Mooring Cove formations missing. The formation lies with apparent structural conformity on the Andersons Cove formation in an exposure south of Fortune Bay and in several exposures northeast of Terrenceville, but the absence of the Mooring Cove formation, which overlies the Andersons Cove formation in the Long Harbour area, suggests a disconformable relationship. The Rencontre formation thus is somewhat younger than the three Middle and/or Upper Ordovician (?) formations, but is older than the Terrenceville conglomerate, for it is metamorphosed while the conglomerate is not, and it supplied pebbles to the conglomerate. Metamorphosed pebbles of the Andersons Cove formation are also present in the conglomerate. As the conglomerate contains Late Devonian plant remains, the author believes the folding and regional metamorphism of the Rencontre formation (and the older ones) occurred during the Caledonian orogeny at the end of the Silurian period.

Thus on the basis of its lying unconformably on Middle and/or Upper Ordovician (?) formations and its being folded by an orogeny presumably Caledonian (Acadian is also represented), the Rencontre formation is considered tentatively to be of Silurian age.

The Silurian (?) age designation for the rocks termed by the author 'metamorphic equivalent of the Rencontre formation' is based on the following evidence:

(1) These rocks are lithologically and structurally similar to those of the Rencontre formation mapped by Widmer (1950) in the Hermitage Bay area and White (1939) in the Rencontre East area.

(2) These rocks locally overlie varved slates and meta-conglomerate that are correlated with the Middle and/or Upper Ordovician (?) Andersons Cove formation.

It is possible, however, that the rocks referred to as the 'metamorphic equivalents of the Rencontre formation' are a southwestward continuation of the Precambrian Musgravetown group in Bonavista Bay (Hayes, 1948). If this is so, the underlying Andersons Cove formation southeast of Fortune Bay is in reality a part of Hayes' Connecting Point group. The apparent lithologic similarity of the 'metamorphic equivalent of the Rencontre formation' to the Musgravetown group and of the Andersons Cove formation to the Connecting Point group is regarded by the author as coincidence.

Devonian

Terrenceville Formation

Definition

The name 'Terrenceville formation' is proposed for a narrow belt of clastic sediments exposed along the south side of Fortune Bay near Terrenceville. They contain Upper Devonian plant fossils.

Distribution

The Terrenceville formation is the youngest stratified rock in two map-areas and underlies only about 1 square mile of land. It is separated from the Southern Hills formation on the southeast by the Terrenceville thrust, a steep reverse fault. Along Fortune Bay, northwest of the thrust, the formation in a narrow belt 2 miles long is partly covered by beach gravel or unconsolidated Quaternary deposits. It is probably cut by the South Shore normal fault, which is parallel with the coast, and may well lie to the north in the graben block beneath Fortune Bay.

The belt of exposure is widest at Terrenceville, where the formation is 1,000 feet thick, but it narrows to the southwest and northeast, where the section is only a few tens of feet thick. As both the upper and lower parts of the section are faulted out, 1,000 feet represents a minimum value for the thickness of the formation.

The formation is not resistant to erosion, but is preserved in sea-cliffs west of Terrenceville because resistant Precambrian rocks above the steep thrust plane protect it from erosion. At Terrenceville the formation is exposed principally in several brooks and at one locality along the coast. Northeast of Terrenceville the only outcrop noted was on the south side of the road 1 mile from town.

Lithology

The Terrenceville formation consists mainly of brown to grey conglomerate and sandstone, with minor amounts of grey-green shale and red mudstone. The conglomerate beds are lenticular throughout the section and channelling and local irregular thickening of beds are common features. Bedding in the conglomerate is crude and irregular, but fairly well developed in the finer facies. The green sandstone shows channelling, bottom-scouring, and abrupt lensing. The red mudstone shows ripple-marks, rain-drop impressions, and poorly developed mud-cracks along bedding planes. Plant fossils are fairly common in the sandstone and finer facies throughout the section; they are poorly preserved in the sandstone but are well preserved in the minor grey-green shale and red mudstone.

The *conglomerate* is composed principally of pebbles and some small boulders in a coarse brown sandy matrix; the mixture is comparable to fine river gravel. The pebbles and boulders vary from well-rounded to subangular and range from pea-size to 3 inches in diameter. Large boulders are uncommon. Most of the pebbles and boulders in the conglomerate are of one or another of the following rock types: green greywacke and greywacke conglomerate, red and purple porphyritic felsite, basalt, thinly laminated slate, red conglomerate, and red sandstone.

The coarse brown *sandstone* has a grain size between ½ and 1 mm., and has a gritty surface. Grains of clear quartz, pebbles of slate, variously coloured felsites, and some metamorphic rocks are visible megascopically and make up at least half of the rock. A few limy nodules were seen in brown sandstone near the western end of the formation, southwest of Terrenceville. As seen in thin sections the brown sandstone consists of angular grains of quartz, plagioclase, orthoclase, perthite, and epidote of which the quartz grains are the most abundant together with fragments of felsite, chert, and diabase. Minor amounts of chlorite, magnetite, and limonite are also present. The feldspars are partly altered to sericite and kaolinite.

Origin

The Terrenceville formation is believed to have originated in a fluviatile flood-plain type of environment because of:

(1) the range in lithology from conglomerate to mudstone,

(2) the red, grey, and green colours,

(3) the evidence of lensing, channelling, local irregular thickening, and bottom-scouring, and

(4) the presence of ripple-marks, rain-drop impressions, mud-cracks, and plant fossils.

Pebbles of the following specific rock types from older formations have been recognized in the conglomerate:

(1) green greywacke and greywacke conglomerate from the Southern Hills formation and the Andersons Cove formation,

(2) red and purple flow banded, porphyritic felsite from the Southern Hills formation and Belle Bay formation,
(3) basalt from several of the older formations,
(4) thinly laminated slate from the Andersons Cove formation,
(5) red volcanic conglomerate and red sandstone, possibly from the Rencontre formation, and
(6) milky-white vein quartz.

Obviously, some of the many quartz veins in the area must have been formed before Late Devonian time. Pebbles of plutonic rocks, such as granite, diorite, and gabbro, are notably absent.

Age and Correlation

The Terrenceville formation is the youngest consolidated stratified unit in the area and is assigned a Late Devonian age on the basis of plant fossils. As the formation is unmetamorphosed but includes pebbles of metamorphosed rocks, its deposition post-dates the regional metamorphism.

Fossils are fairly common throughout the formation and may be collected from exposures along Harbour Brook in Terrenceville. The best specimens are found in the shale several hundred feet from the westernmost cliff exposure, 1 mile west of town. Indifferently preserved fragments of branches and twigs, as much as 6 inches long and ½ to 1 inch in diameter, were collected by the author. These probably include two or three plant types, but their fragmentary condition permitted identification of only one type. These, according to C. A. Arnold (personal communication) of the University of Michigan, bear a close resemblance to Zalessky's *Lepidodendron satteles* from Donnetz, and may be regarded as of Late Devonian age.

The Terrenceville formation is correlated with an Upper Devonian (Great Bay de l'Eau) conglomerate in the Hermitage Peninsula (Widmer, 1950) and in the western part of the Rencontre East area. Conglomerate exposures from Terrenceville and from Corbin Head, 33 miles to the west, are nearly identical in lithology and appearance, the slight difference being due to the lithological differences between the locally derived pebbles.

Intrusive Rocks

Cape Roger Mountain Batholith and Associated Intrusions

The name 'Cape Roger Mountain' is applied to a large granite batholith in the southeastern part of Terrenceville map-area. It is believed to be the oldest of the three batholiths recognized.

Distribution

The Cape Roger Mountain batholith trends northeasterly across the Marystown road in the southern part of Terrenceville map-area. Its minimum length is

18 miles and its width ranges from 1 mile to 10 miles. Its northern end is northeast of Heffern Mountain, and its southern end, apart from a tongue that continues southwest into the area adjoining to the south, is near the boundary of Terrenceville map-area.

The batholith was emplaced largely in the Deer Park Pond formation, but it also intruded meta-conglomerate of the Andersons Cove formation south of the Pond of Islands and in the Hare Hill Pond intrusive embayment west of the Marystown road. The infolded roof pendants of the Deer Park Pond rocks within the batholith are a striking feature. Most of them occur in the southwestern part of the batholith, where they are exposed on the walls and floors of some of the valleys between ridges of foliated granite.

Several smaller intrusive bodies are associated with the batholith, the largest of which is the Jacques Fontaine granite sill, 9 miles west of the southern part of the batholith. Several diorite stocks and a number of diorite and felsite porphyry sills are exposed within 5 miles of the northwest contact of the batholith, and several small granite stocks occur 10 miles northeast of the batholith near the Green Hills, which lie a few miles east of Terrenceville map-area. These small igneous bodies cut meta-conglomerate beds in the Andersons Cove, Deer Park Pond, and Southern Hills formations, and are believed to be related to the Cape Roger Mountain batholith.

Lithology

The Cape Roger Mountain batholith is made up principally of foliated hornblende-biotite granite, but there are minor amounts of aplite and an earlier minor basic phase that consists of rocks ranging from gabbro to granodiorite. This basic phase occurs inside the northwest border zone at the granite batholith, where it was intruded by the granite. It occurs more commonly, however, as stocks and sills beyond the northwest border of the granite. The batholith is cut by lamprophyre dykes that display the regional foliation.

The principal rock type is a light greenish-orange to orange, foliated, hornblende-biotite *granite,* with a grain size of 2 to 5 mm. The granite grades into minor amounts of light orange, sugary aplite. Megascopically, the granite is composed of clear quartz, orange orthoclase, and yellow to green plagioclase, with stringers and patches of green chlorite, biotite, and hornblende. In most areas it is tough and resistant, but locally it is schistose. The granite contains miarolitic cavities, and both it and the aplite are cut by chlorite-epidote veinlets.

The granite in a thin section from the main part of the batholith shows a hypautomorphic granular texture in which there is strained anhedral quartz, orthoclase, orthoclase perthite, untwinned plagioclase, and biotite altered to chlorite. Original hornblende is indicated by altered patches of epidote, chlorite, and calcite that retain the form of the cross-section and cleavage of the amphibole. In another thin section of a specimen of granite cut by epidote veinlets, unaltered hornblende is more common than biotite.

Foliated granite from the Jacques Fontaine sill is nearly identical in thin section with the typical Cape Roger Mountain granite. One difference, however, is that the quartz is in myrmekitic intergrowths with oligoclase throughout. Orthoclase is common, and the feldspars are much altered to sericite and kaolinite. In foliated granite from the Green Hills the feldspars are altered, but other constituents are the same as in the typical granite.

The *aplite* has a grain size averaging 0.5 mm. and in thin sections a xenomorphic-granular texture is visible in which quartz predominates. Orthoclase and orthoclase perthite are abundant and plagioclase is subordinate. The feldspars are altered to kaolinite and sericite. A minor amount of green hornblende occurs.

The *diorite* phase ranges in apparent composition from gabbro to granodiorite, but most of the rock exposures consist of either diorite or granodiorite. This phase is gradational with the granite, but locally the granite is crosscutting. The gabbro is dark green and more than 5 mm. in grain size and contains basic plagioclase, chlorite, hornblende and olivine. One specimen was cut by a white satiny veinlet of tremolite. The diorite is a whitish-green, equigranular rock with an average grain size of 3 mm. Quartz is rarely present. The plagioclase is light green, the hornblende is commonly dark green columnar crystals, and the biotite and chlorite occur in segregations. The granodiorite is lighter in colour, commonly orange-green, and has an average grain size of 2 mm. It is composed of quartz, pink orthoclase, white plagioclase, and biotite and hornblende. Rocks of the diorite phase were not examined in thin sections.

Northwesterly-trending foliated lamprophyre *dykes* cut the granite. The dykes weather into rough plates controlled by foliation at right angles to their walls. The contacts between the black lamprophyre dykes and light-coloured granite are slightly offset at each foliation plane so that they are irregular yet essentially straight lines.

The black, fine-grained lamprophyre from a dyke cutting the Cape Roger Mountain batholith has an average grain size of 0.15 mm. The texture is diabasic, and the rock is badly altered. Labradorite is altered to sericite and kaolinite. Augite is abundant and altered to chlorite and antigorite. Hornblende and olivine are minor constituents; the olivine is rimmed by iddingsite.

These foliated dykes indicate that the regional foliation was imposed sometime after their intrusion. As the dykes appear to be the youngest intrusive members of the intrusive series of which the Cape Roger Mountain batholith is the main member, the regional metamorphism that produced the foliation probably occurred after the intrusion of the entire series.

Age and Correlation

The Cape Roger Mountain batholith is considered to be the oldest of the three batholiths in Gisborne Lake and Terrenceville map-areas because it is foliated and the other two batholiths are not. If the foliation developed, as it is assumed to have done, during a period of regional metamorphism that preceded the intrusion of the Devonian Ackley batholith, the Cape Roger Mountain batholith may have been emplaced during the Silurian period.

Similarly foliated granite occurs in several small stocks at the Green Hills northeast of the Cape Roger Mountain batholith, and at Hickeys Pond east of Terrenceville map-area (Howland, 1940).

Cross Hills Batholith and Associated Intrusions

The Cross Hills batholith is a major intrusive body near Cross Hills, 2 miles north of Grand Le Pierre Harbour. Typical exposures can be viewed along the Grand Le Pierre-Gisborne Lake trail, south and west of Cross Hills. The batholith is unfoliated and probably post-dates the regional metamorphism.

Distribution

The Cross Hills batholith occupies a wedge-shaped area of 50 square miles. Its length averages 12 miles and its width, in the northeast, averages 5; in the southwest it tapers to a point. The batholith intruded the Nine Mile Hill, Grand Le Pierre, and Belle Bay formations. Several smaller intrusions are associated with it, the largest and most westerly of which is the Bakers Pond composite (granite and diorite) sill, which has an area of 4 square miles and intruded the Andersons Cove formation. East of this are the following bodies: (1) a narrow belt of gabbro trending northeast at Eastern Lookout; (2) a rectangular mass of gabbro, 1 square mile, east of Old Tilt Pond; (3) the Round Hill granite stock, 2 square miles; (4) two rectangular fault-bordered masses, each 1 square mile in area, to the north of the Terrenceville-Marystown road intersection; and (5) a number of small diorite and granite stocks mainly to the south of the batholith. The granite of the Cross Hills batholith erodes to form lowlands; the diorite and gabbro are exposed in resistant ridges.

Lithology

The Cross Hills batholith is one-third biotite-hornblende granite and aplite, one-third hornblende-rich quartz monzonite, and one-third gabbro, diabase, and diorite. Over large areas of the batholith, the granite and the quartz monzonite contain tabular xenoliths of gabbro, diabase, and diorite, but there are small areas composed principally of granite, diorite, and gabbro. In most exposures the more acid phases are younger and the contacts between these basic rocks and the enclosing more acid phases are generally sharp (Pl. II B) so that little assimilation appears to have taken place. Diorite is not as common as gabbro and diabase. Pegmatites are rare, but several simple quartz-feldspar pegmatite bodies less than 100 feet in length and less than 3 feet in width can be seen along the southern contact of the batholith, 1 mile northeast of the head of Grand Le Pierre Harbour. Neither the batholith nor the lamprophyre dykes that cut both it and the surrounding country rocks are foliated.

The *granite* is of various shades of yellow, brown, and red and is characterized by a weak porphyritic texture. Orthoclase is the dominant mineral, and quartz and plagioclase are about equally abundant. The phenocrysts of white potash feldspar and quartz average 2 mm. in size, and hornblende crystals are as much as 5 mm. long.

In thin sections specimens of the granite are seen to be largely altered, and to have a hypautomorphic-granular texture in which quartz is anhedral. Zoned orthoclase is more common than orthoclase perthite. The plagioclase is oligoclase. The feldspars are altered to kaolinite and sericite. Quartz is in myrmekitic intergrowths with oligoclase. Green biotite is bleached and altered to chlorite. Hornblende is altered to patches of chlorite, epidote, quartz, rutile, magnetite, and ilmenite, but the shape of the amphibole cross-section is preserved. Accessory minerals include apatite, sphene, and probably zircon. Secondary veinlets of quartz and epidote are present.

The *aplite* is a light reddish-orange, sugary rock with an average grain size of 0.5 mm. Clear quartz and orange orthoclase make up most of the rock, light-coloured plagioclase and a yellowish-green ferromagnesian mineral being subordinate. The aplite has a xenomorphic-granular texture formed by interlocking grains of quartz and slightly kaolinized orthoclase perthite. The plagioclase is sodic oligoclase, and the ferromagnesian mineral is altered to chlorite (variety pennine) and epidote.

The *quartz monzonite* is a mottled steel grey, medium-grained, equigranular rock, with an average grain size of 1 mm. The component minerals differ greatly in colour, thus emphasizing the interlocking granular texture. The most conspicuous mineral is dark green hornblende, which occurs in subhedral crystals from 2 mm. to 5 mm. in length and constitutes 20 to 25 per cent of the rock. Quartz makes up from 5 to 10 per cent. Two feldspars—pink orthoclase and light green plagioclase—form 70 per cent of the rock in about equal amounts. The sequence of crystallization was hornblende, plagioclase, orthoclase, and quartz.

Typical quartz monzonite has a hypautomorphic-granular texture. Plagioclase laths and orthoclase-perthite phenocrysts are slightly kaolinized. The plagioclase is andesine (An_{32}). Quartz is interstitial or anhedral. Hornblende shows cleavage and is pleochroic from brown to green in cross-section. Minor augite is altered to green hornblende. Magnetite and apatite are accessory minerals.

As seen in thin section a darker, fine-grained type of quartz monzonite is more altered and more basic. The plagioclase is much altered to kaolinite and sericite, and the hornblende is altered to chlorite and epidote.

The *gabbro* is dark green and is composed of grains 2 to 5 mm. in diameter. The plagioclase is much sericitized, and diopside is altered to antigorite and chlorite. Hornblende is subordinate to diopside. Green biotite is locally abundant, and magnetite and apatite are common accessory minerals.

The *diabase* is dark green, and contains plagioclase phenocrysts that average 1 mm. in length. It has a typical diabasic texture. Lath-shaped labradorite phenocrysts are embedded in augite that is locally uralitized. Olivine occurs in minor amounts and is altered to antigorite along cracks. Biotite, which is minor in extent, is bleached and altered to chlorite. Magnetite and ilmenite are present locally, the ilmenite in skeleton crystals and altered to leucoxene. Apatite is a common accessory mineral.

The *diorite* is light to dark green and has an average grain size of 2 to 3 mm. Ferromagnesian minerals in places form clusters as large as 5 mm. in diameter. In thin section specimens of the diorite show a hypautomorphic-granular to ophitic texture. Andesine (An_{38}) is partly altered to kaolinite and sericite. Quartz is present in minor amounts. Augite is partly altered to pennine and antigorite or to diopside and epidote. Apatite crystals as large as 0.3 mm. are common. In a specimen of diorite from near Chopping Block Pond, hornblende is the prevalent ferromagnesian mineral and the texture is hypautomorphic-granular.

Age and Correlation

The Cross Hills batholith is believed to be intermediate in the age sequence of the three batholiths and is possibly Middle to Late Devonian in age. It is probably younger than the Cape Roger Mountain batholith because its granite and basic dykes are unfoliated, whereas the Cape Roger Mountain granite and basic dykes display the regional foliation. The Ackley batholith is discordant with the Cross Hills batholith at two contacts, one immediately west of the Whaleback and the other north of Bakers Pond. It is possible, however, that the Cross Hills batholith is an earlier, more basic phase of a composite batholith that includes the Ackley batholith.

The Cross Hills batholith is equivalent both in lithology and in time to the Bay du Nord batholith mapped by White (1939) and Widmer (1950). Both geologists regarded the Bay du Nord batholith as pre-Ackley but also Devonian in age, a view favoured by the present author.

Ackley Batholith and Associated Intrusions

The Ackley batholith was described by White (1939, 1940) and the name applied to granite exposures at the Ackley City molybdenite prospect on Rencontre Lake.

Distribution

The Ackley batholith underlies about 400 square miles of the two map-areas, including most of Gisborne Lake map-area and a small part of Terrenceville map-area. As the coarse-grained granite disintegrates readily to form lowlands, the ridges that do occur in the granite areas are underlain not by granite but by marginal contact zones and roof pendants of volcanic and sedimentary rocks. Exceptional, however, is the Tolt, a prominent ridge of Ackley granite 7 miles northeast of Pin Hill, which the author believes owes its present relief to the protective cover of a roof pendant that was removed by the abrasive action of the Pleistocene ice-sheet.

Three small areas of grey granite-gneiss occur in the northern part of the batholith: one north of Pin Hill, one west of the Tolt, and one in the northwest corner of Gisborne Lake map-area. The granite gneiss forms low ridges locally above the granite lowlands.

An embayment of Ackley granite between Long Harbour and Gisborne Lake extends more than 3 miles into Terrenceville map-area, outlining the Cross Hills batholith in two places, and the granite intruded the Andersons Cove, Nine Mile Hill, Grand Le Pierre, and Belle Bay formations. The southeastern edge of the granite may be in fault contact with the Rencontre pebble-schist.

Southeast of Bay L'Argent, at Berry Hill, is a stock of alaskite believed to be related to the Ackley batholith. It lies 12 miles due south of the batholith.

Lithology

The Ackley batholith is made up principally of coarse-grained biotite granite, which grades into or was locally intruded near the batholith's margins by irregular masses and dykes of alaskite porphyry, alaskite, and aplite. Of these three subordinate rock types, alaskite porphyry is the most common. Along the Long Harbour River between tidewater and 15 miles upstream some grey granite gneiss has been observed, and several pegmatite bodies have been noted. Aplite dykes are more abundant than lamprophyre dykes.

The *granite* is a red, coarse-grained, biotite-bearing rock that ranges in grain size from 5 mm. in the common variety to 30 mm. where the granite locally contains large scattered orthoclase phenocrysts. The typical biotite granite has miarolitic cavities and varies in colour from red to buff. It contains the following minerals, approximately in the proportions indicated: flesh-coloured orthoclase, 45 per cent; white to grey quartz, 25 per cent; white to yellow plagioclase, 20 per cent; biotite, 8 per cent; magnetite and ilmenite, 1 per cent; and honey-coloured spinel, 1 per cent.

The granite has a hypautomorphic-granular texture and is composed chiefly of quartz, orthoclase, perthite with albite, and minor perthite showing exsolution quartz. Sodic oligoclase is altered to kaolinite, sericite, and muscovite, and is iron-stained. Brown biotite is in shreddy patches and clusters with quartz, magnetite, and euhedral apatite. Spinel grains are dark brown.

The *pegmatite bodies* noted along Long Harbour River are associated principally with the granite. They are mineralogically simple, as large as 3 feet long and 1 foot wide, and are composed of quartz, feldspar, and biotite. They show zoning. In one elliptical pegmatite measuring 1 foot by 2 feet, coarse-grained granite grades inward to a 1-inch aplite shell and this to a 3-inch shell composed principally of large quartz grains and feldspar crystals and scattered biotite. The core of barren quartz is 4 inches across. A pegmatite of similar size grades inward to an aplite shell, and this to a fine pegmatite made up of ½-inch crystals. The core is of pegmatite with 1-inch crystals.

Alaskite porphyry exhibits a coarse texture, with orthoclase phenocrysts as large as 20 mm. and quartz phenocrysts of an average diameter of 10 mm. in a fine-grained groundmass of orthoclase and quartz. Its composition is approximately as follows: orthoclase, 60 per cent; quartz, 35 per cent; accessory biotite, 3 per cent; and magnetite, ilmenite, and spinel, 2 per cent. The alaskite porphyry outwardly resembles an arkose containing 'quartz and feldspar pebbles', but its occurrence in dykes with chilled margins cutting granite establishes its igneous origin.

A thin section of a specimen of alaskite porphyry showed the principal mineral to be orthoclase microperthite with an overgrowth of, and partial replacement by sodic oligoclase (An_{12}). The cores of the feldspar phenocrysts are slightly altered to kaolinite and sericite, and brownish-green biotite flakes are corroded and leached. Quartz phenocrysts are anhedral. The matrix has a hypautomorphic-granular texture. It contains quartz, orthoclase, oligoclase, biotite, subordinate microcline, and minor amounts of muscovite and green hornblende. Magnetite and spinel are common accessories, and sphene, zircon, apatite, hematite, leucoxene, and fluorite are also present.

Alaskite is less common than the alaskite porphyry. It has an average grain size of 3 mm., and contains orange orthoclase, clear quartz, and biotite. A dark metallic mineral occurs in miarolitic cavities. As seen in thin section, the alaskite has a hypautomorphic-granular texture in which the principal minerals are coarse-grained orthoclase, oligoclase (An_{15}), and anhedral quartz. The feldspars are only slightly altered to kaolinite and sericite. Corroded brown biotite is present in minor amounts. Magnetite, ilmenite, leucoxene, and limonite occur in dark patches. Spinel is more common than muscovite.

The alaskite in the Berry Hill stock is petrographically similar to the alaskite of the Ackley batholith, is unmetamorphosed, intruded regionally metamorphosed rocks, and occupies the junction area of three faults. An arm of this stock appears to have intruded a fault-bounded wedge, ½ mile wide, that extends east from Jack Fountain Cove. A few outcrops of alaskite were mapped at the eastern end of the wedge, but to the west, valley alluvium covers the bedrock. If the alaskite continues to the west and if the Jacques Fontaine sill of foliated granite is, as it is believed to be, a correlative of the Cape Roger Mountain batholith, the alaskite probably cuts the sill southwest of Jacques Fontaine.

Granite gneiss is exposed in three small sections in the northern part of the Ackley batholith—north of Pin Hill, west of the Tolt, and in the northwest corner of Gisborne Lake map-area. The rocks are similar in these three exposures and range from granite gneiss to gneissic granite and leucogranite. They are older than the typical Ackley granite and are interpreted as part of a contaminated roof zone of the batholith. They are characterized by a finer grain size and a grey colour that results from a greater abundance of biotite.

The attitude of the foliation and the interlayering is N65°E with a dip of 70°NW. The leucogranite is light grey and the granite gneiss is dark grey, the colour being dependent upon the amount of biotite present. These rocks are composed of white orthoclase or plagioclase metacrysts 1 mm. to 2 mm. in diameter, yellow granulated quartz grains less than 1 mm., and patches of biotite and chlorite.

The mosaic structure of quartz grains in the gneiss and the general arrangement of biotite, which resembles the matrix surrounding clastic grains, suggest that the gneiss is of sedimentary origin, and may have developed by the metamorphism of a feldspathic arkose.

The Ackley batholith contains roof pendants of the Nine Mile Hill formation, and several areas of grey granite-gneiss, but small inclusions are rare. One spherical inclusion 3 inches in diameter was noted in the granite along the Long Harbour River about 3 miles from tidewater. This inclusion resembles the grey granite-gneiss of the northwest corner of Gisborne Lake map-area although its grain size is smaller.

Aplite dykes are more abundant than lamprophyre dykes. Both types are unfoliated. The aplite dykes are as large as 75 feet long and 1 foot wide. They carry granite inclusions locally, and in a few places grade inward to quartz-feldspar pegmatite. The aplite is orange and has a sugary texture with an average grain size of 0.5 mm. It has a xenomorphic-granular texture and is composed of anhedral quartz, orthoclase perthite, oligoclase, biotite, and magnetite. The feldspars are brownish and considerably kaolinized.

The *lamprophyre dykes* are not abundant. They are black and fine grained, and show a diabasic texture formed by tiny labradorite phenocrysts and brown grains of augite. Magnetite is common, and chlorite and calcite occur in oval patches. The lamprophyre and aplite dykes were not seen in contact, but the former are believed to be younger.

Age

The Ackley batholith is the youngest of the three batholiths described and is provisionally assigned a Late Devonian age. It is believed to have been emplaced during the Acadian orogeny.

Quaternary

Pleistocene Deposits

The Pleistocene deposits of the area, together with the abundance of glacial striae and *roches moutonnées,* indicate that this part of Newfoundland was strongly glaciated by the last southward advance of the Newfoundland ice-sheet, presumably in Wisconsin time. Glacial deposits include glacial drift, eskers, drift ridges, and glacio-fluvial terraces. Glacial erratics occur on all ridge tops.

The glacial drift, thin and continuous over the Ackley batholith, is composed of erratics and finer material derived from the granite. Some of the other rock types that occur as erratics are exposed in the roof pendants of the batholith. For several miles south of the batholith the most common rock types represented as erratics are coarse-grained biotite granite, alaskite porphyry, alaskite, and aplite derived from the Ackley batholith, and other rock types exposed along the south margin of the batholith. Along the Terrenceville road, near the Paradise River bridge, fragments of dark green basalt, green slates, purple crossbedded siltstone, metamorphic rocks, and milky vein-quartz form a subordinate part of the drift. In addition to small fragments of the rocks mentioned, the finer-sized material at this location includes quartz and orthoclase, in fresh angular grains averaging 10 mm. in size, and lesser amounts of plagioclase and biotite. These are the principal constituents of the coarse-grained Ackley granite and have apparently been derived from its disintegration.

Along the southern border of the Ackley batholith, volcanic and sedimentary rocks project above the granite as resistant ridges. In moving southward out of the lower topographic basin to cross the ridges in its path, the ice-sheet appears to have dropped part of its load, as is indicated by the morainal material deposited on the southwest side of Gisborne Lake. Glacial drift is thin on ridges north of Fortune Bay.

For several miles south of Fortune Bay, where bedrock ridges are common, the glacial drift is thin and the ridges are covered with only small patches of drift. Southeast of Grandys Pond fault, however, ridges are less abundant and the drift is thicker and more continuous.

Eskers ranging in length from 1 mile to 15 miles occur in the northern half of the area but are not found south of the Ackley batholith. The most prominent esker can be traced from the northern part of Gisborne Lake map-area south along the Long Harbour River for a mile, thence along Pin Hill Brook valley to Gisborne Lake. From there it continues southward, forming a peninsula and two islands in Gisborne Lake, and passes underwater across the bottom of the lake at a depth of a few feet. It is exposed for 1,000 feet or more on the western shore of the lake near Southwest Brook and ends in a large deposit of sand and gravel, probably a glacial-lake delta, which now forms the largest peninsula in Gisborne Lake. Another excellently preserved esker extends southward from Carrolls Hat along the east front of the roof pendant zone for at least 2½ miles. An esker in Big Rock Brook can be traced up and through a narrow pass, proof that a subglacial stream is capable of crossing a low divide.

Drift ridges occur only in the eastern half of Terrenceville map-area, where a northeasterly-trending valley-and-ridge topography is bedrock-controlled. They trend northwesterly and are as large as 1 mile long, 1,000 feet wide, and 50 feet high. The only difference between the glacial drift composing them and the typical drift cover in the vicinity is that the glacial drift in the ridges contains more material of local derivation from the Ackley batholith. Several of these drift ridges parallel the main southeasterly drainage and extend along the divide area. On aerial photographs they stand out by reason of their light walls and the dark swath of vegetation that extends for their length. Their exact mode of origin is not known.

Glacio-fluvial terrace deposits are found along Fortune Bay where major streams enter the sea. Prominent terraces occur at the head of Fortune Bay northeast of Terrenceville, at the head of Grand Le Pierre Harbour (Pl. II A), at

Langue de Cerf Cove, and at the head of Long Harbour. Minor terraces are exposed at Spudgel Cove, Pays Cove, English Harbour East, and Jack Fountain Cove. The terrace elevations at Terrenceville are 30, 44, and 64 feet, at Grand Le Pierre 19, 42, and 54 feet, and at Long Harbour 63 feet.

These glacio-fluvial deposits are composed of sands and gravels that are locally stratified and crossbedded and they show evidence of channelling. The pebbles in the gravel are principally of rock types found in the glacial drift with minor amounts of fragments from bedrock exposed upstream from the terrace. The material in the terraces at Grand Le Pierre and Terrenceville is leached locally to a depth of several inches, below which it is iron-stained for a few inches. North of the main Grand Le Pierre terrace on the east side of the tidal inlet, finer sand and clay deposits are exposed about 5 feet above mean sea-level.

These terrace deposits are believed to have been formed in the waning stages of glaciation by meltwater streams that built deltas where they entered the sea.

Post-glacial Deposits

Post-glacial deposits are principally marine deltas, bars, beaches, and spits, soil on some of the glacio-fluvial terraces, valley alluvium in a few of the major valleys, and local deposits of alluvium and peat on the barrens.

The larger streams flowing into Fortune Bay have outwash terraces that are being dissected, and deltas are forming at their mouths. Generally a delta and a lagoon form near the terrace, and a bar, spit, or tombolo bar seaward from the lagoon.

At Terrenceville a magnificent bay-head bar more than a mile long has developed to within 50 feet of the opposite shore, where a narrow tidal passageway is formed. This passageway is locally called a 'gut' and the tidal lagoon behind the bar is called a 'barasway'. The barasway is a little less than a square mile in area and is generally less than 6 feet deep. The tidal fluctuation is about 3 feet. Silt and mud are being deposited over much of the barasway, but the bottom is being eroded near the gut. The bar is composed principally of sand and gravel; it ranges in width from 100 to 600 feet and is as much as 15 feet above sea-level. A little soil is developed on the wide part of the bar.

A similar feature occurs at Grand Le Pierre, where the barasway is a mile long and 1,000 feet wide with an average depth of 4 feet (Pl. II A). The seaward face of a glacio-fluvial terrace at Grand Le Pierre is being dissected. A cobble beach is forming composed of glacial drift from which the sand and gravel have been washed away. Smaller bars, spits, and beaches have developed locally along the coast of Fortune Bay, and sand beaches connect rocky promontories to the mainland at Bay L'Argent, Little Bay East, and elsewhere.

Soil is developed in small patches on the glacio-fluvial terraces and also locally along the coast where weaker formations are exposed, as at Terrenceville and in the peninsulas near Bay L'Argent. Valley alluvium is being deposited in some of the major stream valleys, as, for example, along Terrenceville River, Grand Le Pierre River, Bay de l'Eau River, and the brook at Jacques Fontaine.

In many of the bedrock parts of the area a thin cover of felsenmeer is developing. Stone cells and stone stripes are common both in bedrock areas and in areas of glacial drift. Streams are depositing alluvium derived from the erosion of the glacial drift. Sandy beaches have been formed locally along the shores of some of the ponds, particularly in the northern part of the area on Gisborne Lake, Dunns Mountain Pond, and Mary Ann Pond. Bogs and marshes are extensively developed on the barrens.

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Chapter III

STRUCTURAL GEOLOGY

The structure of Gisborne Lake and Terrenceville map-areas includes angular and erosional unconformities, both observed and inferred, nine major fold systems, all but one trending northeasterly, and five fault systems, four of which also trend northeasterly. These occur chiefly within the 35,000+ feet of sedimentary and volcanic rocks found in the map-areas. Some structural modifications have been effected by three batholiths within the area.

Unconformities

Five unconformities have been recognized or inferred within the thick stratigraphic succession in the present map-areas. Of these, four are erosional unconformities whose presence was determined chiefly on stratigraphic evidence, and one is an angular unconformity that is actually exposed. The nature of the contact between the two Precambrian formations—the Southern Hills and Deer Park Pond formations—is not known.

The most profound unconformity in the two map-areas is between the Middle or Upper Ordovician (?) Andersons Cove formation and the Precambrian Southern Hills formation in the folds of the Southern Hills anticline and the Bay L'Argent syncline. That this contact appears conformable is perhaps surprising in view of the absence of at least four formations (the Belle Bay, Grand Le Pierre, Nine Mile Hill, and Deer Park Pond), which should occur between. The unconformity has been traced from East Bay and Bay L'Argent northeastward to just east of Terrenceville, and from a point 3 miles northeast of Terrenceville to the northeast corner of Terrenceville map-area, where it crosses into the southeastern corner of Gisborne Lake map-area and continues into the adjoining area. Throughout this distance, either greywacke conglomerate or a basalt flow of the Andersons Cove formation overlies various members of the Southern Hills formation. Southeast of the Southern Hills anticline, either greywacke conglomerate or a basalt flow of the Andersons Cove formation conformably (?) overlies the Deer Park Pond formation, which apparently thickens to the southeast. The contact between the Andersons Cove formation and the Precambrian-aged Southern Hills and Deer Park Pond formations is regarded as an erosional unconformity on the basis of (1) the missing stratigraphic units, (2) the apparent time hiatus indicated by the contact, (3) the presence of Southern Hills formation pebbles within the stratigraphically low conglomerate of the Andersons Cove formation, (4) the varied lithologies of the Southern Hills formation immediately underlying the basal conglomerate or lowermost basalt member of the Andersons

Cove formation, and (5) the apparent overlapping by the Andersons Cove formation of the two Precambrian formations in the southeastern part of Terrenceville map-area.

The base of the Upper Cambrian (?) Nine Mile Hill formation is not exposed, but an erosional unconformity is believed to mark the contact between the top of this formation and the base of the overlying Lower Ordovician (?) Grand Le Pierre formation. Evidence for this belief is the presence of pebbles of black siltstone, apparently derived from the Nine Mile Hill formation, within tuffs of the Grand Le Pierre formation. The two formations are not, however, in visible contact, and the nature of the contact can not be regarded as established.

An angular unconformity marks the contact between the Belle Bay formation and the underlying Grand Le Pierre formation. This unconformity has been traced for 2 miles northwest from the western head of Grand Le Pierre Harbour. Along it, volcanic agglomerate of the Belle Bay formation dips gently southwestward and overlies unconformably the vertical beds of the Grand Le Pierre formation. Baked blocks of the Grand Le Pierre tuff were identified in the overlying agglomerate. The surface of this unconformity is fairly regular, having a maximum relief of about 25 feet.

The Belle Bay formation is believed to lie unconformably upon the Nine Mile Hill formation in two places farther north, (1) in the fold complex south of Eastern Lookout, and (2) in the syncline near Dicks Pond, but the exact nature of the contact in these two areas was not observed. It is regarded, however, as an angular unconformity because (1) the Grand Le Pierre formation, which lies with visible angular unconformity below the Belle Bay volcanic rocks west of Grand Le Pierre Harbour, is missing, (2) the basal lava of the Belle Bay formation rests in some places on conglomerate or black siltstone of the Nine Mile Hill formation, in others on a basalt marker bed that is stratigraphically as much as 1,000 feet below the conglomerate or black siltstone, and (3) a mile southwest of Southeast Bight Hills an elliptical block of Nine Mile Hill conglomerate occurs enclosed by lava of the Belle Bay formation at least 100 feet above its base. These observations have led the author to believe that the Nine Mile Hill anticline was formed in early Ordovician time prior to its burial under the lavas of the Middle Ordovician (?) Belle Bay formation. A similar interpretation of the time of folding was made by White (1939) in the map-area immediately to the west.

The base of the Silurian (?) Rencontre formation and that of its possible metamorphic equivalent northeast of Terrenceville are thought to mark an erosional unconformity, although the contact of this formation with the Middle and Upper Ordovician (?) Andersons Cove formation at Harbour Mille and in the folds near Big Southeast Brook at the northeast end of the Southern Hills anticline appears conformable. Nevertheless, the fact that the Mooring Cove formation, which overlies the Andersons Cove formation in the adjoining Rencontre East area, is absent at Harbour Mille and near Big Southeast Brook, coupled with the absence of the Andersons Cove formation itself at Femme Pond, where the

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Rencontre formation overlies the Belle Bay formation, strongly favours the foregoing interpretation of an erosional unconformity. Indeed, White (1939) concluded that the Mooring Cove, Andersons Cove, and Belle Bay formations in the adjoining area were all folded and extensively eroded before the Rencontre formation was deposited. It was not possible to establish from exposures in the present area whether the unconformity between the Rencontre and underlying formations is just erosional or both angular and erosional.

An erosional unconformity is inferred at the unexposed base of the Upper Devonian Terrenceville formation from the presence of pebbles of the Rencontre, Andersons Cove, and older formations within conglomerate of the Terrenceville formation. Structurally, the older Rencontre formation appears to dip as gently and in the same direction as the Terrenceville formation west of Terrenceville, but more than a mile of water of Fortune Bay separates their closest exposures, thus eliminating all chance of establishing any angularity between the two formations.

Folds

The fold pattern of the area, the cumulative result of several orogenies, is complex, and involves a thick section of lenticular formations already divided by erosional unconformities at the time of folding. The fold pattern is further complicated by widespread faulting and by batholithic intrusion. Most of the fold axes, however, have a northeasterly trend, and along their lengths there are undulations that result in numerous alternations in plunge directions.

Nine major fold systems have been recognized in the two map-areas (Fig. 2). All but one of these trend northeasterly but they differ in kind, intensity, time of folding, and age of the rocks involved. These fold systems are described in order of location from north to south.

The Pin Hill Pond anticline and the Pin Hill syncline trend northwest for several miles across the largest of the roof pendant blocks of the Ackley batholith in the north-central part of Gisborne Lake map-area. The Pin Hill Pond anticline is a symmetrical, nonplunging fold that exposes the upper beds of the Nine Mile Hill formation on its steeply dipping limbs, and the lower slates of the formation in its core. The Pin Hill syncline is symmetrical, exposes lavas of the Belle Bay formation on steeply dipping limbs, and plunges southeast. Basalt flows and metasedimentary rocks exposed in the uppermost part of the syncline at Pin Hill are tentatively identified as part of the Andersons Cove formation. The beds in the roof-pendant block are intruded by granite along the northwest, west, and southwest borders, and are cut off to the east by the Pin Hill fault. The southwestern flank of the Pin Hill Pond anticline can be traced southward for 6 miles to Little Nine Mile Hill on the basis of the strikes and dips in roof-pendant blocks of the Nine Mile Hill formation that lie west of the Pin Hill fault.

A major fold, named by White (1939) the Long Harbour syncline and interpreted by him as one of the principal features of a synclinorium underlying Fortune Bay, penetrates the west side of Terrenceville map-area for almost 3

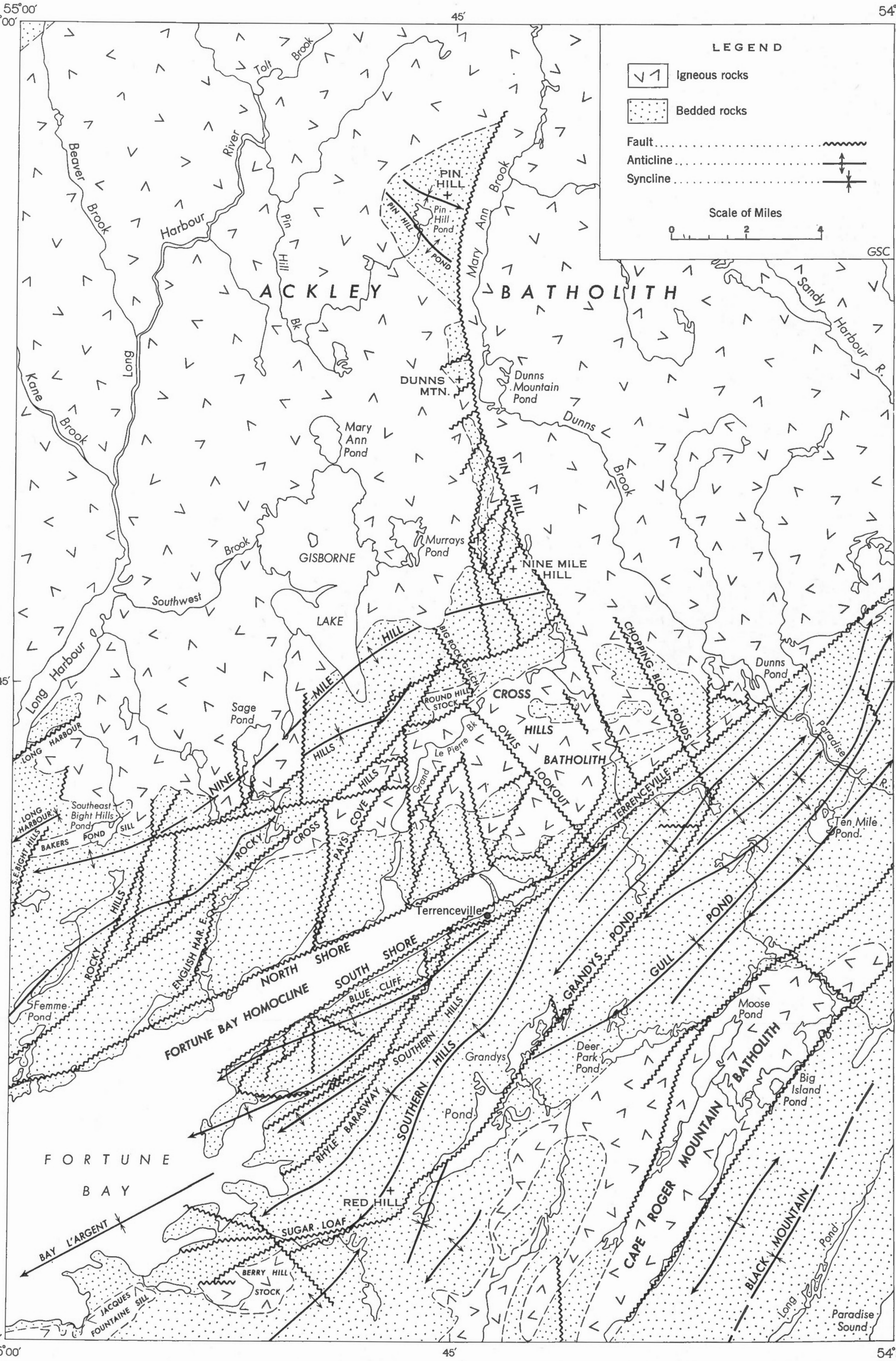

FIGURE 2. Major folds, faults, and intrusions

miles as a vertical, isoclinal, nonplunging structure. It was developed prior to the intrusion of the Cross Hills batholith, for diorite and granite of the Bakers Pond composite sill, an intrusive body related to the Cross Hills batholith, intruded the rocks on its southeastern limb. Within Terrenceville map-area the Long Harbour syncline exposes beds of the Andersons Cove formation that are underlain by acid lavas of the Belle Bay formation on the northwestern limb of the syncline. Between Youngs Hill and the Eastern Lookout, the younger Ackley granite intruded rocks in the syncline and the Bakers Pond sill.

With a slight curvature, the Nine Mile Hill anticline extends for 17 miles from the Southeast Bight Hills northeast to Nine Mile Hill, where it is cut off by the Pin Hill fault. The anticline is a vertical, isoclinal fold plunging west in the Southeast Bight Hills. It is crossfolded southeast of the Eastern Lookout and truncated by the intrusive Ackley granite near Sage Pond. From Gisborne Lake to Nine Mile Hill the anticline is an overturned asymmetrical fold with both limbs dipping northwest. What the anticline exposes is principally rocks of the Upper Cambrian (?) Nine Mile Hill formation into which both the Cross Hills and the Ackley batholiths have been intruded. Exposures a mile southwest of Southeast Bight Hills reveal that prior to burial the Nine Mile Hill anticline was folded under lavas of the Middle Ordovician (?) Belle Bay formation (*see* 'Unconformities').

The Rocky Hills syncline is a broad, asymmetric synclinal flexure separated from the Long Harbour syncline by the Nine Mile Hill anticline. The beds dip steeply on the northwest limb and gently on the southeast limb. The syncline is broken by several faults oblique to structure and is warped locally by crossfolding. The syncline typically exposes lavas and minor sediments of the Belle Bay formation as much as 6,000 feet thick, but the Andersons Cove formation and the lavas of the Mooring Cove formation seem to be missing. At Femme Pond, in the structurally highest part of the fold, where a doubly plunging syncline 3 miles long is almost perfectly expressed in the topography, the upper lavas of the Belle Bay formation are overlain unconformably by 4,000 feet of red clastic rocks of the Rencontre formation.

Southeast of the Rocky Hills is a local fold complex of several tight anticlines and synclines. The rocks along the southern margin of this fold complex are strongly sheared along the Cross Hills fault.

A syncline believed to be the eastward extension of the Rocky Hills syncline occurs to the northeast of the Rocky Hills near Dicks Pond, exposing lavas of the Belle Bay formation in an asymmetric fold 5 miles long. Both limbs of this fold dip northwest, the upright southeastern limb dipping 30 degrees, the overturned northwestern limb 60 degrees. The fold plunges southwest, where it is cut off by a north-south vertical fault.

The part of Fortune Bay within Terrenceville map-area is thought to be occupied by a homocline dipping southeast, and to be bounded by graben faults that coincide with the shorelines of the head of the bay. The covering waters of the bay, the presence of the southshore fault, and the Terrenceville thrust complicate structural interpretation, but the writer believes that this homocline is related to, and is the northeastern terminus of, the Fortune Bay synclinorium defined by White (1939).

The Bay L'Argent syncline in the southwestern part of Terrenceville map-area is also thought to be part of the Fortune Bay synclinorium. The syncline exposes the Andersons Cove formation on the three peninsulas northeast, and on the two southwest, of the town of Bay L'Argent, and exposes the Rencontre formation on the west side of Harbour Mille peninsula, and the possible metamorphic equivalent of the Rencontre formation at Boat Rocks.

The northeastward-trending Southern Hills anticline is the major fold in an *en échelon* series of anticlines and synclines that has a length within Terrenceville map-area of 25 miles. The anticline is 14 miles long and its crest lies 2 miles southeast of Terrenceville. It is a vertical, nearly isoclinal fan fold characterized by longitudinal faults dipping inward on the flanks. The plunge along the axis of the anticlinal series, particularly to the northeast, alternates in direction, so that culminations and depressions are formed. The *en échelon* pattern of the minor related anticlines and synclines shows a general right-handed displacement of the minor folds. The southern end of the Southern Hills anticline is broken by a transverse reverse fault along which Precambrian rocks are thrust southward over Ordovician (?) rocks. Two miles farther south the older rocks appear in an anticline plunging northeast. It is probable that this is a continuation of the *en échelon* series of anticlines and synclines and that the area between the two is a foreshortened structural depression. Most of this southern anticline, however, lies outside Terrenceville map-area.

The Southern Hills anticline exposes a section from the Precambrian-aged Southern Hills formation to what is possibly the metamorphic equivalent of the Silurian-aged (?) Rencontre formation. The Precambrian-aged Deer Park Pond formation is present only on the southeast flank of the anticline, but it is overlapped, as is the Southern Hills formation, by the Andersons Cove formation. The anticline may have been slightly folded in early Ordovician time, when the Nine Mile Hill formation elsewhere in the area was folded, but the principal folding was post-Rencontre.

Vertical foliation and cleavage are so strongly developed in the Precambrian-aged rocks of the Southern Hills anticline that recognition of bedding is difficult. Deformed pebbles give the impression of bedding, but the bedding, particularly in crestal areas, is actually horizontal and perpendicular to the intermediate axes of the pebbles.

The Gull Pond syncline lies southeast of the Southern Hills anticline and trends northeastward, across the southeastern part of Terrenceville map-area. The syncline has a length of at least 20 miles and a width between 1½ and 2 miles. It continues through the closely spaced *en échelon* folds in the Southern Hills formation, beyond the northeastern boundary of Terrenceville map-area. Throughout its southern half, the syncline has broader limbs and exposes both the Deer Park formation and the overlying Andersons Cove formation. Minor related anticlines and synclines were developed west of Pond of Islands and southwest of Black Hill Pond. Granite of the Cape Roger Mountain batholith has been intruded into the Deer Park Pond formation along the southeastern flank of the Gull Pond syncline, and the batholith itself appears to have been emplaced along, and to have largely obliterated, a major anticline southeast of the Gull Pond syncline.

The Black Mountain syncline exposes beds of the Deer Park Pond formation southeast of the Cape Roger Mountain batholith. It has a minimum length of about 15 miles and continues both ways beyond the boundaries of the area within a belt 10 miles wide. Near Double Pond there is a sharp, narrow, northeasterly-trending minor anticline that plunges northeast and exposes basalt flows and acid flows of the Southern Hills formation. Farther southeast along the west shore of Paradise Sound, the Southern Hills formation is exposed in a nonplunging isoclinal anticline in which the beds dip northwest.

In addition to the major fold systems herein described, the axial traces of numerous minor and related anticlines and synclines are shown on the geological maps accompanying this report.

Faults

Faults dominate the structural pattern in Gisborne Lake and Terrenceville map-areas. Few are well exposed, but many are indicated by distinct stratigraphic discontinuities or linear features. Most are marked at least by a gully and some by a scarp as much as 500 feet high. Most of the faults are steep to vertical, and older faults appear to have been offset in a few places by younger faults. Slickensided fault surfaces are rarely exposed, but a few have been seen along the coast or in chasms excavated in youthful valleys. Gouge and breccia are commonly present in exposed fault zones, as are some quartz veins up to 50 feet wide.

Five principal fault systems have been delineated, four of which are within the north-to-east quadrant. Most of the faults appear to be of mid-Palæozoic age or younger and, unless it is otherwise noted, are vertical, steep, or of undetermined dip. The five systems are described below in their approximate age sequence, from oldest to youngest. Twenty-one faults are referred to them.

N45°E Fault System

The N45°E system of faults is the oldest recognized in the two map-areas. The faults belonging to this system are longitudinal, nearly straight, and mostly of the steep reverse type. They are interpreted as developing under northwest-southeast compressional forces at about the same time as the folding of the Southern Hills anticline, the intrusion of the Cape Roger Mountain batholith, and the development of regional metamorphism, possibly during the Caledonian orogeny.

The principal fault of this system north of Fortune Bay is the Cross Hills fault, which lies along the northwest margin of the Cross Hills batholith (Fig. 2). It is a straight, vertical fault, traceable from the Rocky Hills fault for 9 miles to the

Cross Hills, from where it continues in a more irregular course to the northeast for another 6 miles. For most of its course it lies along a sharp-walled valley in which the rocks are intensely sheared.

The Grandys Pond fault, south of Fortune Bay, is another lengthy member of the N45°E fault system. It is a steeply dipping fault that extends from the southwest end of Grandys Pond northeast for 14 miles, and along much of it the adjoining rocks have been intensely sheared. The fault is marked by silicified zones, linear quartz veins, and a topographic lineament along much of its length. South of Grandys Pond the fault swings sharply west in a series of splays and disappears under the sea. In general these offshoot faults are similar to the main part of the fault, but one at least has a shallower dip, viz. 65 degrees west, and a reverse direction of movement. The fault appears to be a hinge fault with a maximum stratigraphic displacement of about 1 mile, southeast of Red Hill, where the lowest felsite of the Southern Hills formation is in contact with a meta-conglomerate stratigraphically high in the Andersons Cove formation. This displacement diminishes to the northeast of Grandys Pond, being almost nil near the Pork Hills, beyond which the fault evidently dies out.

East of Red Hill a granite sill related to the Cape Roger Mountain batholith appears to have intruded the fault zone, and 2 miles northeast of the tip of Grandys Pond numerous granite sills probably associated with the same batholith intruded both hanging-wall and foot-wall blocks. As the Grandys Pond fault is younger than the Ordovician (?) Andersons Cove formation but older than the Cape Roger Mountain batholith, it is believed to have formed during the Caledonian orogeny.

The Southern Hills fault is a reverse fault dipping steeply to the southeast and extending from East Bay northeast for almost 10 miles, with a relatively small left-handed displacement by the Ryle Barrisway fault about 3 miles east of East Bay. The narrow fault zone is marked by six elongate ponds, and a 50- to 200-foot-high south wall consisting of red, resistant, well exposed felsite of the Southern Hills formation. Swarms of quartz veins and zones, some several thousands of feet long, lie along the fault zone and make recognition easy.

Other faults in this system include the Blue Cliff reverse fault, which is north of the Southern Hills fault and is 15 miles long, with one relatively small left-handed offset by the Ryle Barrisway fault, and two faults that cut the Cape Roger Mountain granite batholith.

N15°E Fault System

The faults of the N15°E system appear to offset the N45°E system of faults and folds. They are probably younger and are neither so long nor so straight as the faults that trend N45°E. Most of them dip steeply to the northwest. One appears to cut the Ackley granite north of the Eastern Lookout and the Southeast Bight Hills fault, but it is in turn intruded by granite related to a late dyke stage of the Ackley batholith, which limits the time of faulting to late in the Acadian orogeny. Some are thought to be shear faults related to a couple set up during the intrusion of the Ackley batholith, such a couple being suggested by the presence, along the southern contact of the batholith, of many drag-folds that generally indicate the upward emplacement of the granite toward the northeast. Only one major fault of this system has been recognized south of Fortune Bay.

Representative of this system is the Southeast Bight Hills fault, which lies across the western end of the Southeast Bight Hills and has a minimum length of 4 miles. The fault follows the angular unconformity between the Belle Bay formation and the Nine Mile Hill formation for nearly a mile at the west end of the westward-plunging, closely folded Nine Mile Hill anticline. From there it continues southward entirely within the Belle Bay formation and north-northeastward into the Andersons Cove formation. A 10- to 20-foot-wide dyke of granite lies along this fault zone a short distance south of the southernmost occurrence of the Nine Mile Hill formation; it has been more extensively distintegrated and glacially abraded than the enclosing volcanic rocks and is now exposed within a tight gorge 50 to 75 feet high that is enclosed by the volcanic rocks. The ages of the rocks on either side of the fault show that the east side has moved upwards in relation to the west side.

About 3 miles east of the Southeast Bight Hills fault is the Rocky Hills fault, which has been traced from a mile east of Femme Pond for 6 miles to the Ackley granite contact and for a short distance beyond. This fault dips steeply westward and offsets the Rocky Hills syncline and formations ranging from the Nine Mile Hill up to the Rencontre. The east side of the fault is marked by a steep west-facing fault scarp. Curiously the rocks to the west of the fault appear more deformed than the same kind of units on the east side. Relative displacement along the fault is left-handed, but the extent of offsetting is not certainly known.

Another fault in the N15°E fault system is the English Harbour East fault, which extends for 3 miles from Little Bay de l'Eau through English Harbour East and terminates against the Cross Hills fault. It is essentially a bedding-plane thrust fault, with a curved fault plane concave to the northwest and dipping 30 to 50 degrees northwest. The fault is exposed north of the tip of English Harbour East on the west side of the main brook that flows into the harbour.

Two minor faults belonging to this system trend north-northeastward for several miles from Pays Cove, some 3 miles east of English Harbour East. Both are exposed along brooks within narrow, heavily wooded valleys, and the eastern fault is also exposed along the east shore of Pays Cove.

Only one major fault belonging to the N15°E system occurs south of Fortune Bay within Terrenceville map-area. This is the Ryle Barrisway fault, which can be traced from Little Bay north-northeastward for almost 8 miles to the Ryle Barrisway, where it is well exposed on the shore. In this exposure the fault dips steeply southeastward, transverse to structure, and shows reverse movement, but with some horizontal displacement.

One other major fault is included in this system, although its trend is more toward the northeast. This is the Long Harbour fault, originally described (White,

1939) in the adjoining Rencontre East area, where it is best exposed. It is included in this system because it cuts the Ackley granite and has produced an apparent horizontal displacement, possibly of several miles. The fault lies for 2 miles along the contact of the Belle Bay formation and the Ackley granite, on the east side of Long Harbour in Terrenceville map-area. Work done since 1954 in the Rencontre East area has led the writer to believe that movement along the Long Harbour fault was chiefly vertical rather than strike-slip, and that the northwest side dropped several thousand feet relative to the southeast side.

N45°-60°E Thrust System

The N45°-60°E thrust fault system is represented by only one fault, the Terrenceville thrust, and by renewed movement on segments of the Blue Cliff fault. The Terrenceville thrust consists of three parts, all dipping southeast. It commences at the Ryle Barrisway fault and appears to continue for 16 miles to the eastern margin of the present map-areas. Near Terrenceville it strikes N60°E, but farther to the northeast this strike changes to N45°E. The fault plane is well exposed at Pardys Brook, southwest of Terrenceville, where Southern Hills metagreywacke (now green schist) has been thrust northwest over Upper Devonian conglomerate of the Terrenceville formation. The fault plane at this locality dips 65 degrees southeast, and a gouge zone of red clay lies on the foot-wall side. For much of its course, the fault is concealed beneath surficial deposits, but its position can be closely established where the Terrenceville road crosses Harbour Brook, and north of the road the fault is exposed on Black Duck Brook and on Terrenceville Brook one-third of a mile above where they enter the Terrenceville valley. At two of these localities, the thrust dips 65 degrees southeast, with the Rencontre formation to the southeast in contact with the Grand Le Pierre formation. Farther east, the Terrenceville fault appears to be displaced strongly to the southeast by the Chopping Block Ponds fault of the younger N45°W fault system.

Because the Precambrian Southern Hills formation has been thrust over the Upper Devonian Terrenceville formation, the writer suggests that the formation of this fault is related to thrusting in the western part of Newfoundland and refers the compressive movements to the Appalachian Revolution.

North to N45°W Fault System

Several faults in the two map-areas have a north to N45°W orientation. One of these, the Chopping Block Ponds fault, appears to offset the Terrenceville thrust 6½ miles northeast of Terrenceville. Other similarly oriented faults are considered, on the assumption that they are of about the same age, to represent the next-to-youngest system of faults in the area. Their present relationships, however, may be the result of renewed movement on older faults at a late stage in the area's tectonic history. Most of the faults bound roof-pendant blocks on one or more sides in the Ackley and Cross Hills batholiths. The faults of this system are generally poorly exposed and difficult to trace. A few have been postulated largely on topographic features and lineaments.

The largest fault of this system is the Pin Hill fault, which is believed to extend from the Terrenceville thrust at a point 5 miles northeast of Terrenceville, north-northwest for almost 20 miles to Pin Hill. Along part of its southern end it has thrown the Grand Le Pierre formation against the Cross Hills batholith; a little farther north it passes through both the Cross Hills and Ackley batholiths; and at its northern end the Pin Hill fault separates the Ackley granite from the Nine Mile Hill formation. Near its northern end the trend of the fault changes to just east of north. The down-faulting of numerous roof pendants along the west side of this fault has contributed to their preservation to the present, although, curiously, they now rise sharply along the west wall of the fault to heights from 50 to 350 feet above the granite on the eastern side.

Near Nine Mile Hill, a series of subparallel faults that strike between N15°W and N15°E shows horizontal movement with both right- and left-handed displacement. Several of these faults are truncated by the Pin Hill fault and are therefore believed to be older.

The north to N45°W fault system has four other faults, as follows: Chopping Block Ponds fault, 5 miles long; Owls Lookout fault, 5 miles long; Big Rock Brook fault, 4 miles long; and the Moulting Pond fault, 3 miles long.

N60°E Graben System

The N60°E graben system, probably the youngest in the two map-areas, consists of two major faults, herein called the North Shore and South Shore faults, which together control the straight and narrow head of Fortune Bay. They are apparently terminated just north of Terrenceville by two small cross-faults. The graben is believed to be younger than the N15°E fault system because, were the reverse relationship true, the south shoreline would be sharply indented from Terrenceville to Cape Mille.

The North Shore fault can be traced from the head of the bay southwest for 15 miles to Femme Harbour, where it disappears beneath Fortune Bay. The fault plane is exposed only in a few places along the shore, but the straightness of the coast-line is considered to establish the continuity of the fault between exposures. The fault plane is well exposed at the Grass Grounds, near Terrenceville, where the Rencontre formation is faulted against the Grand Le Pierre formation. Drag-folds on the beds indicate that the south side (the hanging-wall) moved downward relative to the north side. This is therefore a normal fault. Farther west, the position of the fault across protruding headlands is marked by aligned indented coves on opposite sides of each harbour and by gullies leading inland therefrom. The apparent curvature of parts of the fault trace reflects the 60-degree dip of the fault plane. Breccia and barite and copper mineralization mark the fault zone west of the entrance to English Harbour East.

The South Shore fault is likewise a normal fault and is believed to extend for 10 miles along the south shore of Fortune Bay from just east of the Terrenceville bar to Cape Mille, beyond which it presumably lies entirely offshore. Exposures along this course are few and are limited to a few small rock promontories projecting north of the faultline, as at Cape Mille, where quartz veins cut the brecciated and slickensided fault zone. The straightness of the coast-line is considered a major clue to the presence of the fault.

A mile west of Terrenceville, the Terrenceville thrust can be traced to within a few tens of feet of the South Shore fault. The writer believes that the South Shore fault has dropped the thrust-fault plane into Fortune Bay. If the Terrenceville thrust fault developed during the Appalachian Revolution, as suspected, the younger graben structure may well be Triassic in age, as are the grabens in Nova Scotia and the eastern United States.

Chapter IV

ECONOMIC GEOLOGY

Gisborne Lake and Terrenceville map-areas show signs of mineralization, but no metallic deposit of economic importance has yet been found. The area is structurally favourable for metallization, and the close association of the minerals fluorite and molybdenite with intrusive rocks and faults is strikingly similar to nearby fluorite deposits to the southwest, at St. Lawrence, and molybdenite deposits to the west, at Ackley City on Rencontre Lake. The stratigraphic formations and intrusive rocks in the present map-areas are nearly identical with those in which these deposits occur.

Mineral Occurences

Iron

Magnetite is present as an accessory mineral in many of the rocks of the area and is abundant in some basalt flows. In the Nine Mile Hill formation near Nine Mile Hill, and at the west end of the Southeast Bight Hills, the magnetite locally concentrated within basalt flows is sufficient to interfere with compass readings. In both places, however, outcrop areas are small and the percentage of magnetite is low. One 2-inch-wide magnetite vein 20 feet long was also observed at Black Hill, a mile northwest of the crossing of the Marystown road over the Eastern Feeder.

Hematite occurs in a quartz vein near the Cross Hills fault and north of Round Hill. This vein strikes N10°E, dips 60 degrees northwest, and has a width of several inches along a length of 10 feet. It contains some platy blue hematite partly altered to limonite. Bluish specular hematite was also observed in several small quartz veins that trend N60°E in the Southern Hills.

Copper

Malachite-stained rocks have been observed in both the Blue Cliff and the North Shore fault zones. The malachite is locally accompanied by bornite. These copper minerals were noted near veins of quartz, calcite, and barite but were not seen in the veins. No great quantity of copper has been seen, but the mineralization is encouraging. On the Blue Cliff fault, two showings were observed 10 miles apart. One is at Blue Cliff, on Fortune Bay, and the other is along the Terrenceville road, on the opposite side of the valley from Black Duck Brook. The copper minerals appear to be localized in late Palæozoic or Triassic fault zones.

Malachite-stained rocks of the shear zone at Blue Cliff, 6 miles southwest of Terrenceville, give a greenish blue appearance to an area of about 1,000 square feet on the steep cliff face. Small amounts of bornite in addition to the malachite form a coating on the rocks. The sheared green meta-conglomerate of the Southern Hills formation nearby is cut by quartz-calcite-barite veins. Malachite-staining and minor amounts of bornite were also noted on the south side of the Terrenceville road directly opposite the valley from Black Duck Brook. There the copper minerals occur as a coating on the hanging-wall, sheared meta-conglomerate of the Southern Hills formation. The amount of copper mineral, however, is less than at Blue Cliff.

Malachite and bornite are found in small amounts in the fault zone on the west side of English Harbour East, where they are associated with breccia-filling of quartz, calcite, and barite. Minor amounts of cubic, purple fluorite are also present. No copper minerals were noted in either the quartz or the barite veins.

Molybdenite

Molybdenite was identified in a glacial erratic of white alaskite found in a gully on the east side of the Eastern Lookout. Alaskite is not exposed nearby, but this locality lies along the southern contact of the Ackley batholith, where alaskite commonly occurs (White, 1940).

Fluorite

Fluorite occurs sparingly in the granite and alaskite of the Ackley batholith. It also occurs in local brecciated zones of the Belle Bay formation and on the north side of Fortune Bay in the North Shore fault zone. One occurrence of fluorite near the Bay L'Argent road appears to be related to the stock at Berry Hill.

Fluorite is present in a gossan exposure 1 mile southeast of the Eastern Lookout on a hillside bordering two small ponds. The country rock is brecciated felsite of the Belle Bay formation, and the hillside is broken by vertical fractures striking N37°E. Most of the gossan has tumbled to a talus pile on the north slope of the hill. The area containing the fluorite is about 100 square feet, within which fluorite, quartz, and barite cement a breccia composed of angular fragments of felsite as large as 2 inches in diameter. Some of the quartz forms a box work. Other minerals present are horizontally banded chalcedony, red earthy hematite, pyrite, and limonite. No other exposure of this type was found nearby.

On the west side of a road cut along the fault zone southeast of the stock at Berry Hill, light-purple fluorite is present in a coating $\frac{1}{4}$-inch thick over an area of 1 square foot on a joint surface. The country rock is green sheared meta-conglomerate of the Andersons Cove formation. The fluorite is located 750 feet from the granite stock, which is petrographically similar to the Ackley granite.

Small amounts of purple fluorite occur with cubic pyrite in the North Shore fault zone west of English Harbour East.

Barite

Barite in small amounts occurs at Cape Mille, where it cements brecciated felsite of the Southern Hills formation in the South Shore fault zone. Barite veins are present along the North Shore fault on the west side of English Harbour East about 500 feet from the coast. These veins are 2 to 3 inches wide and 5 to 10 feet long.

Pyrite

An outcrop in which pyrite has replaced a bedded, grey felsitic tuff is exposed southeast of Gulls Pond about 3 miles north of Terrenceville. This exposure is part of a roof-pendant block of tuff in the Cross Hills granite, which outcrops about 1,000 feet away. The exposure of pyritized tuff measures about 50 feet long by 20 feet wide and is surrounded by glacial drift. A sample of pyritized tuff was analyzed for gold but was found to contain none.

Quartz

Quartz veins and zones cut all the stratified rocks of the area. Nearly all of them are vertical and most strike about N60°E. In many places the quartz veins are subparallel and interlocking. Locally, hundreds of them form a swarm a mile or more long, such as the one trending inland from the cliff opposite the northern end of the Terrenceville bar. Other less extensive vein swarms are located north of the town of Bay L'Argent, in the Southern Hills, in the Pork Hills south of the road intersection, and at the east side of Big Rock Brook.

The quartz zones are large masses, each of which is 20 to 50 feet wide and as much as 1,500 feet long. They occur near Blue Cliff, north of Pin Hill, and at Black Hill. Hematite has been noted in the quartz veins of the Southern Hills, and a black manganese mineral cements a local breccia southwest of Sugarloaf Hill. All other quartz veins and zones are barren.

Road Metal

Road metal is available in quantities sufficient to supply only the local need. Gravel deposits close to the roads have been used in their construction and maintenance, but this supply is limited. In a few places, crushed and sheared rock in fault zones has been used where gravel is not available.

Peat

Peat is fairly widespread in the area but has not been used locally for fuel. Peat and glacial drift occupy the barrens with its maze of small ponds and brooks. Readily accessible peat accumulations extend for several miles on both sides of the Terrenceville-Marystown road. Not much is known of their thickness or quality, but drainage ditches in many places along the road expose the peat for easy inspection and evaluation.

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