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STEPHENVILLE MAP-AREA, NEWFOUNDLAND

G. C. Riley

1962

STEPHENVILLE MAP-AREA, NEWFOUNDLAND

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PLATE I. View northeast from the Lewis Hills (left foreground) over Fox Island River (right foreground), and hummocky terrain underlain by the Humber Arm group. The relatively flat-topped Long Range is on the horizon.

GEOLOGICAL SURVEY
OF CANADA

MEMOIR 323

STEPHENVILLE MAP-AREA, NEWFOUNDLAND

By
G. C. Riley

DEPARTMENT OF
MINES AND TECHNICAL SURVEYS
CANADA

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PREFACE

Many geological investigations have been carried out on the west coast of Newfoundland in the past century, including the standard stratigraphic studies of Professors Schuchert and Dunbar. The Geological Survey of Canada began systematic reconnaissance mapping in Newfoundland in 1949. Field work in the Stephenville area was started by F. Q. Barnes in 1952 and completed by G. C. Riley in 1955.

The report includes unpublished data gathered by Barnes, J. W. Sullivan, and the author. It provides the first detailed information on the complex of intrusive and metamorphic rocks of the Long Range, formerly considered to be Precambrian in age. It also presents data indicating that at least one period of major folding in the map-area differed from the characteristic northeast direction found throughout the Appalachians.

This is the first memoir to include a brief geological discussion of magnetic anomalies resulting from an aeromagnetic survey. The aeromagnetic and geological maps, which are on the same scale, are in the map pocket of the text.

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

OTTAWA, February 24, 1961

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STEPHENVILLE MAP-AREA, NEWFOUNDLAND

Abstract

The Stephenville map-area is underlain by rocks ranging in age from Precambrian to Lower Pennsylvanian. Foliated basic and acidic intrusive rocks of Precambrian age make up the Indian Head Range north of Stephenville Crossing. Miogeosynclinal limestones, dolomites, shales, and sandstones of Cambrian and Early and Middle Ordovician age underlie much of the Port au Port Peninsula and part of the region north of Stephenville. These are overlain by eugeosynclinal black shales, conglomerates, greywackes, some limestones, and volcanic rocks of Middle Ordovician age. A narrow band of red, continental, Lower Devonian sandstones, shales, and conglomerates is faulted against Middle Ordovician rocks on the northwest side of the Port au Port Peninsula. Mississippian and Pennsylvanian continental-type sandstones, limestones, shales, gypsum, and coal occur south of Stephenville and on the Port au Port Peninsula. Pre-Carboniferous and probably post-Ordovician acidic to basic intrusive and metamorphic rocks underlie the Long Range. Carboniferous rocks are faulted against the Long Range in the southern part of the area, but nonconformably overlie Long Range anorthosite near Mount Howley. Ultrabasic and basic rocks cut Humber Arm strata (Middle Ordovician) north of Stephenville. Glacial deposits of varying thicknesses occur throughout the map-area. Glacial ice probably flowed southerly in the southeastern part of the area and westerly along the western border of the Long Range Plateau.

The structure in the map-area is complex, but the main structural trend is northeasterly as in other parts of Newfoundland. Several northwesterly-trending structures have been observed or determined, however, which may reflect older patterns of deformation. Evidence of two ages of folding is present on the Port au Port Peninsula and between St. George's and the Anguille Mountains. Structural trend lines in the Long Range are varied. Many folds and faults have been recognized.

Aeromagnetic anomalies correspond fairly closely to areas underlain by basic and ultrabasic rocks.

Gypsum, limestone, and sand and gravel are being quarried in the area at present.

Résumé

La région de Stephenville est constituée de roches dont les âges varient du Précambrien au Pennsylvanien inférieur. Des roches intrusives précambriennes, d'aspect folié et de composition basique et acide, forment les monts Indian Head au nord de Stephenville Crossing. Les calcaires, dolomies, schistes et grès du Cambrien et de l'Ordovicien inférieur et moyen constituent presque toute la péninsule de Port-au-Port ainsi qu'une partie de la région au nord de Stephenville. Ces roches représentent un miogéosynclinal et sont recouvertes par les schistes, conglomérats, grauwackes, un peu de calcaires, et les roches volcaniques de l'Ordovicien moyen et d'un eugéosynclinal. Les grès, schistes, et conglomérats du Dévonien inférieur affleurent sur le versant nord-ouest de la péninsule de Port-au-Port où ils forment une étroite bande de roches rouges d'origine continentale en contact de faille avec les roches de l'Ordovicien

moyen. Les grès, calcaires et schistes, le gypse et le charbon du Mississippien et du Pennsylvanien sont d'origine continentale et se rencontrent au sud de Stephenville et sur la péninsule de Port-au-Port. Des roches intrusives et métamorphiques d'âge pré-carbonifère et probablement post-ordovicien et de composition acide à basique, forment les monts Long Range. Les roches carbonifères sont en contact de faille le long des monts Long Range dans la partie sud de cette région, mais reposent en discordance sur l'anorthosite des monts Long Range à proximité du mont Howley. Des roches ultrabasiques et basiques coupent les strates Humber Arm de l'Ordovicien moyen au nord de Stephenville. On trouve des dépôts glaciaires d'épaisseurs variables partout dans la région à l'étude. La glace s'est probablement déplacée vers le sud dans la partie sud-est de la région et vers l'ouest le long du rebord ouest du plateau Long Range.

La tectonique de cette région est complexe, mais l'orientation structurale principale est en direction nord-est tout comme en d'autres endroits de Terre-Neuve. On a cependant observé ou déterminé plusieurs alignements de structure en direction nord-ouest qui peuvent être des vestiges d'un système de déformations antérieures. Dans la péninsule de Port-au-Port et entre St. George et les monts Anguille, on a découvert des indices de deux phases de plissements. L'orientation structurale dans les months Long Range est variée et on y a relevé plusieurs failles et plis.

Les anomalies aéromagnétiques correspondent assez bien aux régions formées de roches basiques et ultrabasiques.

On y fait aujourd'hui l'extraction du gypse, des calcaires, du sable et du gravier.

Chapter I

INTRODUCTION

Location and Means of Access

The Stephenville map-area lies between latitudes 48° 00′ N and 49° 00′ N, and longitudes 58° 00′ W and 59° 00′ W. A part of the Port au Port Peninsula that is west of the 59th meridian has been mapped with the Stephenville area for this report.

The main centres of population are Stephenville, which is the site of Harmon Airfield, a military and commercial base, Stephenville Crossing, St. George's, and Petries, which is on Humber Arm. Many villages are scattered along the coast between Cape St. George at the west end of Port au Port Peninsula and Highlands on the southwest shore. Other villages are along the railway, which connects Corner Brook, northeast of the area, and Port aux Basques at the southwestern corner of the island of Newfoundland.

Pulp and paper, general woods industries, fishing, agriculture, and employment at Harmon Field provide most of the income for the area.

Cargo and passenger ships give access to the area via Port aux Basques or Corner Brook. Trans-Canada Air Lines maintains a port of entry at Stephenville. The Trans-Canada Highway connects Port aux Basques and Corner Brook. Other roads serve the Port au Port Peninsula. The Canadian National Railways, operating on a narrow-gauge line between Port aux Basques and St. John's, on the east coast of Newfoundland, provides service between North Branch and Corner Brook. Numerous lumber roads and trails are in the area. Bowater Pulp and Paper Company owns roads that extend into some of the otherwise inaccessible regions, such as Grand Lake, Corner Brook Pond, and Serpentine Lake. A few roads, though shown on various topographic maps, have fallen into disrepair and are unsuitable for motor travel. The southeastern part of the map-area is most easily reached by charter aircraft, operating out of South Brook, a few miles northeast of Corner Brook, or from Gander, about 150 miles east of Corner Brook.

Previous Geological Work

J. B. Jukes was the first who seriously studied the geology of western Newfoundland. His recognition of coal seams at St. George's is now of historic interest, as is his report of 1842. J. P. Howley, in 1873 and 1874, studied the stratigraphy

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of the St. George's-Port au Port area. C. S. Schuchert and C. O. Dunbar combined the results of expeditions between 1910 and 1933 in a memoir on the stratigraphy of western Newfoundland, published in 1934. This work proved to be the standard reference for later investigations, its influence being particularly noticeable in most of the reports on the present map-area. In 1934 and 1935 J. R. Cooper mapped ultrabasic rocks in the Lewis Hills and Blow Me Down Mountain. The following year, A. O. Hayes and H. Johnson studied the Carboniferous strata of St. George's Bay. J. W. Sullivan investigated the Port au Port Peninsula in 1940 for a doctoral thesis at Yale University, but his report was not published. In the same year W. H. Twenhofel and Paul MacClintock described the physiography and glacial history of the region and R. F. Flint discussed post-glacial changes in sea-level on the west coast.

Several studies of economic interest were completed under the direction of the Newfoundland Geological Survey during 1943: strontium deposits were examined by H. Johnson on Port au Port Peninsula; the iron deposits of Indian Head area were studied by A. V. Heyl and J. J. Ronan; and deposits of magnetite and gypsum in the Sheep Brook-Lookout Brook area were investigated by D. M. Baird. These reports were not published until 1954.

Much of the map-area was examined in detail by T. N. Walthier between 1945 and 1947, and a Precambrian age for the rocks in the Long Range was designated. About the same time, a small part of the area north of Humber Arm was mapped by J. L. Weitz for an unpublished doctoral thesis presented at Yale University.

Re-examination of the region began in 1946 when W. A. Bell made a detailed study of Carboniferous strata in the St. George's Bay area. In 1952 and 1953 F. Q. Barnes examined outcrops in the area exclusive of the Long Range Plateau, the Lewis Hills, and Blow Me Down Mountain, but did not publish his findings. C. H. Smith spent the summers of 1951, 1952, and 1953 investigating the Bay of Islands igneous complex, which included the Lewis Hills and Blow Me Down Mountain. His report was published in 1958. The author mapped what is now known as the Long Range igneous and metamorphic complex during 1953 and revisited in 1955 that part of the map-area that lies north of Humber Arm.

The present report incorporates the field work of Barnes, Smith, and the author, but the author alone assumes responsibility for the text.

Acknowledgments

The author was ably assisted in the field by A. Vance, L. Smith, and the late A. MacIntyre. The kind cooperation of Bowater Pulp and Paper Company in allowing unrestricted use of their roads and bush camps is herewith acknowledged. C. H. Smith provided much helpful criticism, and an unpublished report tendered to the Geological Survey of Canada by F. Q. Barnes was freely used.

Physiography

Topography

The physiographic history of the map-area is complex. Six topographic units are recognized (Fig. 1), and each is directly related to bedrock geology.

The first topographic unit or division, which is in the northwest and consists of the Lewis Hills and Blow Me Down Mountain, is underlain by ultrabasic

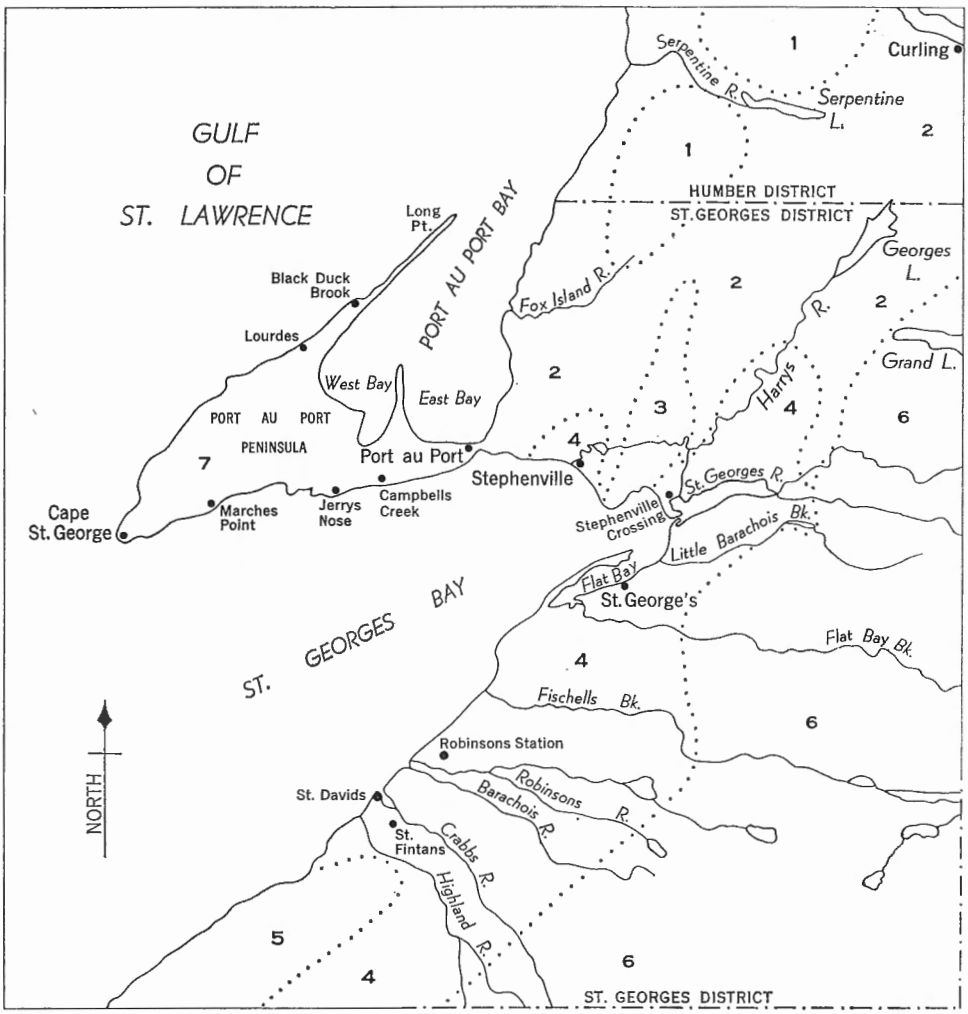

FIGURE 1. Generalized map showing topographic units: 1, Lewis Hills and Blow Me Down Mountain; 2, North easterly striking hills and ridges; 3, Indian Head Range; 4, Gently rolling drift-covered lowlands; 5 Anguille Mountains; 6, Long Range Plateau; 7, Port au Port Peninsula.

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and gabbroic rocks. The lack of vegetation in the areas thus underlain is visible for many miles. This unit has been described as "an uplifted, deeply dissected peneplane bounded by steep slopes" (Smith, 1958, p. 4)[1]. Its gently undulating upland surface is more than 2,000 feet above sea-level and has a maximum elevation of 2,672 feet. Abrupt scarps with large accumulations of talus along their lower margins mark the contact between intrusive rocks and the surrounding sedimentary strata. Numerous youthful V-shaped canyons exist along the edges of the Lewis Hills and Blow Me Down Mountain. Cirque-like forms are present at the heads of some of the valleys. These may be cirques (MacClintock and Twenhofel, 1940; Cooper, 1936), but some are related to the headward migration of knickpoints and to rapid lateral recession by slumping (Smith, 1958, p. 6). The drainage pattern is influenced by the strikes of the igneous and sedimentary rocks that underlie this region and by numerous northwesterly-striking transverse faults.

The second topographic unit consists of northeasterly-striking hills and ridges north of St. George's Bay and west of the Long Range (*see* frontispiece). These hills and ridges are underlain by limestones and dolomites of the Table Head and St. George groups and by quartzites of the March Point group. Many of the valleys are underlain by shale. In this unit an old erosion surface is apparent at about 1,100 feet, and summits do not exceed 1,500 feet.

The third topographic unit consists of hills underlain by granitic and basic rocks, known as the Indian Head Range. A possible erosion surface occurs at about 1,500 feet, and summits exceed 1,800 feet.

The fourth topographic unit consists of a gently rolling, thickly drift-covered lowland that has less than 800 feet of relief. This lowland is underlain by Carboniferous arenaceous strata between St. George's Bay and the Long Range, by outwash deposits between Indian Head and Romaines Brook, and along the valley of Harrys River south of Georges Lake. A meandering drainage pattern is established in this unit.

The fifth topographic unit consists of the flat-topped Anguille Mountains, which are underlain by conglomeratic and arenaceous beds of the Mississippian-aged Anguille group. An erosional surface is present at about 1,600 feet and summits are at about 1,800 feet.

The sixth topographic unit is that of the Long Range Plateau, which is underlain by igneous and metamorphic rocks. A mature upland surface appears to be established at about 1,500 feet, out of which isolated hills rise to over 2,000 feet. The southwestern margin of the plateau is marked by an extensive fault scarp that extends in a northeasterly direction from the southwest part of the map-area to where it crosses Fischells Brook. At Fischells Brook a north-northwesterly-trending scarp marks the edge of the anorthosite body that underlies this part of the plateau. The drainage system on the plateau is in part controlled by the structure of the bedrock, but it has been modified extensively by glaciation and

[1] Names and dates in parentheses are those of references cited at the end of this report.

uplift. The main streams transect the regional strike, and stream capture is evident in the upper parts of Crabbes Brook and Robinsons River. Present headward extension of the drainage system that originates on the plateau is evident in the upper reaches of Flat Bay Brook and Robinsons River. Numerous small streams cascade from hanging valleys in the larger river valleys. Swamps and ponds are scattered over the upland surface, and numerous brooks wander aimlessly over the plateau.

The Port au Port Peninsula might be considered as a seventh topographic unit. Northeasterly-trending hills underlain by resistant limestone and dolomite rise out of a gently rolling lowland, which is underlain by less resistant sandstone and shales of Mississippian and Ordovician age. An erosional level is visible on this peninsula at an elevation between 1,000 and 1,100 feet. The drainage pattern reflects the bedrock structure, and many streams are confined to fault valleys.

The accordance of certain summit and other levels in the map-area has often led to speculation concerning erosion surfaces on the Island. Twenhofel and MacClintock (1940) postulated the presence of three uplifted, mature to old-age surfaces in western Newfoundland, which they called the Longe Range Peneplain (2,000 feet), the High Valley Peneplain (1,300-1,700 feet), and the Lawrence Peneplain (500-1,000 feet). The elevations of these surfaces decreased toward eastern Newfoundland.

In the southeastern part of the map-area, isolated hills rise as much as 2,000 feet above a broad rolling surface about 1,500 feet in elevation. Another, or third, level occurs within the Long Range Plateau at an elevation between 1,000 and 1,250 feet. It might be compared to similar levels south of Georges Lake, at Table Mountain, and on the Port au Port Peninsula.

The coastal lowlands have an average elevation of 100 feet, and the extensive valley systems of Flat Bay Brook and Little Barachois Brook have floors that lie between 200 and 350 feet over much of their courses.

Evidence for the age of each of the erosional periods is obscure. The present rapid rate of downcutting in post-glacial streams shows it to be most unlikely that the Long Range Plateau could have survived erosion at its present elevation if it had been present at the end of the Mesozoic era. Although an erosional surface may have existed at that time, the existence of the three or more levels indicates successive stages of uplift during Cenozoic time. As mentioned by Smith (1958, p. 5) a later Cenozoic time of uplift, which has continued to the present, seems probable.

Glaciation

The map-area has been extensively and completely glaciated. U-shaped valleys, hanging valleys, cirques, and *roches moutonnées* are common. Perched erratics occur on all hills in the Long Range, of which knob and kettle topography is also characteristic. Numerous lakes dot the landscape, especially in the upper reaches of Fischells Brook. The Carboniferous lowlands between Fischells Brook and Flat

Bay Brook are overlain by a thick layer of drift, which probably comprises morainal deposits. Northwesterly-striking, drumlin-shaped hills of anorthosite boulder till are present south of Dribble Brook.

The directions of ice flow, as determined by striae, boulder trains, and *roches moutonnées,* in the map-area, are not well established. Striae are not common in the uplands owing to the intense mechanical weathering and type of rock exposure. They are numerous, however, along the coast, but there many of them probably resulted from sea-ice push. The orientation of the glacial striae and the topography indicate a southerly flow of ice in the southeastern part of the area and a westerly flow along the western border of the Long Range Plateau.

Glacial deposits between Gallants road and Stephenville Crossing consist of poorly sorted gravels, composed 5 to 20 per cent of boulders, 5 to 20 per cent of cobbles, 15 to 40 per cent of pebbles, and 35 to 75 per cent of sand. The sand is composed of quartz, red feldspar, mica, and scattered dark minerals. Rarely, the gravels contain beds or lenses of sand. For about 2 miles north of the road into Grand Lake, gravels are characterized by materials derived from granitic rocks; farther to the northeast, the gravels contain materials corresponding to the underlying bedrock lithology. Along the Grand Lake road, as Grand Lake is approached, the amount of sand interbedded with the gravel increases and its grain size decreases. Sand layers range in thickness from 8 inches to 6 feet and exhibit variable dips. Deposits along the shores of Grand Lake are predominantly micaceous, fine-grained sands, with some gravel layers and a few sandy clay beds. Much of the late glacial or immediately post-glacial drainage in this region was probably eastward through Grand Lake.

The northern and western limits of the Harrys Valley drift area are approximately outlined by an esker that F. Q. Barnes traced intermittently for 10 miles from Gallants road to Black Duck Pond.

Between Stephenville Crossing and Flat Bay Brook the deposits consist of interbedded sands, gravels, and clays. Gravel beds are unsorted, and are composed of layers commonly consisting 15 to 20 per cent of igneous-rock boulders, 30 to 35 per cent of cobbles, 35 to 40 per cent of pebbles, and 10 to 15 per cent of sand. The gravels in this area grade northeasterly into better-sorted sandy strata and to the south into finer-grained sediments. The sands, loosely consolidated, are commonly micaceous and vary in coarseness along strike. Clay layers here and there are noticeably stratified and change colour laterally from brown to red. Most of these clay layers dip gently to the west and northwest, but a few dip easterly. The shape and composition of these sediments suggest a deltaic deposit, possibly originating from a drainage system previously existing between Flat Bay Brook and Harrys River. (For a more detailed description of these deposits see MacClintock and Twenhofel, 1940.)

Finer-grained sediments become more common toward the south, between Flat Bay Brook and Fischells Brook. The lowest strata exposed are till-like, consisting of red clays containing angular fragments of red Codroy sandstone and a

few granitic boulders. These strata are overlain by interbedded sands, silts, and gravels that grade into a finer facies in a southerly direction. The presence of lens-shaped bodies of pebbly sands in the gravel suggests tributary deposition.

South of Fischells Brook the red clay decreases in amount and is replaced by brown sands containing bedrock fragments of sandstone. Gravels are scattered along the coast between Fischells Brook and Robinson's, overlying clay or sandy strata. South of Robinson's, deposits consist of sand and gravels.

Chapter II

GENERAL GEOLOGY

Regional Geology

The ages of the rocks in the Stephenville map-area range from Precambrian to Lower Pennsylvanian. Structures reflect the northeasterly trend that is common over much of Newfoundland, but a vestige of an east-west structural trend is apparent in the east and southeastern parts of the area.

The Indian Head Range comprises foliated basic and acidic intrusive rocks, which are the only rocks of Precambrian[1] age in the area.

Cambrian rocks consist of a succession of miogeosynclinal shales, sandstones, limestones, and dolomites. These are overlain conformably by more limestone and dolomites of Lower and Middle Ordovician age.

Eugeosynclinal rocks of Middle Ordovician age occur immediately above the Lower and Middle Ordovician limestones and dolomites. These rocks include black shales, conglomerates, greywackes, some limestones, and basic flows and pyroclastic rocks. Crustal instability in Middle Ordovician time is indicated by the presence of a diagenetic breccia, part of the Cow Head breccia in the Table Head group, and by the presence of more conglomerate and breccia in the Humber Arm group. Ultrabasic rocks in the Lewis Hills-Blow Me Down Mountain area cut Humber Arm strata and are probably related to the basic volcanic rocks of that group. Silurian rocks are not known to exist in the area, and the only known Devonian strata are in fault contact with Ordovician rocks along the western shore of the Port au Port Peninsula. The lithology of the Lower Devonian Clam Bank group indicates a continental environment of deposition, which shows that geosynclinal deposition in the map-area ceased prior to Devonian time. Although there is no record of Middle or Upper Devonian sedimentation, continental conditions apparently continued into Carboniferous time. Mississippian and Lower Pennsylvanian sandstone and conglomerate, shale, and limestone lie unconformably on Ordovician rocks and unconformably on, or in fault contact with, the Long Range intrusive and metamorphic rocks.

Anorthosites form part of the Long Range complex and are in fault contact with granitic and gneissic rocks that also form part of the complex. The granitic rocks cut Cambrian strata and have metamorphosed Ordovician Humber Arm and older sedimentary rocks. Rocks of the complex were a source of material for

[1] Since this manuscript was submitted, a potassium-argon age of 830 m.y. was determined on biotite from a specimen of granite gneiss that was collected from an outcrop on the highway near Long Gull Pond, between Stephenville and Stephenville Crossing (ref. Lowden, J. A.: Age Determinations by the Geological Survey of Canada, Report 2—Isotopic Ages, Paper 61-17, 1961) [Ed.]

Carboniferous strata. The complex is, therefore, pre-Carboniferous. Parts of it are probably of Devonian age, but it is possible that the complex includes reworked and remobilized granitic and gneissic rocks of Precambrian age.

Table of Formations

Era	Period or Epoch	Formation (thickness in feet)	Lithology
Cenozoic	Pleistocene and recent	Post-glacial sediments 0–150+	Stratified sand, gravel, clay; re-worked glacial till
		Minor disconformity	
		Glacial drift	Till, sand, and gravel
		Angular unconformity	
Palæozoic	Lower Pennsylvanian	Barachois group, including Searston beds of Late Mississippian age 5,000+	Grey, red, pebbly micaceous sandstone, grey siltstones, coal, conglomerates, minor shale, limestone conglomerate
	Upper Mississippian	Codroy group	Brown, red, green, and grey sandstones, siltstones (commonly pebbly), conglomerates, limestone, gypsum
	Lower Mississippian	Anguille group 2,600+	Limestone conglomerate with lenses of grey sandstone, grey sandstone, shales, siltstones
	Fault contact with Long Range		
	Lower Devonian	Clam Bank group 1,879+	Red sandstone, shale, conglomerate, minor limestone
	Fault contact with Long Point group		
	Pre-Carboniferous —Post-Middle Ordovician	Bay of Islands igneous complex	Peridotite, dunite, pyroxenite, gabbro, anorthosite, troctolite, serpentinite, amphibolite
	Intrusive contact with Humber Arm group		
	Pre-Carboniferous	Long Range igneous and metamorphic complex	Granite, granodiorite, adamellite, tonalite, diorite; granite-gneiss, granitic gneiss, mafic gneiss; anorthosite, minor anorthositic gabbro, gabbro, quartz gabbro, minor quartz diorite and syenite

Table of Formations—Conc.

Era	Period or Epoch	Formation (thickness in feet)	Lithology
	Fault contact with St. George group		
Palæozoic (cont'd)	Middle Ordovician	Long Point group 1,432+	Limestone, sandy shale, possibly equivalent to upper part of Humber Arm
		Humber Arm group 5,000+	Red, green, and black pyritiferous shales, limestone, greywacke, limestone conglomerate, sandstone; basalt, tuff, agglomerate
			"Cow Head Breccia"
		Table Head group 807 – 813	Black and grey, knobbly weathering, limestone, black carbonaceous shales, black shaly limestone
	Erosional disconformity		
	Lower Ordovician	St. George group 2,400+	Massive grey, buff, and pink dolomite; shaly dolomite, black limestone
		Green Point group 1,270+	Shale, limestone, sandstone (probably in part equivalent to lower part of St. George group; may be in part Upper Cambrian.)
	Not in contact		
	Upper Cambrian	Petit Jardin formation 331	Grey shale, limestone, dolomite
	Middle Cambrian	March Point formation 857+	Sandstone, shales, limestone, dolomite
	Lower Cambrian	Kippens formation 900+	Black shale, limestone, minor quartzite
	Nonconformity?		
Precambrian		Indian Head Range intrusive complex	Foliated basic intrusive rocks; foliated granitic intrusive rocks; may include minor post-Cambrian intrusive rocks

Sedimentary Rocks

Cambrian Rocks

Three Cambrian formations are in the map-area, two of them in the Port au Port Peninsula. The lowermost, the Kippens formation, is composed predominantly of shale and is of Lower Cambrian age. It is overlain conformably by a sequence of quartzitic rocks, shale, limestone, and dolomite, which make up the March Point formation of Middle Cambrian age. The contact between the Middle and Upper Cambrian strata, found only on the Port au Port Peninsula, is defined on faunal characteristics (Lochman, 1938). The Upper Cambrian Petit Jardin formation consists of shale, limestone, and dolomite.

Between the Port au Port Peninsula and Grand Lake, the two Middle and Upper Cambrian formations are grouped together on the geological map, with their lower contact at the base of the quartzitic sandstone and their upper contact at the base of the massive grey dolomite of the St. George group. As this upper contact is obscure, some Upper Cambrian beds may possibly be included in the lower Ordovician group. In this region two different types of sedimentation have taken place: quartzites and limestones are more common in the western area; toward Grand Lake metamorphosed shales are the characteristic rock type.

Other rocks of presumed Cambrian age outcrop along the western flank of the Long Range near Grand Lake. They are referred to by Walthier (1949, p. 18) as part of the Grand Lake Brook series. In this report they are classed as undivided meta-Cambrian rocks.

Kippens Formation

Distribution and Thickness

Rocks of the Kippens formation outcrop along Romaines Brook, and along the brooks on the west side of Indian Head Range, north of Long Gull Pond. The formation has been estimated as at least 912 feet thick near the mouth of Romaines (Kippens) Brook (Walthier, 1949, p. 70). F. Q. Barnes (unpublished report, on file, Geol. Surv., Canada) has suggested that the formation is about 1,300 feet thick on the west side of the Indian Head Range, north of Long Gull Pond.

Lithology

The formation is composed of grey and black shales, and interbedded grey limestone up to 3 feet thick. Fossiliferous zones are scattered through both shales and limestones.

Structure

Rocks of this formation dip westward off the crystalline rocks of the Indian Head complex. The contact is concealed by 200 feet of drift, and no evidence exists for any intervening fault. The formation outcrops on Romaines Brook along a northeasterly-trending, probably northerly-plunging, anticline that is faulted on its east side against the Lower Ordovician St. George group. North of Long Gull Pond the formation is overlain conformably by March Point quartzitic sandstones.

Metamorphism

Low-grade metamorphism of the formation in two localities on the east and west sides of Indian Head Range, north of Long Gull Pond, has produced meta-shale[1], phyllite, and red and pink pyritiferous, crystalline limestone. Bedding planes in the meta-shales are strongly micaceous, and here and there secondary cleavage is well developed.

Fauna and Age

The Kippens formation yields the trilobite *Paedeumias* cf. *P. transitans* Walcott and the cephalopod *Volbrothella concavi* (Walthier, 1949, pp. 72-73), both of which are confined to the Lower Cambrian strata.

March Point Formation

Distribution and Thickness

The March Point formation outcrops along the southwest shore of Port au Port Peninsula. East of the peninsula this formation has not been separated from the overlying Petit Jardin formation, and both formations make up one map unit. Faulted sections of this unit outcrop on the west side of Romaines Brook and also 2 miles west of Indian Head Range near the source of Romaines Brook. The formation is poorly exposed along the west side of the range, but is well exposed on the east side between North Brook and Black Duck Pond. Rocks lithologically similar to those of the March Point formation are found on Trout Brook, 5 miles southwest of Grand Lake.

The March Point formation has been measured and described by Schuchert and Dunbar (1934, pp. 34-35), Lochman (1938, p. 461), Sullivan (1940), and Walthier (1949, p. 17). As defined by Lochman the formation (beds 1-22 inclusive) is, at a minimum, 850 feet thick.

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[1] A finely recrystallized, mostly massive argillaceous rock lacking characteristic shaly cleavage.

Lithology

The March Point formation comprises dolomites, shaly and silty beds, and basal quartzose sandstone. Shales are more common east of Stephenville. Albite, microcline, and sphene are common in the sandstones that outcrop near the Indian Head Range crystalline rocks.

A generalized section of the formation, as exposed near Marches Point, is as follows (Walthier, 1949, p. 17):

Bed No.	Description	Thickness (feet)
14–22	Dolomite and oolite	300
6–13	Shaly and silty beds	200
1–5	Basal sandstones	350

Structure

The March Point and Petit Jardin formations may be considered as a structural unit. On the Port au Port Peninsula the March Point formation outcrops in a broad arch plunging gently to the north. On both the upper and lower parts of Romaines Brook it is exposed on the west limb of an open anticline that is downfaulted on its east side. Along the west side of the Indian Head Range the formation is on the west limb of a northerly-plunging anticline, probably part of the previously mentioned anticline at the head of Romaines Brook. The formation is also exposed along another northerly-plunging, broad anticlinal arch on the east side of the range, but this structure is complicated by minor open folding parallel to a northeasterly-trending fold axis. The formation is exposed along the east limb of a northerly-plunging syncline on the upper part of Trout Brook.

The March Point formation exhibits conformable contacts with overlying and underlying formations, but was not found in contact with rocks of the Indian Head Range intrusive complex.

Metamorphism

The March Point and the Petit Jardin formations are metamorphosed only along Trout Brook. Here, contact with the adjacent intrusive granitic rocks resulted in the development of meta-limestone[1], meta-shale (which is composed 60 per cent of green biotite), and quartzites. The two formations are, significantly, not metamorphosed along Indian Head Range.

[1] A finely recrystallized limestone.

Fauna and Age

The presence of *Marjumia newfoundlandenis* Lochman in Schuchert and Dunbar's bed 10 of the March Point formation, together with associated palaeontological data, has permitted Lochman (1938) to assign the formation beds 1-22 to the Middle Cambrian. Beds 6-10 are tentatively correlated palaeontologically with Neoleneus-Marjumia beds of Middle Cambrian in the Cordilleran region.

Petit Jardin Formation

Distribution and Thickness

The Petit Jardin formation has the same distribution as the March Point formation. Its thickness as reported in the descriptions of Schuchert and Dunbar (1934), Lochman (1938), and Walthier (1949) differs as follows: 256 feet (Schuchert and Dunbar), 331 feet (Lochman), and 116 feet (Walthier).

Lithology

The Petit Jardin formation comprises siltstones, shales, limestones, and dolomites. The following is a generalized section from near Marches Point (after Schuchert and Dunbar, 1934; Lochman, 1938)

Bed No.	Description	Thickness (feet)
28–30	Well-bedded cliff-forming dolomite; minor amounts of thin-layered dolomite and shale	215
25–27	Shaly and calcareous siltstone; oolite, silty dolomite; shale	41
23–24	Siltstone, grading into thin-bedded limestone	75

Fauna and Age

Fauna in beds 23 and 24, characterized by *Arapahoia raymondi* Lochman, enabled Lochman (1938) to correlate these beds of the Petit Jardin formation with the oldest faunal zone assigned to the Upper Cambrian series. The top of the formation must be arbitrarily placed, as no Cambrian fossils have been found above bed 24. Lochman defined the Petit Jardin formation as Schuchert and Dunbar's beds 23-30 inclusive, but Walthier (1949, p. 17) said that the resemblance of beds 28-30 to the basal beds of the Ordovician exposed farther east was so striking as to suggest that these three beds belonged within the Ordovician St. George group. If this is true, the Petit Jardin formation consists only of beds 23-27.

Undivided Metamorphosed Cambrian Rocks

Metamorphosed shaly strata lithologically unlike the March Point or Petit Jardin strata underlie massive carbonate rocks near Grand Lake. The relative

absence of limestone, dolomite, and sandstone, which make up the March Point and Petit Jardin formation elsewhere, may be indicative of a facies change to a predominantly argillaceous lithofacies in this region. As these strata apparently underlie carbonate rocks lithologically similar to strata in the Lower Ordovician St. George group, they are interpreted as undivided metamorphosed Cambrian rocks.

Distribution

Undivided metamorphosed Cambrian strata outcrop along the western flank of the Long Range between localities 4 miles southwest and 2 miles northeast of Camp 33 on Grand Lake. They extend beyond the map-area to the northeast of the headwaters of Grand Lake Brook.

Patches of metasedimentary rocks, probably of Cambrian age, occur within the Long Range, both north and south of Grand Lake. Farther east and out of the map-area, the rocks are predominantly paragneiss and their age is not known.

Lithology and Metamorphism

The original strata deposited near Grand Lake included shales, interbedded shales and limestones (with limestone layers up to 300 feet thick), minor dolomite, limestone, and sandstone. These rocks have now been metamorphosed to phyllites, marble, quartzites, and schists of varying mineral composition, each unit determined by the composition of the original sediment. The dominant rock type on the edge of the Long Range near Grand Lake is a limy meta-shale, which here and there is phyllitic and pyritiferous, with layers of marble up to several inches thick. Biotite schists and gneisses are common within the Long Range and along the shores of Grand Lake. The components of these rocks are 50 per cent quartz, 15 per cent albite, 25 per cent green biotite, 5 per cent white mica, 3 per cent magnetite, and small amounts of sphene and zoisite. Other rock types in this region include sericite schists, garnet- and cordierite-bearing schists and gneisses, and granite gneiss. Lenses of impure meta-limestone and of marble, up to 300 feet thick, outcrop here and there. Quartz-carbonate veins and granitic material are scattered through the area.

The grade of metamorphism is predominantly of the greenschist facies; in a few places, however, it rises to the albite-epidote-amphibolite facies (Turner, 1948) or the low side of the redefined almandine-amphibolite facies (Fyfe, Turner, and Verhoogen, 1958). The intensity of metamorphism and effect of granitization appear to increase eastward as limy shales pass into schists, which in turn become predominantly gneissic and granitic east of the map-area.

Structure

On the western edge of the Long Range, Cambrian metasedimentary rocks are exposed along the east limb of a northeasterly-plunging syncline. Near Grand Lake, adjacent schists and gneisses are probably isoclinally folded, but they are structurally and perhaps lithologically related to an asymmetric, northeasterly-plunging anticline of granite gneiss. The axis of this fold lies just east of Camp 33 on Grand Lake. More schists and mineralogically similar gneisses, as well as scattered lenses of marble and impure meta-limestone, are exposed along the eastern flank of this anticline.

Age

The band of limy meta-shales near Grand Lake underlies Lower Ordovician strata and thus may possibly be Cambrian. The schists and gneisses may also be Cambrian, but might include metamorphic remnants of younger Palæozoic rocks.

Ordovician Rocks

The oldest Ordovician rocks in the map-area are in a faulted block on the Port au Port Peninsula at the base of Long Point. Elsewhere Cambrian strata are overlain, probably without a break, by a thick succession of dolomite and limestone, with interbedded shale, that is known as the St. George group. A slight erosional discordance not everywhere present separates this unit from the overlying succession of limestone and shale that is called the Table Head group. The miogeosynclinal Table Head group sediments are succeeded by the eugeosynclinal Humber Arm group sediments, a change in rock types that indicates an abrupt change in conditions of sedimentation. Probably about the same time the Long Point group was laid down as an off-shore platform facies of the Humber Arm group. Crustal instability, which evidently had begun as early as Middle Cambrian time, resulted in the formation of much of the limestone conglomerate known as the Cow Head breccia. The incorporation of Long Point rock in some of this breccia shows that the formation of the breccia was not complete until at least well into Black River time.

Green Point Group

Distribution, Thickness, and Lithology

The Green Point group occurs in the map-area only on Port au Port Peninsula near the base of Long Point, where it occupies a faulted wedge between the Humber Arm and Long Point groups. Schuchert and Dunbar (1934, pp. 45-46) described a 1,251-foot section of this wedge, which was composed of black

and greenish-grey shales with some sandstones and thin-bedded limestones. Sullivan (1940) gave a minimum thickness of 1,270 feet for the following section measured 1 mile northeast of the village of West Bay.

Bed No.	Description	Thickness (feet)
4	Thin-bedded limestone and sandstone	200
3	Interbedded limestone and shale. Grey limestone in beds up to 3 inches thick, with greenish fissile shale in beds up to 4 inches thick; pyrite nodules and graptolites	375
2	Dark-grey arenaceous shale, alternating with thin-bedded grey limestone, grading downward into beds of black and greenish shales	550
1	Sandy limestone and interbedded shales, some limestone beds	145
	Total	1,270

Structure

Strata of the Green Point group dip to the north and are presumably bounded to the north and south by two easterly-trending faults. Sharp lithologic changes and age differences between adjacent groups indicate considerable movement along these two faults.

Fauna, Age, and Stratigraphic Relations

The following graptolites were collected by Sullivan (1940) from bed 3 in the section just described:

Dictyonema flabelliforme (Eichwald)
Staurograptus dichotomus Emmons

Their existence in shales below the Deepkill shale of New York State places them as early Ordovician.

Schuchert and Dunbar (1934, p. 40) stated that the Green Point group was older than the St. George group. If so, it should occur between the Petit Jardin formation and the St. George group, but no graptolite-bearing shales are found in that position. Also, too small a stratigraphic interval exists between the Petit Jardin formation and the St. George group for the inclusion of a thick sequence of shales in the region along the south shore of the Port au Port Peninsula. The Green Point group, as exposed on Long Point, may represent a northerly shaly facies of lowest Ordovician strata, but because both the Upper Cambrian beds and the lowest St. George beds are unfossiliferous, the exact relationships of the Green Point group cannot be established.

St. George and Table Head Groups

The St. George and Table Head groups have been defined and described by Schuchert and Dunbar (1934) and by Walthier (1949). Both groups are composed

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of thick-bedded limestone and dolomite. The upper beds of the St. George group consist of limestone, and the lower strata of the Table Head are also predominantly limy. The two groups are separated by a disconformity visible in many places along the shores of Port au Port Peninsula, but at only one locality east of the peninsula. As the scale of mapping precluded their separation, they have been combined as a single unit on the accompanying geological map. Both groups are described separately, but their regional structural aspects are discussed together.

ST. GEORGE GROUP

Distribution and Thickness

The type section of the St. George group is exposed along the south shore of Port au Port Peninsula between Marches Point and Port au Port. The group also outcrops: along the north and west shores of the peninsula; along the western flank of Table Mountain; in the area northwest of Gallants; south and east of Big Gull Pond; and along the edge of the Long Range, north and south of Grand Lake. The thickness of the group has been reported as 2,000 feet plus by Schuchert and Dunbar (1934, p. 50) and as 2,450 feet plus by Sullivan (1940; *see* Appendix, Section 2).

Lithology

The St. George group comprises buff, pink, and red dolomite, marble, massive and thin-bedded grey and black limestone, shale, and a few bands of chert. Numerous cryptozoon beds are exposed along the shore northeast of The Gravels. The dark- and light-coloured marbles that form the basal beds of the group are overlain by shaly dolomite. Shaly material occurs in the group northwest of Gallants but is a less common component on the Port au Port Peninsula. A slight eastward change of lithofacies is thus indicated. Details of the lithology of the group on Port au Port Peninsula are given in the Appendix, Sections 1-2, at the end of this report.

Structure

The St. George group is overlain disconformably by the Table Head group on Port au Port Peninsula. An erosion surface of irregular relief was developed in the uppermost St. George strata. Contact relationships with the underlying Upper Cambrian rocks are obscure, but the Petit Jardin formation probably passes upward conformably and with little or no change in sedimentation into the St. George group.

The lowest beds of the St. George group conformably overlie limy shale of presumed Cambrian age along Grand Lake Brook. The contact here and to the west is greatly contorted and difficult to find because the lithological differences between the two groups of rocks are only slight.

Fauna

Fauna collected from the St. George group by Schuchert and Dunbar, Sullivan, Walthier, and others, indicate that it is of Lower Ordovician (Canadian) age. Walthier collected *Lecanospira* cf. *L. compacta* from strata on East North Brook. This fossil is common in the middle part of the Canadian series. *Ceratopea,* widely distributed in Upper Canadian rocks, has been collected from the uppermost limestone of the group on Port au Port Peninsula and East North Brook.

The number of fossils collected by Sullivan (1940) suggested that the St. George group was equivalent to the Beekmantown formation of Canadian age. His faunal list[1] for the St. George group follows:

Arthropods
- *Euchasma blumenbachi* (Billings)
- *Leperditia* sp.

Cephalopods
- *Diphragmoceras* sp.
- *Orthoceras explorator* (Billings)
- *Piloceras* sp.
- *Protocycloceras lamarcki* (Billings)
- *Tarphyceras prematurum* Hyatt

Gastropods
- *Ceratopea keithi* Ulrich
- *Euconia etna* (Billings)
- *Helicotoma tritonia* Billings
- *Lecanospira* cf. *L. compacta*
- *Maclurites affinis* (Billings)
- *Maclurites oceanus* (Billings)
- *Maclurites rotundatus* (Billings)
- *Murchisonia* cf. *M. obelisca* Whitfield
- Opercula for *Maclurites*
- *Ophileta nerine* Billings
- *Pleurotomaria hyale* Billings
- *Pleurotomaria normani* Billings
- *Straparollina pelagica* Billings
- *Turritoma acrea* (Billings)

Brachiopods
- *Archeorthis hippolyte* (Billings)?
- *Billingsella* sp.

Porifera
- *Calathium anstedi* Billings

Algae
- *Cryptozoon* sp.

[1] Sullivan's fossils were identified at the Peabody Museum, Yale University, New Haven, Connecticut.

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He also suggested that these fossils seemed to arrange themselves naturally into the following zones characterized by a dominant form:

		Distance below top (feet)
Zone of *Ceratopea*	(Beds 44-52)	40 to 95
Zone of *Maclurites*	(Beds 36-38)	610 to 890
Zone of *Diphragmoceras*	(Bed 17)	1,431 to 1,446
Zone of *Lecanospira*	(Bed 2)	2,200 to 2,220
Zone of *Piloceras*	(Bed 2 or 1)	2,430 to 2,500?

TABLE HEAD GROUP

Distribution and Thickness

Outcrops of the Table Head group have been recognized west of Table Mountain and northeast of The Gravels. Basal beds are exposed at the quarry at Aguathuna. Other exposures of the group are along Piccadilly Bay and along the western shore of Port au Port Peninsula. The Table Head group on Port au Port Peninsula is about 841 feet thick according to Schuchert and Dunbar (1934, p. 66) and 813 feet according to Sullivan (1940) (*see* Appendix, Section 3). The group evidently thins to the north and east. At Corner Brook, just north of the map-area, a section of the Table Head measures 545 feet; here the total thickness of the group is possibly as much as 650.

Lithology

The group comprises three divisions: basal knobbly-weathering limestone; thin-bedded limestone and shale; and thin-bedded black shale. These units are similar to those at the type locality at Table Point, about 100 miles north of Stephenville.

Structure

The Table Head group lies disconformably upon the St. George group. It is overlain conformably by Humber Arm strata wherever it was observed by Barnes (unpublished report), but on Port au Port Peninsula the contact may be disconformable (Sullivan, 1940).

Fauna

The Table Head group contains abundant fauna. From the dark graptolitic shales and limestones of the upper Table Head, not only in Black Cove, 1 mile

northeast of Port au Port village, but in other parts of Port au Port Peninsula where the same beds are exposed, Sullivan (1940) collected the following:

Arthropods
- *Megalaspis huttoni* (Billings)

Brachiopods
- *Leptobolus* cf. *L. walcotti* Ruedemann
- *Lingula* n. sp.
- *Obolus* sp.

Graptolites
- *Climacograptus parvus* Hall
- *Climacograptus* sp.
- *Didymograptus sagitticaulus* Gurley
- *Glossograptus whitfieldi* (Hall)
- *Ptilograptus plumosus* Hall
- *Phyllograptus* sp.
- *Tetragraptus quadribrachiatus* (Hall)

From the upper part of the Table Head limestones along the shore northeast of The Gravels, and from the upper 200 feet of the Table Head limestone at Terrible Brook near Cape Cormorant, Sullivan (1940) collected the following:

Arthropods
- *Leperditia concinnula* Billings
- *Pliomerops barrandei* (Billings)

Cephalopods
- *Dawsonoceras priamus* (Billings)
- *Vaginoceras piscator* (Billings)

Gastropods
- *Maclurites emmonsi* (Billings)
- *Maclurites* sp.

From the lower part of the group exposed along the shore just east of Port au Port village, and also from the same part of the group exposed at the Goodyear lead prospect on top of an anticline behind Round Head (just south of Lourdes), Sullivan collected the following:

Arthropods
- *Ectenonotus westoni* (Billings)
- *Illaenus* sp.
- *Pliomerops barrandei* (Billings)
- *Leperditia concinnula* Billings

Cephalopods
- *Dawsonoceras priamus* (Billings)
- *Orthoceras* sp.
- *Tarphyceras extensum* Hyatt
- *Vaginoceras piscator* (Billings)

Gastropods
- *Eccyliomphalus* cf. *E. distans* (Billings)
- *Hormotoma augustina* (Billings)
- *Maclurites acuminatus* (Billings)
- *Maclurites* sp.
- Opercula for *Maclurites*

Brachiopods
- *Aporthophyla aurora* (Billings)

Porifera
- *Calathium fittoni* Billings

The *Climacograptus parvus* Hall, *Phyllograptus,* and *Tetragraptus* in the uppermost black-shale member lie above limestone correlated by Twenhofel *et al.* (1954, p. 298) as post-Canadian. The graptolitic fauna according to Twenhofel are pre-Normanskill, but Normanskill shales are probably of Black River age (Cooper and Cooper, 1946) and not necessarily of Chazyan age. The *Leptobolus* cf. *L. walcotti* Ruedemann collected by Sullivan has a stratigraphic distribution of Porterfield to Richmond (Cooper, 1956, p. 141). *Aporthophyla aurora* (Billings) and *Archaeorthis electra* collected by Sullivan from the lower part of the Table Head group have a stratigraphic range from Canadian to Porterfield, the *Aporthophylla* being restricted to the Whiterock (Cooper, 1956, p. 138).

Cooper (1956) assigned the Table Head group to a new Whiterock stage, which is post-Canadian but pre-Chazyan.

ST. GEORGE-TABLE HEAD UNIT (UNDIVIDED)

Distribution, Thickness, and Lithology

The St. George and Table Head groups are mapped as a single unit in the following parts of the map-area: over much of Port au Port Peninsula; along Table Mountain; north and west of the Indian Head Range; on the south side of Serpentine Lake; in much of the area southeast of Stag Pond; east of Georges Lake; and east of the Trans-Canada Highway near Grand Lake road.

Barnes (unpublished report) suggested 3,263 feet as a total thickness for this undivided St. George-Table Head unit. The upper 93 feet comprise black shales interbedded with grey limestone beds up to 6 inches thick. These are underlain by massive grey limestone and dolomite that weather to hackly and knobbly surfaces. Chert beds are common and shales occur lower in the section,

especially near the base. Limestone conglomerate is interbedded with limestone below the upper shaly member of the St. George-Table Head unit at Cape Cormorant, and also is found at, and near, the base of the overlying Humber Arm group. Limestone cobbles are also in shales immediately above the carbonate strata of the unit on East North Brook. Here the shales do not contain beds of limestone as they do along the shore of Port au Port Peninsula, and are indistinguishable from the overlying Humber Arm rocks.

Structure

The strata of the two groups on Port au Port Peninsula trend easterly, but are bowed into a broad arch, whose axis trends northeast parallel to the common direction of folding east of the peninsula. The structure is more complex on the western side of the peninsula. Asymmetrical folds and indications of northwesterly thrusting are found at Cape Cormorant and Round Head.

The St. George-Table Head rocks east of Port au Port Peninsula commonly are folded into broad, open, northerly-striking and north-plunging anticlines. Scattered through this part of the map-area, however, are indications of easterly-striking, more complex structures, such as those present along the flanks of the Long Range near Grand Lake.

Metamorphism

Limestone and dolomite of the St. George-Table Head unit are slightly recrystallized. Interbedded shales are, in part, phyllitic in the area west of the Long Range; and white and pink dolomitic marbles and phyllites occur at the base of the unit along Grand Lake Brook. The carbonate rocks are mostly equigranular, but locally are inequigranular, with coarse-sized crystals. The grain size of carbonate rocks varies but appears to increase toward Grand Lake, where calcite grains, commonly sugary-textured, are up to ¼ inch in diameter. Coarse-grained carbonate stringers and veins are numerous.

Humber Arm Group

Distribution and Thickness

Sedimentary rocks of the Humber Arm group outcrop on Port au Port Peninsula, along the north shore from near Boswarlos to Rocky Point; on the west shore from Three Rocks Cove to near Mainland; and along the shore cliffs of Big Cove, north of Cape St. George. East of Port au Port Peninsula they outcrop along the shore north of Port au Port and on the upper parts of Fox Island River. They also occur in the area bounded by the Lewis Hills, along the Trans-Canada Highway near Georges Lake, and at Petries.

Humber Arm volcanic rocks are exposed south and west of the ultrabasic complex in an area north of Fox Island River, and volcanic flows are intercalated with sediments on the east side of the ultrabasic complex.

The Humber Arm sediments are well exposed only along the sea shore. Volcanic rocks of the group are strongly resistant to erosion and are commonly exposed in hills, whereas the sediments weather rapidly and have formed a relatively flat lowland topography. The thickness of the Humber Arm group, which includes a volcanic member of 1,500 feet, is reportedly somewhat less than 5,000 feet (Walthier, 1949, p. 23). Other estimates range from 2,500 to 9,000 feet. This wide variation in estimated thicknesses is attributable to the complexity of the structure. Three stratigraphic sections of parts of the Humber Arm group, as measured by Sullivan (1940), are given in the Appendix, Sections 5-7.

Lithology

The Humber Arm group is composed predominantly of clastic sediments, together with some limestone, and volcanic rocks. The sedimentary rocks comprise: red, green, and black, highly fissile shales containing scattered concretions of pyrite and marcasite; limestone conglomerates; shaly conglomerates; massive limestone; interbedded shale and limestone; sandstone and conglomerate; and quartzites, phyllites, and argillites. The volcanic rocks comprise: flows of andesitic to basaltic composition and tuffs and agglomerates that are common both in the streams entering Broad Cove (south of Bluff Head) and on Fox Island. A slightly modified version of Walthier's (1949, p. 23) three lithologic divisions of the group is as follows:

3 Upper Humber Arm black shales and sandstones with interbedded thin strata of limestone from 1 to 6 inches thick

2 Cooks limestone (beds commonly up to 100 feet thick)

1 Lower Humber Arm shale, sandstone and conglomerate

These divisions are representative of the group in the area east of the Lewis Hills. To the west, however, volcanic rocks and greywacke are relatively abundant and limestone and white sandstone scarce, and a limy conglomerate occurs at or near the base of the section.

Massive, coarse-grained greywacke, with lenses of well-sorted pebble conglomerate, is a common member of the group along the west coast. A thin section of this rock contains 60 per cent angular quartz, 30 per cent shale fragments, 5 per cent albite, microcline, and perthite, and 5 per cent carbonate, chlorite, and hematite. The rock is moderately sorted and has a grain diameter of ½ mm. Perthite is similar to that in the March Point arkose.

East of the ultrabasic complex, arenites are numerous. In contrast to the massive greywacke on the west coast, they are relatively well-sorted and compact

and exhibit definite bedding features. The components of sandstone near East North Brook are 60 per cent quartz, 25 per cent carbonate, 10 per cent shale fragments and chlorite, and white mica, albite, and carbonaceous material. Grains are angular and are commonly $\frac{1}{5}$ mm in diameter.

The volcanic complex of Bluff Head and Mount Barren (Cooper, 1936) comprises altered basalt, and hornblende and plagioclase porphyries. These are intruded by dykes of diabase and granitic rocks ranging in composition from soda granite to granodiorite. Other volcanic rocks in the Humber Arm group are of andesitic to basaltic composition. They exhibit pillow and vesicular structures and weather red where intercalated with Humber Arm sediments. East of Port au Port Peninsula they are composed of fine-grained phenocrysts of plagioclase (andesine) in a fine-grained, dark-green groundmass, which also holds scattered grains of iron oxide. Agglomerates such as those on Fox Island contain fragments of granite, syenite, and andesite (Walthier, 1949, p. 75).

Structure

The Humber Arm group is conformable wherever it is in visible contact with the Table Head group, but lies nonconformably on the intrusive rocks of the Indian Head Range. Humber Arm sediments consist mainly of incompetent strata, which, in contrast to the Table Head group, are highly deformed. However, massive, thick limestone and sandstone beds north of North Brook are competent and form a series of broad, northerly-plunging folds, one of which has been described as the Humber Arm syncline (Walthier, 1949, p. 25). South of Serpentine Lake, Humber Arm strata and underlying carbonate sequences are in northeasterly-plunging folds. Thin limestone strata, where interbedded with shales, are broken into boudins and are enveloped by the highly deformed shales.

The strata are more competent where volcanic rocks are intercalated with shaly beds. The thicker volcanic accumulations are relatively flat-lying and apparently resisted deformation, acting as buttresses against which Humber Arm sediments have been shoved. Shales and interbedded sandstones, well exposed along the shores of Humber Arm, show pronounced anticlinal and synclinal structures, many of which are asymmetrical. The strata are highly deformed, and commonly dip steeply. Both overturned and isoclinal folds are exposed on the north shore of the Arm.

Metamorphism

Much of the Humber Arm group is only slightly metamorphosed. However, contact metamorphism of volcanic and sedimentary members of the group by rocks of the ultrabasic complex has produced narrow aureoles and masses of amphibolites, phyllites, schists, and a few rocks of pyroxene hornfels facies. The aureole is narrow except where the contact between the intrusive rock and the Humber Arm strata is relatively flat-lying, as it is southwest of Hines Pond. In such regions the aureole

may be up to 1 mile wide. The aureoles are composed mostly of actinolite schists with scattered patches of phyllitic sediments. North of Hines Pond, however, diopside occurs in metasedimentary rocks within 10 feet of the ultrabasic rocks. Smith (1958) noted that the metamorphic aureoles surrounding the ultrabasic rocks have been strongly modified by post-intrusion deformation that has caused retrogressive metamorphism of the country rock. Both Smith (1958) and Cooper (1936) have described in detail the contact relationships and the metamorphic rocks of the Humber Arm group.

Regional metamorphism, or metamorphism related to granitization processes in the Long Range has resulted in the development of phyllites in Humber Arm shale as far west as Georges Lake. Toward the Long Range from the Georges Lake region, shales have been converted to phyllites and sandstones to quartzites. In many areas, however, the effects of regional metamorphism are obscured by the increase in deformation of the shales and sandstones along the eastern margin of the Humber Arm group.

Shales of the group that nonconformably overlie rocks of the Indian Head Range are not metamorphosed. Fragments and cobbles of the underlying igneous rock are incorporated in the lower few feet of shaly Humber Arm strata on Hunter Brook. A thin section of shale from a stratigraphic horizon about 10 feet above the crystalline rocks at the upper end of West North Brook contains extremely fine-grained white mica aligned parallel to the bedding, minor amounts of quartz? and feldspar, hematite in seams, a little chlorite and silty? detritus. Signs of recrystallization or contact metamorphism are not evident.

Fauna and Age

Sullivan (1940) collected the following fauna from shales near the base of the Humber Arm group at Cape Cormorant, and in the hills several miles east of that locality:

Arthropods
- *Agnostus* sp.

Brachiopods
- *Paterula amii* Schuchert

Graptolites
- *Climacograptus caudatus* Lapworth
- *Climacograptus scharenbergi* Lapworth

Cooper (1956, p. 171) assigned *Paterula amii* Schuchert to his Porterfield stage, thus placing at least a part of the Humber Arm strata in the Middle to uppermost Middle Ordovician. The age of the uppermost beds of the group is problematical; they might even be of Upper Ordovician age.

Cow Head Breccia

The Cow Head breccia is so named from its excellent exposure on Cow Head Peninsula about 70 miles north of the map-area. Limestone conglomerates were first described by Logan (1863, pp. 291 and 877) from field observations of Richardson, in the area between Hawkes Bay and Cape Norman and at Cow Head, on the northwest shore of the Island. Schuchert and Dunbar (1934) fully described conglomerates at Cow Head and also reported on other limy conglomerates on Port au Port Peninsula that were first found at Cape Cormorant by Dunbar and Leith a year earlier. The stratigraphy of the rocks in the Cow Head region has been amply described by Kindle and Whittington (1958).

Most of the Cow Head breccia in the map-area is scattered along the shore of Port au Port Peninsula at or near the base of the Humber Arm group. Limestone conglomerate is interbedded with limestone of the Table Head group at Cape Cormorant (Barnes, unpublished report), and cobbles of limestone are in shale immediately above the thick carbonate sequence of the St. George-Table Head unit on East North Brook. Conglomerate composed of slightly finer material than that at Cape Cormorant outcrops at South Head and 1½ miles north of Port au Port. The rocks at these two localities apparently are not associated with sharp flexures and are not as thick as those at the cape.

The Cow Head breccia consists of limestone ranging in size from minute fragments to blocks 600 feet long, within a fragmental limestone matrix. The larger blocks are angular but the smaller ones may be subrounded. The breccia is commonly in unbedded or only crudely stratified, discontinuous layers, locally up to at least 50 feet thick. Barnes believed that the coarse limestone conglomerates at Cape Cormorant were deposited prior to the deformation of all the strata at the Cape.

Many earlier workers had attributed the formation of the breccia to thrusting and faulting. Schuchert and Dunbar (1934, pp. 84-86) suggested that the breccia at one locality at Cape Cormorant is a talus or landslide deposit, formed at the nose of a thrust that was active in Middle Ordovician time. Barnes, however, found no evidence for faulting along the postulated thrust lines except at the Cape, and even here conglomerates and interbedded limestones and shales are conformable with underlying massive limestones, dipping at the same angle.

It is now known that the "Cow Head breccia . . . is not a single formation but a succession of conglomerates and intervening beds ranging in age from Middle Cambrian to Middle Ordovician. The boulders of any conglomerate are approximately the same age as the immediately underlying strata, . . ." (Kindle and Whittington, 1956). With such a wide stratigraphic range it is no longer possible to consider the breccia as a simple deposit related to thrust faulting.

Probably an important factor in the formation of the breccia was the presence in Ordovician time of a geosyncline along what is now the west coast of Newfoundland. This geosyncline must have originated as a deepening trough in early Ordovician time or even as early as Middle Cambrian time. Slumping in conjunction with crustal adjustment along the flanks of this deepening trough may have resulted in the formation of the breccia.

Long Point Group

Distribution and Thickness

The Long Point group outcrops on Long Point, Port au Port Peninsula. As rocks of the group are faulted against Humber Arm, St. George-Table Head, and Clam Bank strata, only a minimum thickness can be given. Schuchert and Dunbar (1934, p. 71) suggested 1,500 feet, and Sullivan (1940) and Barnes (unpublished report) measured a composite section, 1,432 feet thick around Long Point.

Lithology

The Long Point group consists of fossiliferous limestone, sandstone, and shale. A composite section compiled by Sullivan (1940) from observations on both sides of Long Point is given in the Appendix, Section 4.

Structure

The Long Point group rocks, on Long Point, dip to the west in a gentle monocline, and at Lourdes and Three Rocks Cove are overturned to the southeast.

Fauna and Age

Long Point strata contain abundant fossils of Black River and earliest Trenton (Middle Ordovician) age. Cooper (1956, p. 13) correlated brachiopods in the group with his Upper Wilderness stage. Thus the Long Point group is younger than the Table Head and lower Humber Arm strata. It is possible that the Long Point group represents a westerly offshore facies of the Humber Arm group and is equivalent to the upper part of that group, and that thrusting has brought them into closer relationship.

Devonian Rocks

A few Lower Devonian marine sediments occur in the map-area. Silurian strata are unknown in western Newfoundland.

Clam Bank Group

Distribution and Thickness

The Clam Bank group outcrops along the west side of Port au Port Peninsula from Black Duck Brook to Salmon Cove. Measured sections indicate that it is from 1,700 feet (Schuchert and Dunbar, 1934, p. 104) to 1,879 feet thick (Sullivan, 1940).

Lithology

The group comprises reddish-brown, poorly sorted, crossbedded, friable sandstone, mud-cracked buff and green siltstone, and silty shale, red conglomerate, and greenish fossiliferous limestone. Details of the lithology are given in the Appendix, Section 8, which describes a composite section of the group as measured by Sullivan (1940).

Structure

The group outcrops in an open syncline, with dips of up to 60 degrees on the limbs. A normal, slightly oblique slip fault has dropped the group into contact with the Long Point group. This is the only occurrence of Devonian strata in western Newfoundland; unfortunately, their relationship to younger and older strata is obscure.

Fauna and Age

Limestone beds of the Clam Bank group have yielded abundant crinoids, corals, brachiopods, bryozoa, and trilobites. According to Sullivan (1940) this fauna appears to be somewhat transitional between Silurian and Devonian, but it is best correlated with that of the Helderberg limestone of Early Devonian age.

Carboniferous Rocks

Carboniferous rocks in the map-area are divided into three stratigraphic units: the Anguille, Codroy, and Barachois groups. The lowest or Anguille group contains a thick sequence of grey sandstone overlain by coarse conglomerate with interbedded lenticular layers of grey sandstone. This group probably represents alluvial-flood-plain deposits. The orientation of ripple marks and the coarseness of the conglomeratic rocks at Fischells Brook and Robinsons River as compared with finer-grained, well-sorted strata in the Codroy area, just southwest of the map-area, lead to the conclusion that the source of the Anguille sediments lay to the north and northeast. It is probable that these sediments were deposited in an intermontane subsiding basin that extended northeast out of the St. George's Bay area (Bell, 1948). The middle, or Codroy, group contains marine sediments and fauna. Siltstones and sandstones are predominantly red, and dolomitic limestones are sparingly

fossiliferous. Thick gypsum deposits suggest marine inundations and a semiarid climate. Recurrent marine inundations continued in the southwest part of the basin for a longer time than in the St. George's Bay area (Bell, 1948, p. 37), with the result that on the basis of lithologic differences, the contacts of the group with overlying strata have little time significance.

Although Searston beds, which Bell (1948, p. 20) described and identified on fossil evidence, are of late Mississippian age, they are included with the Pennsylvanian Barachois group. The main lithologic differences between the Searston beds and the Codroy strata are that in the Searston coalified drift stems are present and red beds are absent. The differences between the Searston beds and the overlying early Pennsylvanian Barachois strata, except for the presence of coal seams in Barachois beds, are minor. Except where located palaeontologically (Bell, 1948), the upper contact of the Codroy group is arbitrarily placed, being vaguely defined by colour changes in the sandstones, the presence of carbonized plant remains, and the absence of marine limestone beds. Subaerial conditions were in effect, in the St. George's Bay area, during the time the upper part of the Codroy was being deposited, and they continued during the deposition of the Barachois group, which consists mostly of micaceous sandstone and siltstone.

Differences have arisen in the mapping of Carboniferous strata in the Flat Bay-Sheep Brook-Coal Brook region, and in certain places along the flank of the Long Range scarp. Barnes (unpublished report) mapped the rocks in these areas as Codroy and Barachois, respectively, whereas Baird (1959) suggested that Anguille strata underlie these areas.

Barnes' mapping of the Carboniferous rocks is used in this report, although much of it is interpretative and based on relatively few field observations. Observations by Baird (personal communication) on Crabbes Brook and the Coal Brook-Sheep Brook area have been used to extrapolate the boundaries of his Anguille group in the intervening area. The interpretations of both Barnes and Baird will probably be modified by more detailed work.

Anguille Group

Distribution and Thickness

The Anguille group outcrops in the Anguille Mountains, on the upper part of Crabbes Brook west of the Long Range, and along parts of Robinsons River and Fischells Brook. Coarse, loose conglomerate, similar to upper Anguille conglomerate on Robinsons River and Fischells Brook, is exposed on the low hills about a mile southeast of the Flat Bay railway station. The thickness of Anguille strata, which make up most of the group (Bell, 1948, p. 6), as exposed along the coast southwest from Ship Cove, has been estimated to be at least 2,000 feet (Hayes and Johnson, 1938, p. 13).

Lithology

In the present map-area the group consists of fine-grained sandstone with beds of grey to black sandy shale, and an overlying conglomerate with interbedded lenses of grey or brown friable sandstone in beds from 3 inches to 2 feet thick. Cobbles in the conglomerate are well rounded and are commonly about 6 inches in diameter. The matrix is arkosic. The components of the cobbles on Fischells Brook are 55 per cent limestone, 25 per cent quartzite, and, 5 per cent each, chert, feldspar porphyry, and various granitic rocks. Limestone and quartzite in the cobbles are similar to the limestone of the St. George-Table Head groups and the quartzite of the March Point group. On Robinsons River, cobbles and pebbles are 35 per cent quartzite, 15 per cent limestone, 10 per cent quartz, 10 per cent quartz porphyry, 5 per cent feldspar porphyry, 5 per cent dioritic rocks, 5 per cent granitic rocks, and 15 per cent gabbroic rocks, gneiss, chert, and undivided igneous rocks. Rough shingling in the conglomerates exposed in Fischells Brook suggests that they were deposited by southerly-flowing streams (Bell, 1948, p. 6).

Structure

Outcrops of the group in the Anguille Mountains indicate that the group occupies a northerly-plunging anticline. Another anticline, which Barnes mapped as a doubly-plunging structure, is exposed north and south of Fischells Brook. This structure continues to the south to Barachois Brook, where it appears as a south-westerly-plunging anticline (Bell, 1948, p. 35). The Anguille group as exposed at Crabbes Brook is faulted against the Long Range and probably represents a dome structure. The bottom of the group is not exposed.

Flora

Fossilized plant debris, much of it unidentifiable, is common in the Anguille group, and indicates that the group is of Mississippian age. The group is probably equivalent to the Upper Horton of Nova Scotia (Bell, 1948, p. 5).

Codroy Group

Distribution and Thickness

Most exposures of the Codroy group are south of Flat Bay Brook and west of the Long Range. Good sections are exposed between Fischells Brook and Ship Cove, and short sections are exposed in fault blocks on Crabbes Brook. A few outcrops occur along the boulder-strewn streams of the coastal lowlands, along the coast at St. George's, on the southeast side of Indian Head Range, and at the mouth of Romaines Brook. A patch of conglomerate, possibly an outlier of the Codroy group, overlies the St. George-Table Head unit with angular unconformity on North Brook, about 1 mile upstream from Dons Brook. In the same region, red

soil along a branch road to Landowns Pond may also represent outliers of the Codroy group. Numerous exposures are on Port au Port Peninsula between Port au Port and Piccadilly, on Red Island, at Big Cove and Cape St. George, and between Lower Cove and Fiods Cove on the south shore.

The thickness of the group in the map-area is between 4,900 feet (Bell, 1948, p. 24; Hayes and Johnson, 1938, p. 12) and 8,800 feet (Baird, 1951, p. 160). Structural complications make measurements subject to considerable error.

Lithology

The Codroy group was laid down during three stages (Bell, 1948). Grey limestone, dolomitic siltstone, and thick gypsum zones with associated red mudstone and siltstone, make up the deposits of the first stage and are indicative of marine deposition. The Ship Cove limestone is thought to be the natural base of the group (Bell, 1948, p. 18). The sediments of the first stage are completely marine in the Codroy area to the southwest, but in the northeastern part of the basin the sediments of the later part of the first stage are alternatingly marine and nonmarine.

During the second stage, sediments deposited in the map-area were mainly nonmarine. These included green and red shales and siltstones, which are probably equivalent to the Woody Cove beds (Bell, 1948). They also include a few beds of grey limestone and grey sandstone of marine origin, which have been referred to as the Crabbes and Jeffreys limestones and interbedded sandstone (Bell, 1948; Baird, 1951). Bell interpreted the interbedded marine and nonmarine sediments as indicating emergence at the time of deposition, what is now the area around St. George's being in the subaerial part of the delta, and the area around Codroy being periodically flooded by the Windsor sea.

Strata deposited during the third stage are nonmarine and contain some fossil plant remains. They include crossbedded, locally ripple-marked sandstones and some siltstones, shales, and limestones. In the Ship Cove-Fischell region, Baird (1951) grouped the upper beds of the Codroy together as the Highland sandstone. This unit is apparently equivalent to the Woody Point beds (Baird, 1951) or Woody Head beds (Bell, 1948) in the Codroy region. As the Highland sandstone beds are lithologically similar to the overlying strata, some Upper Codroy strata may have been mapped and included with the Barachois group (Barnes, unpublished report).

The Searston beds are the youngest Mississippian beds in the Stephenville map-area. They consist of conglomerates, coarse gritty sandstones, and arenaceous shales that have a high mica content. These beds are included, for mapping purposes, with the Barachois group.

Carboniferous red arkoses, and cobble conglomerates that contain anorthosite and granitic boulders occur at Mount Howley. Reddish arkoses, conglomerates containing boulders of anorthosite, and siltstone are exposed on the south-flowing tributary of Fischells Brook near the Long Range.

Red siltstone, sandstone, and pebble conglomerate that outcrop on Coal Brook and Sheep Brook were interpreted by Barnes as part of the Codroy group because of lithologic similarities peculiar only to the Codroy, as well as for the following reasons:

1. The rocks of the Anguille group are typically grey, whereas the Codroy strata are characteristically red and contain gypsum. The strata in question are predominantly red.

2. The beds in question include conglomeratic material similar to that of the Codroy group on Flat Bay Brook.

3. The conglomerate below the gypsum on Coal Brook is poorly sorted and is composed of pebbles and cobbles in an abundant red arenaceous matrix, whereas Anguille conglomerates below the gypsum on Robinsons River and Fischells Brook and on the low hills southeast of the Flat Bay railway station contain cobbles and boulders in a much less abundant grey matrix. Gypsum beds on Coal Brook and Sheep Brook are believed to be higher in the Codroy section than the gypsum beds overlying the Ship Cove limestone at the base of the Codroy.

4. Cobble and boulder material of the Anguille conglomerate on Robinsons River and Fischells Brook are mainly of limestone, dolomite, and quartzite, which were probably derived from lower Palæozoic strata to the north, whereas the coarse material exposed on Coal Brook and Sheep Brook consists principally of igneous rocks.

On Port au Port Peninsula the Codroy group consists of red, green, and grey shales, micaceous sandstones, grey limestone, and limestone conglomerate. These strata were probably deposited during the second stage and are apparently indicative of an invasion of the Windsor sea.

Beds at Red Island and at Cape St. George are unfossiliferous and differ from other Codroy strata (Sullivan, 1940). They comprise red and green conglomerate, and medium-grained, crossbedded sandstone. Cobbles of porphyry that contains pink feldspar phenocrysts are characteristic of the conglomerates. These sandstones and conglomerates have been included in the Codroy group until more is known of them.

Structure

The Codroy group is overlain and underlain conformably by other Carboniferous strata. The group is faulted against rocks of the Long Range on Sheep Brook but lies unconformably on the Long Range rock at Mount Howley. The lower contact of the group is placed at the base of the Ship Cove limestone. The upper contact, however, is gradational, and is arbitrarily located on the basis of lithology, except where defined palaeontologically.

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Codroy strata are incompetent and are more deformed than the underlying strata of the Anguille group. Nevertheless they conform to the anticlinal structure of the Anguille group in the Anguille Mountains and north of Robinsons River, and are gently folded at the mouth of Highlands River in the northwesterly-striking Highland syncline. The strata lie in a basin that is occupied at present, on Barachois Brook and Robinsons River, by the coal-bearing Barachois group. Small anticlines and synclines complicate the structural pattern.

On Port au Port Peninsula, Codroy beds lie relatively flatly upon truncated, early Palæozoic rocks. Codroy rocks of the first stage of deposition are presumably missing on the peninsula. "Accordingly, the Codroy deposits as a whole in the Port au Port area are considered to be outlying remnants of different members of the Codroy series that overlapped upon Ordovician limestone, which throughout most of Codroy time lay above the sea and formed the northwest borders of the Codroy subsiding basin of deposition." (Bell, 1948, p. 34).

Fauna

Sullivan (1940) collected the following fauna from limestones exposed in the coves immediately east of Port au Port village and from limestone lenses in Big Cove on the west side of Port au Port Peninsula:

Arthropods
- *Paraparchites* sp.

Cephalopods
- *Orthoceras* sp.

Gastropods
- *Naticopsis* sp.

Pelecypods
- *Aviculopecten lyelli* Dawson
- *Parallelidon dawsoni* Beede

Brachiopods
- *Camarotoechia acadiensis* (Davidson)
- *Composita dawsoni* (Hall and Clarke)
- *Martinia galataea* Bell
- *Pugnax dawsonianus* (Davidson)
- *Schuchertella* sp.

Vermes
- *Conularia planicostata* Dawson

The Codroy group has been correlated, on the basis of fossil evidence, with the Windsor group of Nova Scotia. However, the upper beds of the Codroy group contain plant fossils younger than those in the upper strata of the Windsor group and thus may be equivalent to a lower part of the Canso group of Nova Scotia (Bell, 1948).

Barachois Group

(including Searston beds of Late Mississippian age)

Distribution

Strata similar to the coal-bearing formations (Hayes and Johnson, 1938) on Robinsons River and Barachois Brook, and beds similar to the Searston beds on Crabbes Brook (Bell, 1948), were recognized by Barnes on Codroy Brook at the south boundary of the Stephenville map-area, and on Fischells Brook. Other outcrops of this group are on a parallel tributary of Crabbes Brook, between Crabbes and Barachois Brooks, and on a tributary to Fischells Brook. Coal- and plant-bearing sediments outcrop on Blanche Brook in the heavily drift-covered area around Stephenville, on the upper part of Blanche Brook, and on the brook 1½ miles northwest of Long Gull Pond.

Lithology

The Barachois group (including the Searston beds) consists of predominantly grey, micaceous, coarse-grained sandstone, siltstone, and beds of conglomerate, as well as nonmarine, micaceous, silty limestone, coal beds, and silty shale. Carboniferous strata on the upper part of Blanche Brook comprise flat-lying limestone conglomerate derived from underlying beds of the St. George-Table Head unit.

Structure

Rocks of the group on Barachois Brook and Robinsons River outcrop in a basin structure known as the St. Georges syncline (Bell, 1948). Secondary folds are common, as are northeasterly-trending faults. Strata on Codroy Brook are probably the northerly extension of the southeasterly-dipping, coal-bearing strata near South Branch (just south of the map-area) that are in fault contact with the Long Range (Hayes and Johnson, 1938). Around Stephenville, beds are relatively flat-lying and may represent an overlap, lying as they do upon early Palæozoic rocks.

Flora

Searston beds contain *Diplotmena adiantoides,* indicating a late Mississippian age and a correlation in part with the Canso group of Nova Scotia (Bell, 1948, p. 38). The younger coal-bearing strata of the Barachois group carry *Sphenoptris hoeninghousi,* which indicates an early Pennsylvanian age for that group. Spores taken from coal horizons on Blanche Brook in the Stephenville region indicate a correlation with Middle Pictou strata of Nova Scotia (Hacquebard, P.A., personal communication).

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Igneous and Metamorphic Rocks

Precambrian Rocks

Indian Head Range Intrusive Complex

Distribution

The Indian Head Range extends north-northeast from Indian Head on St. George's Bay for about 17 miles. The Range is divisible into three generalized units: (1) a southern unit, south of Long Gull Pond, containing most of the basic rocks of the complex; (2) a middle unit, between Long Gull Pond and Cambrian strata that lie 3 miles farther north, consisting of silicic gneiss and minor basic phases; and (3) a northern unit, extending to within 2 miles of North Brook and consisting of silicic gneisses.

Lithology

The southern and middle units were mapped and fully described by Heyl and Ronan (1954). Basic rocks, except for peridotite and diabase dykes, are the oldest rocks of the complex. They include the following types:

1. Hypersthene diorite and norite gneiss with biotite inclusions. This unit has layers of dark norite alternating with light-coloured diorite. Large inclusions of biotite schist exhibit bedding planes and probably represent altered thin-bedded siltstone and impure quartzite.
2. Hornblende-plagioclase gneiss occurring as dykes and small stocks.
3. Granoblastic norite gneiss. This rock has been injected and replaced by anorthosite, soda granite-gneiss, pegmatite and basic dykes.
4. Hypersthene pyroxenite. This rock is intruded into norite gneiss.
5. Anorthosite occurring as a gently-plunging, stock-like body.
6. Dykes of aphanitic doleritic basalt, lamprophyre and peridotite.

A small amount of pink soda granite-gneiss outcrops in the southern unit, where it is associated with the basic rocks. It is composed mainly of oligoclase and quartz, is the oldest of the silicic rocks in the complex, and differs from the younger silicic phases by the absence of microcline.

The younger, silicic gneisses are in the northern parts of the range. They comprise microcline-biotite granite gneiss, hornblende-microperthite gneiss, hornblende-microcline-plagioclase augen granite gneiss, and granite pegmatites.

Structure

The southern part of the Indian Head Range intrusive complex is interpreted as an elongated dome, with an anorthositic core, and a long axis plunging 15 to

30 degrees to the northeast. Northerly-trending oblique slip faults cut the complex south of Long Gull Pond. The drift-filled valley occupied by the pond is probably the location of a major northerly-dipping thrust plane, whose presence is suggested by several easterly-trending, northerly-dipping thrust faults exposed on the north shore of the pond.

Age

Rocks of the Indian Head Range are considered to be Precambrian[1], for the following reasons (Barnes, unpublished report):

1. Early Palæozoic sediments around the range are generally not metamorphosed, whereas similar sediments are contact-metamorphosed around known post-Cambrian intrusions.

2. Unmetamorphosed Humber Arm sediments lie unconformably on Indian Head Range crystalline rocks and enclose fragments of these rocks in their lower members.

3. Accessory minerals in the rocks of the complex occur as detrital minerals in March Point sandstone and in arkose presumably belonging to the March Point group.

The low-grade metamorphic rocks scattered through the middle part of the range may have been metamorphosed by small post-Cambrian intrusions, such as those known to occur less than 9 miles away to the east in the Long Range.

Pre-Carboniferous Rocks

Bay of Islands Igneous Complex (Southern Part)

Much work has been done on the ultrabasic rocks in the Bay of Islands area (Cooper, 1936; Smith, 1958; Barnes, unpublished report). The following is a summary of the more detailed published and unpublished observations of these three geologists.

Distribution

The ultrabasic rocks of the Lewis Hills and Blow Me Down Mountain form the southern half of the Bay of Islands igneous complex. This complex forms a belt about 10 miles wide parallel to the coast from Bluff Head, on Port au Port Bay, northward (beyond the map-area) to Bonne Bay, a distance of about 60 miles.

Lithology

The intrusions are composed of thick, banded ultrabasic zones that include (1) dunite, peridotite, and minor enstatite pyroxenite, (2) a narrow transition zone,

[1] *See also* footnote, p. 8, re the potassium-argon age of 830 m.y. for granite gneiss from this range. [Ed.]

and (3) an overlying zone of banded and massive gabbros. The ultrabasic rocks contain olivine (forsterite), enstatite, accessory chrome spinel and serpentine, and, locally, small chromitite bands. Gabbros are composed essentially of bytownite, feldspar, and augite. Olivine is present in the lower members. Where altered to hornblende gabbro, they are difficult to distinguish from metavolcanic rocks of the Humber Arm group.

In the interbanded zone between the ultrabasic and gabbroic rocks, feldspars appear in the ultrabasic zone and give rise to such rock types as well-banded, feldspathic dunite, picrite, and troctolite. Thin-banded structures are due to variations in the relative abundance of olivine, pyroxene, and feldspar.

Basic dykes, such as porphyritic diabase in the Mine Cove area and hornblende gabbro in the Rope Cove Canyon area, cut the ultrabasic and gabbroic rocks.

Structure

The shape of the intrusions can no longer be described by such simple terms as 'laccolith' or 'lopolith', as has been done in the past (Ingerson, 1935; Cooper, 1936). The eastern contacts of the ultrabasic rocks are conformable along strike with Humber Arm rocks. The western contacts, however, where not marked by faults, are irregular and less easily defined. Smith (1958) concluded that the ultrabasic intrusions are wedge-shaped in section, with a generally conformable floor and an irregular-shaped roof.

Northwesterly-trending tear faults cut the ultrabasic rocks and in many places, noticeably in Blow Me Down Mountain, bound them. Serpentine Valley probably represents a wide fault zone that has split a once-continuous ultrabasic body into two separate units.

Age

Rocks of the Bay of Islands igneous complex cut Humber Arm strata of Middle Ordovician age. No other direct evidence of age is available. However, the ubiquitous association of ultrabasic rocks with basic volcanic rocks suggests that they have a common origin and are thus of similar age—in this instance, of Ordovician age.

Long Range Igneous and Metamorphic Complex

Distribution

The Long Range igneous and metamorphic complex comprises rocks that underlie the southeastern and eastern part of Stephenville map-area. The area around Grand Lake consists predominantly of gneisses and a few granitic rocks. Anorthosite occurs west of the Long Range fault between Fischells Brook and Bottom Brook. A mass of tonalitic rock and associated granitic and basic rocks

is outlined between the headwaters of Fischells Brook and Long Pond. Granite and granodiorite are common near Rocky Pond. A lenticular unit comprising granite, adamellite, and granodiorite extends in a northeasterly direction for about 12 miles from the south-central margin of the map-area. The remainder of the Long Range is underlain by gneisses and scattered granitic and basic rocks.

Lithology[1]

The complex comprises granitic rocks, ranging in composition from alaskite to quartz gabbro, diorite, gabbro, anorthosite, minor dykes of pyroxenite and peridotite, and acidic, intermediate, and basic gneisses. Scattered outcrops of greenstone, diabase, lamprophyre, and perhaps rhyolite and basalt are also found.

Granitic Rocks

Tonalite. The dominant granitic rock type is tonalite, which forms an irregular-shaped body around Wolf Brook and a few outcrops elsewhere in the Long Range complex. The Wolf Brook mass comprises fine- to coarse-grained, equigranular to porphyritic aggregates of quartz, feldspar, and ferromagnesian minerals. Potash feldspar is commonly missing and is always less than 5 per cent of the rock. Textures are mostly allotriomorphic granular. Most of the tonalite is massive, but a faint foliation that is imparted by minute layers of muscovite has been observed locally, and at its southwest margin massive tonalite grades into a gneissic rock of the same composition.

Thin sections of 22 specimens of the Wolf Brook mass were examined. Quartz ranges from 20 to 48 per cent and is commonly 40 per cent. Many grains exhibit strain shadows and fractures; a few are recrystallized. Potash feldspar, where present, is invariably microcline. Plagioclase ranges from 35 to 65 per cent of the rock. Its anorthite content is apparently bimodal at 30 and 40 and ranges from 22 to 58. Green amphibole forms up to 10 per cent, and biotite, mostly olive brown or green, also forms up to 10 per cent of the rock. Steel-grey, fine-grained magnetite and ilmenite and minor amounts of pyrite are generally present, but are less than 1 per cent. Accessory minerals include apatite, sphene, zircon, and, in one sample, garnet. The tonalite is not extensively altered, but most of the thin sections contain epidote, saussurite, sericite, and zoisite. Amphibole and biotite are unaltered in some samples and partly or completely changed to chlorite in others. In a few samples chlorite and epidote make up 10 per cent of the rock. Although the composition of the Wolf Brook tonalite is variable, field observations indicate a mineralogical and apparent chemical sequence. Gradational relationships are locally present, as at the headwaters of Fischells Brook, and a sequence—quartz gabbro (An_{58})→ tonalite (An_{38})→

[1] The petrographic terms used in this section are as defined by Johannsen (1939).

quartz tonalite (An_{38}, quartz 50 per cent)—is established. In other outcrops tonalite grades into quartz tonalite, which passes into granodiorite.

Contact relationships between the Wolf Brook tonalite and other rocks of the Long Range complex are either missing or obscure.

Adamellite. The next most common granitic rocks are adamellites. They occur in widely scattered outcrops, or masses, in other granitic bodies and probably comprise the middle part of the northeasterly-trending, lenticular-shaped granitic unit in the southern part of the area. They also probably form most of the unit at the head of Robinsons River. These rocks are commonly medium-grained, equigranular, and flesh- to pink-coloured, and consist of quartz, flesh-coloured feldspar, and ferromagnesian minerals. Coarse- and fine-grained varieties are present. The rock is massive and the texture is allotriomorphic granular.

Quartz ranges from 20 to 35 per cent in the adamellites, and is commonly strained. Microcline ranges from 5 to 35 per cent and (replacement) microcline perthite forms up to 40 per cent of the rock in samples that are low in primary microcline. Plagioclase (An_{20-35}) forms from 20 to 40 per cent of the rock. Green amphibole ranges from 0 to 10 per cent but commonly comprises less than 3 per cent of the rock. Olive-brown biotite commonly makes up 5 per cent. Accessory minerals include sphene, apatite, and iron oxides. Both amphibole and biotite are partly altered to chlorite in many samples. Plagioclase has commonly altered to epidote, sericite, and saussurite, but in many specimens the feldspars are relatively fresh. Albite rims more calcic plagioclase in some samples, and also has locally replaced microcline, producing microcline perthite.

As commonly happens with most of the granitic rocks, contact relationships, other than with the gneisses, are obscure or are not found.

Granodiorite. Granodiorite is about as abundant as adamellite. It is commonly associated with tonalite and probably forms the northern part of the lenticular-shaped granitic unit in the southern part of the area and the circular mass immediately to the north. It is fine- to coarse-grained, equigranular to porphyritic, and is predominantly pale grey.

Quartz ranges from 15 to 50 per cent but commonly makes up 35 per cent of the granodiorite. Microcline and minor microcline perthite form up to 10 per cent. Plagioclase (An_{18-42} but mostly An_{20-25}) forms up to 50 per cent of the rock. Some grains are zoned. Green amphibole and biotite form up to 10 per cent of the rock, and a little clinopyroxene is present in some thin sections. Much of the granodiorite is slightly altered, but in a few outcrops it is greatly altered. Sericite, epidote, chlorite, muscovite, and iron oxide are the common alteration minerals.

Granite. Granite forms the southern part of the lenticular-shaped granitic unit in the southerly part of the area, much of the area around Rocky Pond, and

possibly some of the region north of the upper reaches of Crabbes Brook. It also occurs in numerous single outcrops in other parts of the Long Range. An interesting exposure occurs within the folded gneisses north of Cross Pond, where the relationships indicate that the granite was emplaced along the axis of a fold during the later stages of folding.

The 'granites' include kalialaskite, alaskite, kaligranite, leucogranite, and granite (as defined by Johannsen, 1939). These rocks are predominantly medium-grained and equigranular, but range from fine- to coarse-grained to slightly porphyritic. Most are pinkish, but a few are grey; all are massive.

Quartz, only slightly strained, makes up 15 to 45 per cent of the rock and commonly forms 35 per cent. Potash feldspar, up to 75 per cent of the rock (kalialaskite), consists of both microcline (about 40 per cent) and microcline perthite (in part vein, in part embayments). Plagioclase (An_{5-28} but chiefly An_{12-15}) constitutes between 2 and 20 per cent of the granites. Biotite is present in minor amounts. Alteration products include chlorite, sericite, epidote, and muscovite. Allanite was observed in a few thin sections.

Basic Rocks

Diorite. Minor amounts of diorite outcrop south of Rocky Pond, near the upper reaches of Fischells Brook, and with gabbroic rocks north of Crabbes Brook. Most of it is fine- to medium-grained and is composed of plagioclase (An_{38}) and altered amphibole. Unlike the granites, most of the diorite contains a relatively large amount of iron oxide—up to 3 per cent.

Gabbroic rocks. Two fairly large bodies of gabbroic rocks outcrop in the Long Range complex, one 8 miles northwest of Rocky Pond, the other on Crabbes Brook. The former consists of fine- to medium-grained, equigranular, greyish gabbro, composed mostly of plagioclase and altered pyroxene. Specimens from near the middle of its northern margin contain minor amounts of altered olivine, clinopyroxene in part altered to amphibole and chlorite, and plagioclase. Specimens from the outer edges of this gabbroic body, however, contain up to 70 per cent plagioclase (An_{55-70}), plus clinopyroxene, amphibole, and iron oxides, but no olivine. The Crabbes River gabbros have a highly variable mineral composition and include hypersthene-gabbro, amphibole-gabbro, and quartz-gabbro phases; around their margins and between them occur diorite, tonalite, granodiorite, monzonite, syenite, and hybrid-rock phases. These gabbroic rocks contain from 40 to 75 per cent plagioclase (An_{45-70}) and, in a few specimens, up to 25 per cent quartz. Plagioclase (An_{55}) forms about 65 per cent of the quartz-rich specimens, and hypersthene about 6 per cent.

Anorthositic rocks. Anorthositic rocks underlie much of the area west of Dennis Pond. The rocks vary from fine- to coarse-grained, from equigranular to coarsely porphyritic, from black to grey, to brown, to red, to white, and from true

anorthosite to a gabbroic variety. Plagioclase (An_{48-75}) commonly forms 95 per cent of the rock, but may constitute as much as 100 per cent. Pyroxene, amphibole, and biotite are generally present, and in gabbroic phases make up more than 40 per cent of the anorthositic rocks. The anorthositic rocks contain inclusions of amphibolite, hybrid gneisses, and greenstone, and are cut by basic dykes, diabase, and pegmatitic dykes. Gneissic inclusions are finer-grained, lighter-coloured, and more vein-like in appearance, and generally differ lithologically from most of the gneissic rocks elsewhere in the Long Range igneous and metamorphic complex. Numerous gneissic phases, many chloritic, are present along the eastern margins of the anorthosites, noticeably near Dennis Pond and on Flat Bay Brook. Titaniferous magnetite forms pockets, lenses, and masses throughout the anorthosites. The anorthosite and magnetite occurrences in the Sheep Brook-Lookout Brook area have been described elsewhere (Baird, 1954).

Other basic rocks. Two small exposures of ultrabasic rocks have been observed in the Long Range igneous and metamorphic complex. The first, a pyroxenite, occurs as an inclusion (?), with obscure contact relations, in granite a mile west of Rocky Pond. The second exposure, only 20 feet long and 10 feet wide, consists of greenstone and an unaltered enstatite peridotite in a gneissic terrane. It lies 2 miles south of the headwaters of Fischells Brook. Again, contact relations are obscure.

Gneissic rocks. The remainder of the Long Range igneous and metamorphic complex is underlain predominantly by gneisses of diverse types and origins. Although they exhibit numerous textural differences, most of these gneisses are tonalitic in composition. Texturally they include banded gneiss, venites[1], probably some arterites[1], and numerous migmatites[1] and agmatites[1]. Similar textural variations are found in the less abundant gneisses of granitic and granodioritic composition. Banded gneisses of basic composition are also scattered through the area.

Because of the reconnaissance type of mapping, the areal distribution of the gneisses is not well defined, but those of tonalitic composition are close to the areas underlain by relatively massive tonalite and the gabbro on Crabbes Brook. The banded gneiss consists of alternating layers of felsic and mafic minerals as well as a few layers of amphibolite. Textures of this variety of gneiss are planar, mostly owing to differences in composition between adjacent layers.

Structure and Field Relationships

Fold axes in the Long Range igneous and metamorphic complex commonly trend to the southwest or northwest, and plunge westerly, southeasterly, and northeasterly. Here and there northeasterly-plunging lineations are observed in

[1] As defined by Barth, 1952.

the igneous rocks. Folds in many areas are cut by intrusive rocks, but some contacts are concordant. Fractures form northeasterly- and northwesterly-trending patterns.

Field relations between the various rock types that comprise the complex are not clear. Anorthosites are separated from the gneisses and granitic rocks by the northeasterly-striking Long Range fault, and are overlain nonconformably by Carboniferous strata. Gabbroic rocks are present in the anorthosite as gradational phases and intrusive tongues. Granitic rocks in the Grand Lake region cut, as well as pass gradationally into, stratified gneisses, which in turn grade into schists that bear marked resemblance to lower Palæozoic sediments found elsewhere in the map-area. Between Grand Lake and Bottom Brook, granitic rocks cut Cambrian strata and probably produced the metamorphism of the Humber Arm sediments near Georges Lake. Granitic and gabbroic rocks in the Long Range igneous and metamorphic complex are cut by dykes of syenite and diorite. Gabbro is cut by granodiorite, and syenite is intruded by thin vertical masses of quartz feldspar porphyry. Gneissic rocks are cut by the granitic, gabbroic, and dioritic rocks, but also exhibit gradational contacts with these rocks.

Metamorphism

The gneissic rocks are characterized by the presence of epidote, chlorite, biotite, and amphibole. Plagioclase is commonly An_{28} but ranges from An_{20} to An_{40}. Thus the grade of metamorphism is just greater than that of the epidote amphibolite facies (Turner, 1948; Ramberg, 1952) and is probably equivalent to the lowest grade of the almandine amphibolite facies (Fyfe, Turner, and Verhoogen, 1958). The presence of chlorite, which is evidently unrelated to the SiO_2 content of the rock, probably indicates some retrograde metamorphism.

Age

The age of the Long Range igneous and metamorphic complex is still uncertain, but it is certainly pre-Carboniferous and probably post-Ordovician. However, the lower age limit of the anorthositic rocks is not known. It is also conceivable that some of the granitic rocks are older than Ordovician, especially if some of these units have been reworked.

Chapter III

STRUCTURAL GEOLOGY

The most prominent structural feature in Stephenville map-area is the general northeasterly structural trend of the rocks. This is accompanied, however, by some northwesterly structural trends that are locally contorted and modified and may reflect older patterns of deformation.

At least two periods of folding have deformed the sedimentary rocks in the map-area. Evidence for these two ages is seen on Port an Port Peninsula, where Codroy beds rest with angular unconformity on Ordovician strata. The intensity of post-Carboniferous folding was not great on Port au Port Peninsula, but it was pronounced between (what is now) St. Georges and the Anguille Mountains, where two major fold structures are present.

Trend lines that strike westerly, southwesterly, and southeasterly are common in the gneissic terrane of the Long Range. These reflect southwesterly and southeasterly-plunging fold structures as well as northeasterly-plunging culminations. The westerly trends reflect either an older period of folding or flexures in the fold belt.

The Bay of Islands igneous complex (southern part) conforms structurally with the general northeasterly trend of the adjacent areas, but northwesterly-trending structures are present in the Lewis Hills and Serpentine Valley.

A further expression of the forces that caused the deformation are numerous northeasterly-striking longitudinal faults, such as the Long Range fault, and northwesterly-striking transverse faults.

The use of plunge in the graphical construction of folds, according to the technique of Stockwell (1950), has provided a clearer, more comprehensive picture of the structures in the map-area. This method was particularly useful for interpreting structures in the Long Range metamorphic rocks, but has also been employed for interpreting structures in the less metamorphosed Palæozoic sedimentary rocks.

Folds

Many early Palæozoic strata outcrop in broad, northerly-striking and plunging anticlines and synclines. In the more competent rocks this type of fold structure is present, whereas the less competent shaly sediments are highly deformed and commonly asymmetrical. However, the shaly beds that make up the lower 200 feet of the Table Head group, in which they overlie the more massive carbonate rocks of the St. George group, are the exception, for they

reacted to deformation in the same way as the carbonate rocks. The shales above this lithologic unit were incompetent and are now highly deformed.

The folding of the Palæozoic strata is not as intense on Port au Port Peninsula as east of it, but some asymmetrical folds are present, such as the anticlinal flexure at Cape Cormorant, which is overturned to the northwest.

Folds in Humber Arm Rocks

The folds in the Humber Arm strata vary in intensity according to the type of rock and its geographic position. Humber Arm strata are less deformed on the west side of the Bay of Islands ultrabasic complex than on the east side, presumably because of the protective shadow of the ultrabasic rocks. The anticlinal structure that exposes St. George-Table Head limestones south of Serpentine Lake probably developed as a result of late movement along the northwesterly-striking transverse fault in Serpentine Valley. Slight compression could have bowed the strata between the Lewis Hills and Blow Me Down Mountain.

Folds in the Lower Palæozoic Rocks near the Long Range

Folds with easterly and southeasterly plunges are present in areas adjacent to the Long Range that are underlain by Cambrian and Lower and Middle Ordovician rocks. They commonly are only gently deformed in comparison with the more tightly deformed, northeasterly-plunging folds. However, the easterly- and southeasterly-plunging folds become more tightly deformed towards the Long Range, and recumbent folds occur within the Long Range complex.

Folds in the Carboniferous Rocks

Carboniferous strata in the Anguille Mountains outcrop in a northeasterly-plunging anticline whose western limb is overturned to the northwest. Anguille strata are also exposed, farther to the north, on Robinsons River and Fischells Brook in a broad, doubly-plunging anticline. Codroy strata commonly outcrop in northeasterly-plunging anticlines and synclines that apparently conform to the regional structure. Between the Long Range and the Anguille Mountains Codroy formations are exposed in broad synclinal structures, but between the Anguille Mountains and the coast the strata are tightly folded. The difference in intensity of folding is probably related to the degree of incompetency of the Codroy group and to the overturning of the Anguille anticline. At Highlands a pronounced change in strike is apparent, expressed in a moderately plunging, northwesterly-striking, probably symmetrical syncline.

The Barachois group occupies the basin structure known as the St. Georges syncline. This structure is complicated by numerous northeasterly-striking and plunging, closely spaced anticlines and synclines. Fold axes that plunge and strike in a westerly direction are scattered through this area.

Folds in the Long Range

Fold patterns in the Long Range igneous and metamorphic complex have not been completely studied, but a few observations can be made at present. Near Grand Lake, tight isoclinal folds and broad folds with overturned beds plunge to the south or in an easterly direction. Northeasterly plunges with southwesterly culminations are also present. It is possible to show, by Stockwell's method of fold construction (Stockwell, 1950), that some structures in this region are overturned, and that they plunge moderately to the east with axial planes striking N 40° E, and dipping about 40 degrees to the southeast.

The fold at Cross Pond appears from surface exposure to plunge in a southeasterly direction, but a southerly flexure is present. Near Portage Lake easterly, westerly, and southwesterly plunges are visible. Southwesterly, northerly, and northwesterly-directed plunges occur near the Long Range front just south of the anorthosites. In the southern part of the map-area, southwesterly and northwesterly plunges are also common.

Summary

Dating of the periods of Palæozoic deformation within the map-area cannot yet be done with reliability. Two ages of folding are known, the older of which deformed Middle Ordovician strata and the younger affected Carboniferous strata. Both periods of folding are therefore post-Middle Ordovician and presumably pre-Triassic. The intensity of deformation during these two periods of folding evidently varied from place to place within the map-area.

Faults

There are numerous faults in the map-area, but few of them provide information concerning direction and type of movement. Most of them are classified as either longitudinal or transverse faults, with strikes in a northeasterly or northwesterly direction respectively. A few northerly and easterly striking faults are also present. Strike-slip, oblique-slip, and dip-slip movements have been recognized in the longitudinal and transverse faults. Low-angle thrust faults and high-angle reverse faults occur in a few localities.

Faults on Port au Port Peninsula

Northeasterly-striking, steeply dipping, normal faults, downthrown on their eastern sides, form prominent topographic linears between Piccadilly Bay and the south side of the peninsula. Stratigraphic displacement on these faults is between 1,000 and 2,000 feet (Sullivan, 1940).

A straight-line fault scarp, probably indicating a high-angle fault plane, extends in a northeasterly direction from Three Rocks Cove toward West Bay.

Near the cove, rocks of the St. George-Table Head group are apparently thrust against rocks of the Long Point group. The fault surface is not visible, but its presence is indicated by a mixed breccia of carbonate rocks in both units and the overturned attitude of the Long Point beds.

Two east-northeasterly-striking faults separate Green Point strata from younger rocks on the west side of Port au Port Bay. Neither of the faults is exposed, but their presence is indicated by lithological and palæontological differences in the strata adjoining them. The southern fault is apparently an eastward continuation of the thrust fault at Three Rocks Cove; the north fault is probably vertical.

A northeasterly-striking, nearly vertical fault cuts rocks of the Humber Arm group at Rocky Point on West Bay. It had an apparent strike-slip movement of about 2,000 feet, with the southeast side moving to the southwest. A northeasterly-striking fault visible in a brook half a mile north of Clam Bank Cove has brought Devonian Clam Bank strata against Long Point beds. Numerous northerly-striking normal faults, with displacement of from 100 to 200 feet, cut the north and south shore of Port au Port Peninsula, where they have influenced the formation of such coves as Lead Cove and Belman's Cove.

Faults North of Stephenville

Romaines Brook Faults

A north-northeasterly striking linear near Romaines Brook that parallels the axis of the Table Mountain anticline probably represents a major fault, because the eastern limb of the anticline is missing. An easterly-striking fault extending from Two Guts Pond has brought a triangular block of Cambrian strata into contact with the surrounding Ordovician rocks. The relative movement on this fault is north side up.

A northeasterly-striking fault probably occurs (Barnes, unpublished report) on the western side of the St. George-Table Head unit, on the east side of Romaines Brook, because of the absence of Cambrian quartzite between easterly-dipping Ordovician carbonate rocks and shales that are assumed to belong to the Humber Arm group. Slight anticlinal folding could also explain the elimination of surface exposures of the Cambrian strata.

Blanche Brook Fault

A high scarp underlain by strata of the undivided St. George-Table Head groups along Blanche Brook marks the location of a north to northeasterly-striking fault. A breccia zone visible on a tributary of Romaines Brook probably lies along the same fault.

Fox Island River Fault

An east-southeasterly-striking fault has been proposed (Barnes, unpublished report) to explain the otherwise anomalous relation between Humber Arm shales and strata of the undifferentiated St. George-Table Head groups about 10 miles northeast of the mouth of Fox Island River. Walthier (1949) shows a fault in about the same area.

West North Brook Fault

A fault separates argillites of the Humber Arm group from carbonate rocks of the St. George-Table Head unit on the upper reaches of West North Brook (Barnes, unpublished report). The lithology of the limestone near the fault is similar to that of certain limestones forming part of the St. George group. The fault probably does not extend any distance, because no evidence of its continuation north or south has been found and because the contact between the rock types to the northeast is conformable.

Island Pond Faults

Barnes has suggested a fault pattern comprising northeasterly- and northwesterly-striking faults near Island Pond, where strata of the Humber Arm group are faulted against rocks of the St. George-Table Head unit. Barnes regarded the fault planes at these contacts as nearly vertical and postulated that the faults had a relatively small dip-slip movement. In contrast, Walthier (1949, p. 32) considered the contact to mark a substantial thrust plane, modified by later normal faulting.

Serpentine River Valley Faults

A northwesterly-striking fault zone north of Serpentine Lake separates Humber Arm shales from ultrabasic rocks of the Bay of Islands igneous complex. Both shales and ultrabasic rocks are contorted and relatively deformed along the fault zone. The direction of movement along this zone is not clear, but Smith (1958) has shown that the north side of the fault moved west relative to the south side.

As contacts are sheared and adjacent sediments are not metamorphosed, the northern end of the Lewis Hills is assumed to be bordered by faults.

Faults South and East of Stephenville

Crabbes Brook Fault

Rocks of the Barachois group are down-faulted against a gypsum zone of the Codroy group on Crabbes Brook (Bell, 1948). The amount of displacement is not known.

Long Range Fault

The Long Range fault extends from the southwestern boundary across Stephenville map-area in a northeasterly direction for about 52 miles. It is part of a major zone of movement extending in a relatively straight line from the south coast to the north end of Grand Lake (northeast of the map-area) and probably beyond that to White Bay on the north coast of Newfoundland. In Stephenville map-area the fault zone has been observed on Flat Bay Brook, about 4 miles east of the power-house. Elsewhere its position is defined by a remarkably straight linear along scarps and steep-walled valleys, by chloritic schist outcrops, and by strongly chloritized zones in the granitic rocks, gneisses, and anorthosites. The fault zone is about 600 feet wide on Flat Bay Brook and is intensely shattered and drawn out, imparting a gneissic appearance. Bands of chlorite, chlorite schist, and augen gneiss are common. The foliation of schlieren and drawn-out bands strikes N 15° E and dips vertically. Possibly lineation on fault striae is S 15° W at 15 degrees. On the west side of the fault zone, the foliation strikes N 60° E and is vertical. The presence of numerous bands of chlorite and schlieren indicates a zone of multiple movement. The last recorded movement had an oblique slip component, probably on a steeply dipping fault plane.

Sheep Brook Faults

A northerly-trending, easterly-dipping, relatively high angle, reverse fault has brought anorthosite into contact with contorted Carboniferous sediments 7 miles above the mouth of Sheep Brook. The actual fault zone is highly deformed and is exposed for only a short distance, and its direction and the extent of movement along it are not known. This fault probably extends to the southwest as far as Journois Brook, and to the north into a drift-covered area.

Numerous high-angle normal and reverse faults apparently associated with the thrust fault are exposed near the head of Sheep Brook.

Other Possible Faults

Numerous straight-line scarps and linears are visible both on the ground and on aerial photographs of the map-area. One of these, a northeasterly-striking straight scarp marking the western edge of the southern part of the Indian Head Range complex, is parallel to known faults in the intrusive rocks (Heyl and Ronan, 1954).

Another scarp occurs at the anorthosite-drift contact south of Little Barachois Brook. It has a northeasterly strike, roughly parallel to the strike of the Long Range fault.

Problems of faulting in the Lewis Hills were discussed by Smith (1958). In 1952 Barnes examined many exposures along the Lewis Hills thrust fault (as named by Cooper, 1936) on the western side of the Lewis Hills and con-

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cluded that this fault did not exist as such. The rocks are much deformed, but have not evidently been greatly displaced (Smith, 1958). Much of the fault evidence can probably be explained by movement between competent and incompetent rocks. The Lewis Hills and Blow Me Down Mountain have probably moved relative to each other many times along the transverse faults in Serpentine Valley. If the ultrabasic rocks were originally part of a single intrusive body (Cooper, 1936), their present separation is best explained by the proposal of rotation and tilting (Smith, 1958).

Bedding

The reliability of bedding determinations varies with the rock type on which the observations were made. Massive dolomite, limestones, and quartzites give reliable indications of major structures, but thin shales and shaly limestones are locally too deformed to serve as a basis for reliable bedding determination. Few top determinations could be made on early Palæozoic shales, and some of these rocks are probably overturned. However, tops are assumed to be up in the broad open folds of the competent March Point quartzites and St. George-Table Head carbonate rocks.

Crossbedding and ripple-marks are rare in the early Palæozoic strata, but are common in the Carboniferous rocks.

Joints

Joint sets and patterns are developed throughout Stephenville map-area. The scale of mapping, however, has greatly limited the number of observations made.

Around North Brook, vertical to nearly vertical joints strike west, northwest, and northeast. The westerly-trending set of joints is best developed and contains most of the exposed carbonate- and sulphide-bearing veins (Barnes, unpublished report). Apparently, the best developed joint sets in this area maintain a constant strike irrespective of their position in relation to the axis of folding.

Northwesterly, northerly, northeasterly, and easterly-striking, steeply dipping or vertical-joint sets are common in the Long Range. The most prominent of these strike east-northeasterly. Prominent northeasterly linears appear on aerial photographs of parts of the Long Range.

Chapter IV

GEOPHYSICAL DESCRIPTION

The entire Stephenville map-area has been surveyed by airborne magnetometer, and the consequent aeromagnetic maps have now been published. A partly simplified compilation of these maps on a reduced scale is included in this report.

The map-area is divided into three broad regions on the basis of magnetic intensity; each of these three regions or areas can be further divided geographically, as follows:

A. Areas of relatively strong magnetic intensity
   - a. Lewis Hills and Blow Me Down Mountain
   - b. Indian Head Range, Flat Bay Brook, and Steel Mountain areas
   - c. South and east parts of area, in Long Range

B. Area of relatively weak magnetic intensity
   - d. Palæozoic and Carboniferous Lowlands

C. Areas of weak magnetic intensity
   - e. Gneissic terrane
   - f. A narrow northeasterly-striking belt west of Dennis Pond
   - g. A wide northeasterly-trending belt in northeastern part of map-area

For clarity, subdivisions (c, e, f) in the Long Range are herein treated as a unit.

Areas of Relatively Strong Magnetic Intensity

a. Lewis Hills and Blow Me Down Mountain

An area of high magnetic relief and also of strong magnetic intensity occupies the northwestern part of the map-area. Two well-defined anomalies, underlain by rocks of the Bay of Islands igneous complex, are separated by a northwesterly-trending belt of weak magnetic intensity along Serpentine River. This belt conforms remarkably closely with the areal extent of the rocks of the Humber Arm group, although the actual magnetic relief may be modified by the area of strong magnetic intensity directly to the south.

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b. Indian Head Range, Flat Bay Brook and Steel Mountain Areas

A well-defined, magnetic pattern of low relief is underlain by rocks of the Indian Head Range intrusive complex. Owing to the spacing of the flight lines and the inaccuracy of the original base maps, magnetite deposits in the complex (Heyl and Ronan, 1954) are not reflected in the magnetic pattern.

An area of relatively strong magnetic intensity, though mostly of weak relief, occupies the region between Sandy Point, Robinsons Head, and Mount Howley. Most of this area is underlain by Carboniferous strata, but anorthositic rocks are exposed at several places on Journois Brook (Baird, 1959). The large magnetic anomaly is probably caused by a mass of anorthositic rock underlying the Carboniferous strata. Dips of the Carboniferous strata in this region may possibly be the result of deposition upon an irregular surface.

Anorthosites in the Steel Mountain region contain significant tonnages of titaniferous magnetite. The deposits are characterized by sharp increases of magnetic relief, and include the Hayes Prospect, Hudson Prospect, and Bishops Claim (Baird, 1954).

c. South and East Parts of Map-Area in the Long Range
(including areas of weaker magnetic intensity e and f)

The southeastern part of the area exhibits a bird's-eye pattern comprising small, isolated, relatively intense magnetic anomalies in an area of relatively high magnetic relief. Some of these anomalies are probably directly related to the underlying rock types. An anomaly of high relief and strong intensity 6 miles northwest of Rocky Pond is underlain by gabbroic rock containing variable amounts of magnetite and ilmenite. The two anomalies north of the headwaters of Crabbes Brook are underlain by rocks of gabbroic composition that range from gabbro to monzonite. These rocks contain relatively large amounts of ferromagnetic minerals. The area of weak magnetic intensity separating the two anomalies appears to be underlain by hybrid rocks, some gabbroic, and some granitic.

The Wolf Brook region of relatively strong magnetic intensity and flat relief is underlain mainly by rocks of tonalitic composition. In some places, such as west of Portage Lake, anomalies of greater relief are located on or near the contact zone between gneisses of tonalitic composition and the tonalitic rocks. Tonalites here grade in composition from gabbro to adamellite, and both the gneisses and the tonalitic rocks contain relatively large amounts of ferromagnetic minerals.

A northerly-trending area of strong magnetic intensity, although not of extreme relief, lies northwest of Wolf Pond, near an assumed contact between gneisses and tonalitic rock. The location and characteristics of the anomaly, in conjunction with relationships between tonalite and gabbro in this region, indicate that the anomaly is possibly underlain by gabbroic rock.

Much of the Long Range between Highlands River and Fischells Brook, and north of Bottom Brook, near Grand Lake, is characterized by areas of relatively

weak magnetic intensity and low relief, which are underlain by granitic and granodioritic gneisses, and granite and granodiorite. Most of these rocks contain only minor amounts of ferromagnetic minerals.

A well-defined area of relatively weak magnetic intensity is present south of Dennis Pond. It is underlain by gneisses of granitic composition that contain few ferromagnetic minerals. Sharp differences in magnetic relief mark the contact between the gneissic rock and the tonalites.

Most of the gneisses are associated with areas of weak magnetic intensity, but some are related to regions of strong intensity. Such a relationship is present north of Cross Pond, where basic gneisses contain a higher percentage of ferromagnetic minerals than do the more common granitic gneisses.

Many of the magnetic patterns exhibit pronounced lineations, some of which show sharp relief. Direct relationship of these patterns with faults is common. A typical example, visible immediately west of Dennis Pond, is the narrow, northeasterly-striking, weak-intensity zone (shown by the symbol Cf on the Stephenville aeromagnetic map) that reflects the Long Range fault.

A few anomalies are apparently not very closely connected with the composition of the exposed bedrock surface. One of these, of moderate intensity, lies about 10 miles northwest of Rocky Pond. Its eastern border is underlain by adamellite containing only minor amounts of ferromagnetic minerals. The topographic relief of this rock type is, however, considerably greater than that of the surrounding country rocks, which probably modified the anomaly. The type of rock at the centre of the anomaly is not known, but a small area of strongly ferromagnetic rock may be present at depth. The maximum depth for such a rock type, as calculated from the aeromagnetic data, is 5,500 feet.

Areas of Relatively Weak and Weak Magnetic Intensity

d. and g. Carboniferous and Palæozoic Lowlands

The broad northeasterly-trending zone of relatively weak magnetic intensity extending from Codroy Pond to Mount Howley is underlain by Carboniferous strata, many of which are derived from the Long Range. These rocks contain few ferromagnetic minerals. Underlying anorthositic rocks have considerably modified the magnetic pattern of other areas underlain by Carboniferous strata.

In the region centred about Georges Lake, the flat magnetic relief of an area of relatively weak magnetic intensity is broken in only a few places by small, sharply defined, positive anomalies. These reflect steeply dipping bodies of strongly ferromagnetic rock overlain by a thin cover of Palæozoic sediments. The remainder of this area is underlain by sediments of the St. George, Table Head, and Humber Arm groups. Most of these rocks contain few or no ferromagnetic minerals.

The region north of St. Georges River and immediately west of the Long Range, extending to Humber Arm, is characterized by a northeasterly-trending

pattern of weak magnetic intensity and flat relief. The southern part of this area is heavily drift-covered, and is underlain by St. George and Table Head strata. The northern part is less heavily drift-covered and is underlain by Humber Arm sediments.

In résumé, features of the aeromagnetic map—many individual anomalies, for example—are easily explained with reference to geology. Some negative anomalies are probably explained by their proximity to an associated positive anomaly. Other features are explained in terms of the scale of mapping and spacing of the flight lines. The effect of variation in topography is apparently negligible over most of the area.

The trends of the magnetic pattern in the southeastern and eastern parts of the map-area conform remarkably with the trends of the structure of the region and probably reflect a different direction of folding.

Chapter V

ECONOMIC GEOLOGY

In Stephenville map-area gypsum, limestone, and sand and gravel are being exploited and deposits of peat and marl are numerous. Many other mineral occurrences are scattered throughout the region, but they are not high enough in quantity or grade to permit economic recovery at this time. The lack of a market is also an obstacle to the development of nonmetallic mineral deposits.

Mineral Occurrences

Asbestos

Asbestos has been observed in several places within the Bay of Islands igneous complex. It occurs in cross-fibre veins, up to 1 inch wide, in serpentinized rock of the complex, noticeably in the Lewis Brook, Mine Cove, and Trout River areas (Smith, 1958). Minor cross-fibre asbestos is associated with serpentine, west of Georges Lake, at what used to be the Bond asbestos mine (Walthier, 1949).

Barite and Celestite

Barium- and strontium-bearing mineral deposits occur as roughly tabular replacements of Mississippian Codroy beds near Port au Port. They are commonly associated with calcite, aragonite, and minor amounts of galena and pyrite. Amounts estimated for deposits at Gillams Cove and Hoopers Brook total 167,400 tons of mixed barite and celestite (Johnson, 1954).

Chromite

Small chromite lenses in dunites interbanded with peridotite, or in serpentine interbanded with gabbro, are scattered through the Bay of Islands igneous complex (Smith, 1958).

Coal

Coal seams are present in beds of the Barachois group south of St. Georges in an area of complex structure. The seams are, in many places, crushed and faulted, and are at present of little economic interest (Hayes and Johnson, 1938).

Copper

A little native copper and cuprite occur in sheared dunite near the head of Rope Cove (Cooper, 1936), and chalcopyrite is an accessory mineral at the Lower Drill Brook iron mine just east of Gull Pond (Heyl and Ronan, 1954).

Galena and Sphalerite

A few small showings of galena, sphalerite, and hydrozincite are scattered throughout the map-area, but are most abundant west of the railway near Don and North Brooks. In this region quartz-calcite veins containing lead and zinc sulphides cut massive limestone. Several galena-bearing quartz veins up to 1 foot wide, outcrop in the upper part of Trout Brook in the Long Range. Pyrite, galena, and minor amounts of sphalerite occur in brecciated limestones and sandstones of the Table Head, St. George, and Codroy groups in the coves at the east end of Port au Port Peninsula. The Goodyear Prospect at Round Head, Port au Port Peninsula, comprises galena-bearing calcite veins with some sphalerite, pyrite, and marcasite (Sullivan, 1940).

Gypsum

Gypsum is present in the lower part of the Codroy group, much of it flanking the anticline between Flat Bay Brook and Middle Brook. Other deposits outcrop along Coal Brook and Sheep Brook. Reserves of 200,000,000 tons are indicated by drilling (Johnson, 1959, 1960) in the Flat Bay area. Deposits along the west coast have been described by Baird (1951, 1959).

Iron

Iron deposits are situated in the southern part of the Indian Head Range near Gull Pond, and in the anorthosites of the Long Range near Steel Mountain (Baird, 1954). At Indian Head the deposits consist of nearly flat lying lenses of magnetite and hematite, associated with norite gneiss and pink, soda granite. The ores contain up to 7 per cent titanium and minor amounts of silica and phosphorus (Heyl and Ronan, 1954). Magnetite pockets and lenses are scattered through the anorthosite near Steel Mountain. Relatively intense magnetic anomalies coincide with these deposits.

Limestone

Limestone beds in the lower part of the Table Head group are quarried at Aguathuna. Their relatively low magnesium content makes them usable as flux. Selective quarrying of other carbonate areas might be feasible, but the St. George and Table Head groups consist largely of dolomitic (magnesium-bearing) rock.

Sand and Gravel[1]

Much sand and gravel is scattered throughout the map-area. Large quantities of material have been screened at Harmon Field, Stephenville, to provide various sizes of sand and gravel for the United States Air Force base. Many other deposits have been used to provide material for road construction and repair.

[1] *See* section on glaciation

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APPENDIX

STRATIGRAPHIC SECTIONS 1 TO 8

(*after* Sullivan, 1940)

Section 1

St. George Group

Bed	Descending section northeast of The Gravels, measured toward southwest, from contact with Table Head group, ⅔ mile northeast of The Gravels.	Thickness feet	Thickness inches
25	Thin- and thick-bedded, mottled, reddish and greenish limestone	1	9
24	Ledge of medium-grained, brownish grey limestone. *Cryptozoon* bed. Undulatory contacts at top and bottom	2	
23	Light buff, fine-grained magnesian limestone containing thin laminae of chert which stand out on weathered surface. Hackly fracture	6	
22	Buff, hackly limestone in thick and thin beds up to 1 foot thick. Contains *Maclurites oceanus* (Billings)	14	7
21	Coarse grey limestone with a hackly limestone at base	3	10
20	Grey, siliceous limestone containing chert nodules	1	2
19	Buff, almost white, hackly limestone in beds up to 1 foot thick	4	1
18	Beds of massive, grey to dove limestone, containing stylolites and quartz geodes	25	
17	Very dense, compact, resistant fucoidal limestone; cherty	1	9
16	Grey, unevenly bedded, thin- and thick-bedded limestone, red and green mottled	3	5
15	*Cryptozoon* layer		10
14	Dense, thick- and thin-bedded, dark-red and green limestone. Lowermost beds mud-cracked	4	3
13	Thin- and thick-bedded, greyish, red and green mottled limestone. Uppermost part weathers to knobbly surface. Bedding irregular	7	10
12	Same as bed 13 with red and green mottled dove limestone and interbedded shaly layers	11	7
11	Thin-bedded, compact, brownish grey limestone, weathering light grey; mud-cracked	4	
10	Dense red and green compact limestone	2	
9	Irregular beds of massive limestone containing *Cryptozoons*	1	
8	Conglomerate layers, weathering to thinly laminated shale and pebbles	1	4
7	*Cryptozoon* layer and massive limestone	1	
6	Red and green mottled, hackly, evenly bedded limestone	1	
5	Massive grey limestone. Uppermost beds with *Ceratopea;* lowermost conglomeratic	2	8
4	Thinly laminated shaly limestone. Beds locally crumpled and contorted	5	10
3	Well-defined *Cryptozoon* layer	2	6
2	Thin-bedded, grey limestone with hackly fracture	4	6
1	Same as bed 2, thicker-bedded	7	
	Total	120	11

Fault interrupts section below bed 1. It has small displacement and probably does not obscure great thickness of beds. Section continues downward from fault zone, which is ½ mile northeast of The Gravels.

Bed		Thickness feet	inches
16	*Cryptozoon* layer		
15	Evenly bedded red and green compact limestone with hackly fracture	5	5
14	Thicker-bedded, thinly laminated red and green mottled limestone with hackly fracture	4	
13	Same as bed 14, with beds up to 1 foot thick	3	
12	Evenly bedded grey limestone, red and green mottled, very cherty layers at top	5	5
11	Grey limestone weathering light grey. Upper 6 inches filled with chert nodules. Next lower 6 inches limestone conglomerate, weathering to fine rubble. *Cryptozoons* in lower parts	2	6
10	Thinly laminated grey limestone	4	2
9	Well defined *Cryptozoon* layer	6	3
8	Massive grey limestone with *Ceratopea* in upper part	5	
7	Massive grey limestone with *Cryptozoons*	3	
6	Massive grey limestone. Upper part replete with high-spired gastropods	5	
5	Massive grey limestone, weathering light grey, with *Cryptozoons*	21	10
4	Light-buff hackly limestone	3	
3	Thinly laminated shaly limestone resting with undulatory contact on massive limestone below. *Cryptozoons* in upper part	3	6
2	Massive, dense, cherty limestone in part conglomeratic	3	
1	Buff to white hackly limestone	5	
	Total	80	1

Section 2

St. George Group

Bed	Section descending from contact with Table Head group, ¼ mile northwest of The Gravels, and proceeding westward to big Cove.	Thickness feet	inches
57	Buff, hackly, thinly laminated limestone	3	
56	Massive, grey limestone, with *Cryptozoons*	2	
55	Thin- and thick-bedded, hackly, reddish limestone, changing to buff in lower parts; quartz geodes in lower part	16	4
54	*Cryptozoon* layer	1	
53	Thin- and thick-bedded, red and green mottled, hackly limestone, with occasional very thinly bedded green shaly layers	18	4
52	Grey limestone, cherty in upper part, with *Ceratopea keithi* Ulrich, *Billingsella* sp., and small gastropods. *Cryptozoons* in lower part. From this bed, ¼ mile east of the post office at Aguathuna, was collected *Calathium anstedi* Billings	2	8
51	Thinly bedded, red and green shaly limestone	3	
50	Massive, brownish grey limestone	3	
49	Thin- and thick-bedded, buff to grey hackly limestone	14	2

Bed		Thickness feet	inches
48	Massive grey limestone	8	
47	Grey hackly limestone	7	4
46	Massive grey limestone, with *Cryptozoons*	2	
45	Buff and reddish, thin- and thick-bedded, hackly limestone with thin *Cryptozoon* layers	11	2
44	Irregular and wavy conglomeratic layer with *Cryptozoons* and *Ceratopea keithi* Ulrich. Chert nodules numerous	2	10
43	Alternations of thick grey limestone with buff hackly limestone	12	9
42	Massive grey limestone with thin-bedded red and green shale in middle part. *Cryptozoons* in upper part	6	
41	Buff, almost white, thick-bedded hackly limestone	9	6
40	Thin-bedded, red and green shaly limestone	1	9
39	Alternations of grey massive limestone with buff hackly dolomite. A few red and green shaly layers. Bed 39 is located at road that crosses The Gravels	35	
38	Covered interval between north and south bars of The Gravels. Scattered outcrops show alternating hackly, buff dolomite with massive grey limestone similar to above. Four hundred and fifty feet below the top of this section, and situated about midway between the two gravel bars, is zone of fossiliferous grey limestone which yielded the following fauna: *Euchasma blumenbachi* (Billings), *Maclurites oceanus* (Billings), *Maclurites rotundatus* (Billings), *Euconia etna* (Billings), *Turritoma acrea* (Billings), *Straparollina pelagica* Billings, *Billingsella* sp., and *Orthoceras explorator* (Billings).	675	
37	Light grey dolomitic limestone in thin irregular beds	49	
36	Very thin bedded shaly limestone. Medium grey. Bed 36 situated at west end of southernmost bar at The Gravels. From this bed were collected *Maclurites oceanus* (Billings), *Protocycloceras lamarcki* (Billings), and *Pleurotomaria normani* Billings.	5	
35	Irregularly and wavy bedded, medium grey limestone	11	
34	Thinly laminated grey limestone	3	6
33	Thinly laminated pinkish brown dolomite, with hackly fracture, in beds from 3 to 4 inches thick	3	10
32	Grey, irregularly bedded medium-grained limestone	4	
31	Pinkish, hackly dolomite, as in bed 33	6	
30	Thin- and thick-bedded grey limestone, fucoidal for most part. Beds up to 1 foot thick. Medium-grained	40	
29	Massive grey fucoidal limestone. Beds up to 3 feet thick	10	
28	Laminated brownish grey hackly dolomite	3	
27	Massive grey limestone, thin-bedded in lower part	5	
26	Arenaceous, limestone conglomerate, with pebbles of limestone and chert	2	6
25	Irregularly bedded and thinly laminated grey limestone, fucoidal in middle part	5	
24	Thin- and thick-bedded, grey arenaceous limestone with undulatory bedding. Massive beds interbedded with thinly laminated layers. Upper parts filled with lenses and nodules of brownish red chert. Many geodes of calcite	46	
23	Massive grey limestone with fucoids, alternating with brownish, thinly laminated hackly dolomite. Limestone becomes predomi-		

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Bed		Thickness feet	inches
	nant toward base, occurring in thin irregular knobbly beds, grading downward into 20 feet of *Cryptozoons*. One hundred and four feet below top of this section is grey limestone with many gastropods similar to those in bed 38	165	
	(At this point, ¼ mile southwest of The Gravels, normal fault breaks section. Throw is indeterminate, and unknown thickness of beds has been removed from sight. Judging from relationships here and from habit of the faults in this area, throw is probably small, and total thickness of beds removed is probably less than 50 feet.)		
22	Regularly bedded, buff to light grey dolomite in beds up to 3 or 4 feet thick. Hackly fracture. Several cherty layers	45	
21	Upper part of massive grey limestone, alternating with buff, hackly dolomite, each alternation being about 8 feet thick. Bedding irregular. Lower part of irregularly bedded grey limestone in thin knobbly layers. Fucoidal and cherty	85	
20	Dense, fine-grained, brownish grey dolomite, fucoidal with many chert nodules	30	
19	Thin beds of dense dolomite replete with gastropods, alternating with beds of coarse-grained grey limestone	45	
18	Massive grey limestone, fucoidal, in thick beds	25	
17	Very irregularly bedded, massive, cherty grey limestone. Extremely fossiliferous. Bed 17 is the Zone of *Diphragmoceras*, located at Green Head, ¾ mile southwest of The Gravels. From Green Head, shore line of peninsula swings westward to coincide more nearly with strike of St. George group, so that section descends very slowly from this point on. Bed 17 at Green Head contained following fauna: *Diphragmoceras* sp., *Pleurotomaria hyale* Billings, *Archeorthis hippolyte* (Billings)?, *Turritoma acrea* (Billings), and gastropod sp.	15	
16	Massive, irregularly bedded, coarse- to fine-grained, brownish grey and grey limestone. Fucoidal in part. Many chert nodules and lenses	48	
15	Regularly bedded, brownish grey, medium-grained limestone	10	
14	Buff, laminated, hackly dolomite in beds up to 4 inches thick	4	6
13	Buff dolomite, alternating with grey limestone, in regular beds	23	
12	*Cryptozoons*, interbedded with thin-bedded, knobbly limestone, with 3 feet of buff dolomite at base	10	
11	Conspicuous black chert layer. This bed 1 mile southwest of The Gravels		3
10	Series of buff, medium-grained, hackly dolomites in beds up to 4 inches thick. Evenly bedded. Have buff colour with greenish tinge, weathering reddish. A few thin bands of chert and grey limestone	177	
9	Large number of *Cryptozoon* beds interbedded with thin knobbly grey limestone layers. Layers of intraformational conglomerate, with some buff hackly limestone	38	
8	Grey, thin-bedded, knobbly limestone with shaly layers and some buff dolomite. Mainly grey limestones with many *Cryptozoon* layers. Fucoidal in part. Mud-cracked and ripple-marked. Also several beds of edgewise conglomerate. This bed exposed on both sides of Man O' War Cove, as here shore follows strike of the group; re-entrant of cove exposes higher beds of group	53	

Bed		Thickness feet	inches
7	Thin- and thick-bedded dolomite, dolomitic limestone, and shaly dolomite. Bed 7 is exposed along shore between Man O' War Cove and Felix Cove. At latter cove, strata are broken by three faults with downthrow to west on easternmost two faults. This causes higher beds to outcrop along shore. On westernmost fault, upthrow is on west, bringing bed 7 back into view a few hundred yards west of Felix Cove. This relationship is apparent, since 10 feet below top of bed 7 is distinctive and massive bed of pinkish quartzite, exposed on either side of Felix Cove. Sixty-three feet below top of this bed is 1½-foot *Cryptozoon* layer, and 70 feet below top is slight erosional unconformity. Beds are massive and grey but weather to reddish appearance. Many geodes of calcite	87	
6	Medium-grey, laminated, dense limestones in massive beds alternating with thinner-bedded dolomite and shale. Mud-cracked. Many calcite geodes in more massive layers	110	
5	Grey limestone with *Cryptozoons*	50	
4	Pinkish and red dolomite and quartzite	30	
3	Arenaceous and shaly limestone, with very thin-bedded, knobbly limestone layers	42	
2	Light grey, massive, heavy-bedded, dolomitic limestone. Bed 2 is exposed in both salients of Campbell's Cove. Between Campbell's Cove and Big Cove, 9 miles west these same strata are exposed all along shore, not only because shore follows strike from Campbell's Cove to Jerry's Nose, but because west of that locality, despite strata's changing in dip to northwest, series of major normal faults in Ship Cove and Lower Cove have conspired to keep bed 2 constantly in view along shore. These faults have upthrows to west; if it were not for these, bed 2 and those above it would disappear rapidly beneath surface. West of Lower Cove, and to point where the St. George group abuts against fault at Big Cove, bed 2 is again exposed, and beds are perfectly horizontal. Seventy feet below the top of this section is distinctive fossil horizon containing specimens of *Lecanospira*-like gastropod, *Ophileta nerine* Billings, and *Euchasma blumenbachi* (Billings). This fossil zone occurs in tops of sea-cliffs ½ mile east of Ship Cove, also in beds on east side of Ship Cove, and again in beds exposed at top of waterfall overlooking Sheave's Cove. On west side of Pigeon Head is another distinctive horizon containing *Piloceras* sp., *Euchasma blumenbachi* (Billings), and several species of gastropods. From structural relations of Pigeon Head, this is fault block, beds to east of it having slipped downward, and strata to west having moved upward with respect to block. This relationship does not permit exact placement of this horizon within section, other than that it is below zone of *Lecanospira*. Horizon of *Piloceras* may occur near base of bed 2, or may be within basal bed 1.	320	
1	Basal beds are unexposed, and no clear-cut contact with Cambrian. Cambrian is probably not far below St. George group at Big Cove	?	
	Total	2,441	5+

Section 3

Table Head Group

Bed	Section descends from contact with Humber Arm group 1½ miles northeast of The Gravels to contact with St. George group ⅝ mile farther southwest.	Thickness (feet)
4	Very thinly laminated, black, carbonaceous shale	18
3	Very thin bedded, alternating black shale and grey limestone, shales containing numerous graptolites, such as *Climacograptus parvus, Climacograptus* sp., *Didymograptus sagitticaulus* Gurley, *Glossograptus whitfieldi* (Hall), *Tetragraptus quadribrachiatus* (Hall), *Ptilograptus plumosus* Hall, *Phyllograptus* sp., and brachiopods such as *Leptobolus walcotti* Ruedemann, and *Obolus* sp. Last two also occur in same bed at mouth of Smelt Brook in Piccadilly Harbour, together with *Tetragraptus quadribrachiatus* (Hall)	42
2	Alternating limestone and shale, grading upward into bed 3. Limestone, dark grey to black, in layers up to 6 inches thick, separated from one another by shaly partings, which become dominant toward top of section. Limestone layers contain numerous linguloid brachiopods and trilobites, notably, *Megalaspis huttoni* (Billings), and *Lingula* n. sp. Schuchert and Dunbar (1934) reported also presence of trilobites *Anisonotus glacialis* (Billings), *Niobe lineolata, Raphiophorus semicostatus* (Billings), and *Triarthrus fischeri* Billings. Beds 2, 3, and 4 are all located in Black Cove, 1½ miles northeast of The Gravels	33
1	Uniformly massive, thick-bedded, grey limestone, weathering to rubble. Cliff forming and fossiliferous throughout, with trilobites *Illaenus marginalis* (Hall) and *Ectenonotus westoni* (Billings) occurring throughout strata, along with many other forms. No distinct fossil zones were apparent in these beds.	720
	Total	813

Section 4

Long Point Group

Bed	Composite section measured downward from contact with Clam Bank group at Misty Point, western salient of cove at Black Duck Brook, Port au Port Peninsula.	Thickness (feet)
7	Thin-bedded, knobbly limestone with occasional sandstone layers. Greenish grey. Very fossiliferous, containing *Dinorthis* cf. *D. iphigenia* (Billings), *Hesperorthis tricenaria* (Conrad), *Dalmanella rogata* (Sardeson), *Sowerbyella sericea* (Sowerby), and *Rafinesquina* cf. *R. minnesotensis* Winchell.	300
6	Slabby, greenish grey, sandy limestone beds, sparsely fossiliferous. Exposed near inner part of cove at Black Duck Brook	90

Bed		Thickness (feet)
5	Thin-bedded knobbly limestone, light grey, interbedded with greenish-grey shaly layers. A few sandstone layers. Almost entirely unfossiliferous. Exposed along west shore of Long Point between Black Duck Brook and lighthouse	443
4	Limestone conglomerate with boulders up to 2 feet in diameter, exposed ½ mile south of lighthouse on west shore of Long Point	4
3	Shaly, sandy limestone and interbedded shale beds. Found near lighthouse on both sides of point. Sparsely fossiliferous, with *Leperditia fabulites* Conrad most abundant form.	170
2	Thin-bedded, knobbly, coarse-grained, light grey, and brownish limestones. Contain reefs of *Monotrypa magna* Ulrich and is very fossiliferous, including the following: *Ceraurus pleurexanthemus* (Green), *Cryptolithus* sp., *Encrinurus cybeleformis* (Raymond), *Illaenus* sp., *Leperditia fabulites* Conrad, *Gonioceras* cf. *G. anceps* (Hall), *Maclurites bigsbyi* (Hall), opercula for *Maclurites, Glyptorthis* cf. *G. bellarugosa, Hesperorthis tricenaria* (Conrad), *Rafinesquina deltoidea* Conrad, *Rafinesquina alternata* (Emmons), *Rafinesquina* cf. *R. minnesotensis* Winchell, *Strophomena incurvata* (Shepard), *Valcourea* sp., *Graptodictya* sp., and several bryozoans. Bed 2 is exposed along most of eastern shore of Long Point to within 2 miles of West Bay village. Also exposed at northeast salient of Three Rocks Cove.	240
1	Thick-bedded, massive, cliff-forming grey limestone, grading upward into bed 2. A few greenish-grey shaly layers. Contains *Monotrypa magna* Ulrich, *Maclurites bigsbyi* (Hall), *Gonioceras* cf. *G. anceps* Hall, *Rafinesquina alternata* (Emmons), *Rafinesquina* cf. *R. minnesotensis* Winchell, *Leperditia fabulites* Conrad, *Illaenus* sp. Bed 1 is found on east side of Long Point lying between base of bed 2, 2 miles northeast of village of West Bay, and Green Point shales and limestones, which lie to southeast of large fault cutting across base of Long Point.	185
	Total	1,432

Section 5

Humber Arm Group

Bed	Descending section on Victor's Brook, measured from dam 2, 1 mile from mouth, and proceeding up brook, toward southwest, for 2 miles. Section ends ½ mile above dam 3. Last part of this section lies on flank of anticline located to southeast of Round Head.	Thickness (feet)
11	Conglomerate, with limestone pebbles and green chert	25
10	Black and greyish green fissile shale	30
9	Grey fissile shale	100
8	Boulders of green sandstone and micaceous sandstone layers, interbedded with green shale	12
7	Greyish green fissile shale and green sandstone, with conglomerate	97

Bed		Thickness (feet)
6	Greyish green sandstone. Here thrust breaks section. As beds are same on either side of fault, throw cannot be determined	?
5	Greyish green fissile shale and sandstone	15
4	Green sandstone and conglomerate. Sandstone crossbedded and thinly laminated. Basal part intercalated with thin-bedded greenish shale	190
3	Green sandstone and conglomerate with shaly partings. About 50 feet of dark grey, dense, fine-grained limestone are contained in this section, 250 feet above base. Lowermost 200 feet are of black and green fissile shales; basal part coarse conglomerate with limestone and sandstone pebbles, and green sandy matrix	1,005
2	Upper part green chert, with black and green fissile shale, grading downward into green sandstone and greenish conglomerate with shaly matrix	85
1	Limestone conglomerate with limy pebbles and limy matrix. Appears typical of basal Humber Arm conglomerate.	?
	Total	1,559+

Section 6

Humber Arm Group

Bed	Descending section beginning 3 miles south of point on west side of Shoal Point and proceeding southward to base of Shoal Point. Probably represents part of group stratigraphically higher than that in section 5.	Thickness (feet)
15	Thin-bedded, soft, fissile, clayey shale, varicoloured	56
14	Compact, dense, medium grey limestone	112
13	Black, fissile, soft shale, with interbedded greenish shale, alternating with thick and thin beds of grey limestone	315
12	Coarse green sandstone, alternating with greenish arenaceous shale and soft, green, fissile shale	360
11	Grey limestone	13
10	Black and green fissile shale	44
9	Compact limestone, banded in layers of light and dark grey, with thinly laminated sandy shale partings	12
8	Soft, red, fissile shale with green mottlings	70
7	Red and green chert	8
6	Soft, red fissile shale	578
5	Red and green chert	10
4	Coarse green sandstone	95
3	Covered interval	80
2	Soft, red, fissile shale	47
1	Conglomerate with pebbles of grey limestone and matrix of red and green sandy shale, underlain by coarse green sandstone containing many fragments of red feldspar	50
	Total	1,850

Section 7

Humber Arm Group

Bed	Section runs southwest some 5 miles from southwest salient of Three Rocks Cove to contact with Table Head group at Cape Cormorant.	Thickness (feet)
15	Greatly folded and faulted grey-green sandstones with intraformational conglomerates. Many folds overturned toward northwest, and many broken by thrusts in same direction. Measurements were difficult here, but there are probably several hundred feet of these beds. These beds are exposed in southwest salient of Three Rocks Cove	?
14	Soft, grey-green fissile shale, with thin-bedded arenaceous limestone and sandstone	?
13	Coarse- and fine-grained green sandstone, crossbedded and ripple-marked, with thinly laminated beds of fissile shale	205
12	Interbedded sandstone and fissile, greenish shale	150
11	Thin-bedded, dense, soft, greenish grey fissile shale with green sandstone	172
10	Alternating coarse- and fine-grained, green sandstone and thin beds of fissile green shale	50
9	Very coarse greenish sandstone	35
8	Interbedded, coarse sandstone and soft, green fissile shale. This sandstone contains large quantities of feldspar	45
7	Olive-green, thin-bedded, medium-grained sandstone	156
6	Covered, with occasional outcrops of thin-bedded green sandstone. Folded and faulted and in part may repeat part of section	1,580±
5	Olive-green, medium-grained, crossbedded, and thinly laminated sandstone, alternating with coarser-grained green sandstone	1,950
4	Olive-green, medium-grained, crossbedded, thinly laminated sandstone, interfingered with thin-bedded limestone and fissile shale, with very coarse conglomerate at intervals	136
3	Interbedded limestone and fissile shale, shale being predominant. Interbedded with thin limestone layers and limy conglomerates. A few beds of rather coarse conglomerate. Grades downward into bed 2	148
2	Interbedded limestone and grey fissile shale containing *graptolites* and *brachiopods*; very coarse conglomerate. Toward base, conglomerate becomes predominant and coarser, with boulders up to 4 feet in diameter found in layers up to 10 feet thick. Boulders are coarse and angular. This is talus breccia found at Cape Cormorant	360
1	Limestone conglomerate, with limestone pebbles and limy matrix. Pebbles up to 2 or 3 inches in diameter	200
	Total	5,187[1]

[1]Sullivan (1940) suggested that this figure may be twice the actual thickness owing to considerable folding in this section.

Section 8

Clam Bank Group

Bed	Composite section measured from contact with Long Point group, 1½ miles northeast of Three Rocks Cove, and extending northeast to southern salient of Clam Bank Cove. Basal beds measured between Clam Bank Cove and Black Duck Brook.	Thickness (feet)
7	Interbedded red and green, thin-bedded sandstone, crossbedded and ripple-marked. Bed 7 extends from contact with Long Point group for about ¾ mile to northeast	370
6	Arenaceous and argillaceous limestones, interbedded with sandy shales. Limestone layers are replete with brachiopods *Spirifer modestus* var. *plicatus* Maynard and *Leptaena rhomboidalis* (Wilckens).	409
5	Reddish, crossbedded, sandstone and shale	93
4	Greyish green, mud-cracked, sandy limestone	87
3	Greyish green, sandy limestone and shale. Ripple-marked and mud-cracked. Very fossiliferous, including the following: *Platyceras* sp., *Sanguinolites* sp., *Dalmanella* cf. *D. concinna* (Hall), *Leptaena rhomboidalis* (Wilckens), *Spirifer modestus* var. *plicatus* Maynard, *Strophonella* cf. *S. geniculata* (Hall), *Favosites* sp., and *Zaphrentis* sp. Bed 3 is located at southwestern salient of Clam Bank Cove	125
2	Reddish shale and micaceous sandstone	450
1	Brick-red, thinly laminated, and crossbedded sandstone and interbedded conglomerate. Mud-cracked and ripple-marked. Beds 1 and 2 are best exposed all along shore from Clam Bank Cove to Black Duck Brook, although they are also exposed for about ¼ mile southwest of fault at Clam Bank Cove. This fault has offset these beds to north, thus causing repetition of basal beds in that locality.	345
	Total	1,879