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GEOLOGY OF THE ANTIGONISH HIGHLANDS, NOVA SCOTIA

D. G. Benson

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D. G. Benson

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PREFACE

An objective of the studies carried out by the Geological Survey of Canada is to estimate the potential abundance and probable distribution of the mineral and fuel resources available to Canada and to provide an information basis for the location of such resources. To meet these objectives, a systematic geological framework is essential.

This report provides data needed to meet the objective in a part of Nova Scotia. The area lies within the Appalachian Orogen and includes mixed sedimentary–volcanic and igneous assemblages of lower Paleozoic age which in places are overlain by younger, relatively undisturbed, mainly nonmarine, sedimentary rocks of Carboniferous age. The author describes these rocks and the structural and tectonic history of the region.

The area has been explored for mineral deposits for more than a century and, although geological conditions are favourable, and despite the fact that many small showings of metallic minerals are known, no major deposit has been found.

Y. O. FORTIER,
Director, Geological Survey of Canada

OTTAWA, September 29, 1972

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GEOLOGY OF THE ANTIGONISH HIGHLANDS, NOVA SCOTIA

Abstract

The stratigraphy, structure, and tectonics of the Paleozoic igneous and sedimentary rocks of the Antigonish Highlands are described, as is the geology of the relatively undisturbed flanking Carboniferous sedimentary rocks.

Antigonish Highlands comprise a folded and faulted pre-Silurian eugeosynclinal assemblage, overlain by less disturbed Silurian–Devonian sedimentary rocks. The Carboniferous strata are mostly nonmarine and were deposited in subsiding basins.

Although the variety of rock types, ages, and tectonic history of the map-area presents many possible environments for the formation of economic mineral deposits, only small showings have been found despite more than a century of intermittent exploration.

Résumé

L'auteur décrit la stratigraphie, la structure et la tectonique des roches sédimentaires et ingnées paléozoiques des hautes-terres d'Antigonish ainsi que la géologie des roches sédimentaires du Carbonifère relativement peu dérangées qui flanquent les premières.

Les hautes-terres d'Antigonish constituent dans leur ensemble un eugéosynclinal pré-silurien plissé et faillé sousjacent à des roches sédimentaires siluriennes et dévoniennes moins dérangées. La plupart des strates du Carbonifère ne sont pas marines et ont été déposées dans des bassins de subsidence.

Même si la variété des types de roches, des âges et de l'évolution tectonique de la région crée de nombreux milieux propices à la formation de gisements économiquement rentables, cent ans d'exploration intermittente n'ont permis de recueillir que des indices de peu d'importance.

Chapter I

INTRODUCTION

The Lochaber, Merigomish, and Malignant Cove map-areas, in Pictou, Guysborough, and Antigonish Counties, Nova Scotia, lie between latitudes 45° 15′ and 45° 51′ north and longitude 62° and 62°30″ west, and include approximately 810 square miles of land. These three map-areas will be referred to as the map-area, except where reference is made to an individual map-area. (*See* Maps 1360A and 1361A, *in pocket.*)

Field mapping on a scale of 1 inch = ½ mile, for final publication on a scale of 1 inch = 1 mile, began in the summer of 1962 and was completed in 1965. Foot traverses were undertaken along all streams and coastal sections and, where required, in interstream areas. Many sections were examined in road- and railway-cuts. Some re-examination of key exposures was done during the summer of 1966.

The objectives of this study were to determine the stratigraphy, structure, and tectonics of the Paleozoic igneous and sedimentary rocks of the Antigonish Highland and of the relatively undisturbed, mainly sedimentary rocks on the flanks.

The Trans-Canada Highway (Route 4) and the main Canadian National Railways line to Cape Breton cross the Merigomish map-area. Gravel roads and a few paved secondary highways provide access to most parts of the map-areas. The harbours at Arisaig and Lismore, which have maximum depths at low tide of 8 and 4 feet respectively, accommodate fishing boats up to about 50 feet long. The Nova Scotia Department of Lands and Forests maintains a seaplane base at Eden Lake and a grass covered airstrip about 4 miles to the southeast.

The area is essentially rural in character and the only villages are Merigomish, Kenzieville, Blue Mountain, and Lismore. The town of Antigonish has a population of about 4,000 and is the site of St. Francis Xavier University. New Glasgow, 13 miles west of the area mapped, is an industrial centre with a metropolitan population of about 25,000.

Predominantly coniferous forest, which covers most of the region, formerly supported an extensive lumbering industry whose products were shipped to overseas markets. The large trees of the mature forest have been harvested and intensive forest management is being undertaken to provide a continuing supply of wood for the nearby pulp and paper mills and local sawmills. The large barrens south of Eden Lake are being reforested by the Provincial Department of Lands and Forests.

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Agriculture is now limited to small farms located mainly in areas underlain by calcareous Carboniferous rocks and along the flood plains of the major streams.

About 1800, when the region was originally settled, land was cleared for farming nearly everywhere. Many of these farms were underlain by pre-Carboniferous or siliceous Carboniferous rocks in hilly terrain and have since been abandoned. Few of the farms remaining are self-sufficient and the inhabitants are employed elsewhere.

A lobster and fish packing plant at Lismore is supplied by local fishermen.

The extensive sand beaches, particularly those at Melmerby, Big Island, Arisaig, and Malignant Cove, could form the basis of a profitable tourist industry. Unfortunately, they have been exploited as a source of sand, and may soon lose much of their charm unless proper conservation practices are undertaken.

Previous Work

The earliest geological workers in the area who briefly described their observations were Jackson and Alger (1828, 1829), Gesner (1836, 1845), Dawson (1845, 1850, 1860, 1881, 1891), and Honeyman (1859, 1860, 1864, 1867, 1870, 1874, 1878, 1890).

Fletcher and Faribault (1887) traversed the entire area on foot and horseback and prepared the first geological maps (1 inch = 1 mile) and included detailed descriptions of some stratigraphic sequences. A later report by Fletcher (1892) dealt mainly with the land to the west, but included a small portion of the map-area.

Ami (1900b) studied the paleontology of the Silurian at Arisaig and later recognized and described the Devonian Knoydart Formation (1901).

Twenhofel made an extensive fossil collection at Arisaig in the summer of 1908 and published a detailed subdivision of the strata (1909, 1913), which included a section on correlation by Schuchert.

Williams did field work in the Arisaig district with some assistance by Twenhofel and Schuchert, followed by further work at Yale University (1912, 1914). William's memoir gave an extensive summary of the previous work on the Arisaig district.

Malcolm's report *Gold Fields of Nova Scotia* included a geological map of Nova Scotia and a good summary of earlier geological work (1914). The report was revised in co-operation with Faribault and was published in 1929.

McLearn (1924), under the direction of Professor Schuchert at Yale University, undertook a systematic study of the Arisaig Silurian faunas that was published by the Geological Survey of Canada.

Bell studied the Carboniferous paleontology and rocks of northern Nova Scotia and examined most of the exposures. His memoir on the Pictou coalfield (1940) included a brief mention of the Merigomish map-area.

From the late forties until the late fifties there was a summer school for geological studies at Crystal Cliffs near Antigonish. Most of the students were from the Massachusetts Institute of Technology, and several wrote undergraduate or graduate theses on parts of the map-areas. Two valuable contributions were by Sage (1954) and Maehl (1960, 1961), who described the Windsor Group of Mahone Bay and Antigonish, and the Silurian of Pictou County, respectively.

Mineral exploration has been carried out for more than one hundred years, but only three recent projects provided new information.

The Nova Scotia Department of Mines drilled the iron deposit near Doctors Brook in 1961. An aeromagnetic survey of part of the south half of Merigomish map-area was undertaken for Gordon Minerals in 1954. This same area was later investigated by geochemical and geological mapping by Eastern-Northern Explorations Limited.

Aeromagnetic maps of the rest of the Merigomish map-area (762G) were prepared by the Geological Survey of Canada and those of Lochaber map-area by the Nova Scotia Department of Mines (1954). A high resolution aeromagnetic survey and an Afmag survey were carried out over the St. Mary's River graben (Hood and Sawatzky, 1971; Collett, 1971).

Special attention has recently been paid to the Silurian Arisaig section and adjacent areas (Copeland, 1960, 1964; Boucot *et al.*, 1965; Harper, 1964; Fullager and Bottino, 1968; Bambach, 1969).

Physiography and Glaciation

The dominant physiographic feature of the map-area (Fig. 1) is the Antigonish Highlands (Pictou–Antigonish Highland of Goldthwait, 1924, and Antigonish Highlands of Weeks, 1957). The highlands are bordered to the west by the Cumberland–Pictou Lowland, to the east and south by the Antigonish–Guysborough Lowland and its extension, the St. Mary's River Lowland. The Atlantic Uplands extend barely into the southern part of the Lochaber map-area.

The Antigonish Highlands are a dissected uplands with an average altitude of 750 to 850 feet and a maximum of slightly more than 1,000 feet. The boundary with the lowlands is at about 200 feet. It is underlain by sedimentary and volcanic rocks of the Browns Mountain Group and associated intrusive rocks. The topographic variations appear to be controlled more by geological structure, such as faults and folds, than by differences in the underlying rock type, except for the embayment between French and Barneys rivers, which is underlain by Silurian sediments. The northwestern and southern boundaries of the highlands are fault scarps, and the present altitude of the highlands is probably due to post-Devonian uplift along these faults; the highlands are thus a structural horst. The Hollow, or Bruin's Highway, between the Highlands and the Arisaig Silurian and Devonian resulted from differential erosion along Hollow fault.

The Cumberland–Pictou Lowland is a coastal plain of low relief. A few elongated ridges and drumlinoid hills, and some entrenched stream valleys provide the variety in elevation. Most of the lowland is underlain by gently dipping, easily eroded Carboniferous sediments. Greater relief is displayed in the areas underlain by more resistant Silurian and Devonian rocks and, near Arisaig, there are sea cliffs up to 40 feet high. The relief of the Silurian–Devonian area along the coast is also partly due to post-lower Devonian uplift and tilting of the block.

The Antigonish–Guysborough Lowland is a low undulating surface traversed by large streams that meander across their flood plains. The lowland is underlain entirely by Carboniferous sediments. Sinkholes, ponds, and gypsum–anhydrite cliffs mark the extent of the calcareous Windsor Group. The more resistant Horton sediments give rise to low rolling hills.

The St. Mary's River Lowland, a slightly more rugged extension of the Antigonish–Guysborough Lowland, is underlain entirely by the Horton Group. Low, but distinct ridges are formed by outcrops of arenite with interbedded siltstone layers. The lowland coincides with the St. Mary's River graben, bounded on the north by the post-Carboniferous Chedabucto fault and on the south by the pre-Carboniferous (before deposition of the upper Horton) West River St. Mary's fault.

The Atlantic Uplands are a dissected peneplane with numerous low hills, ridges, lakes, and swamps. The average elevation is about 600 feet in the Lochaber map-area. The interior

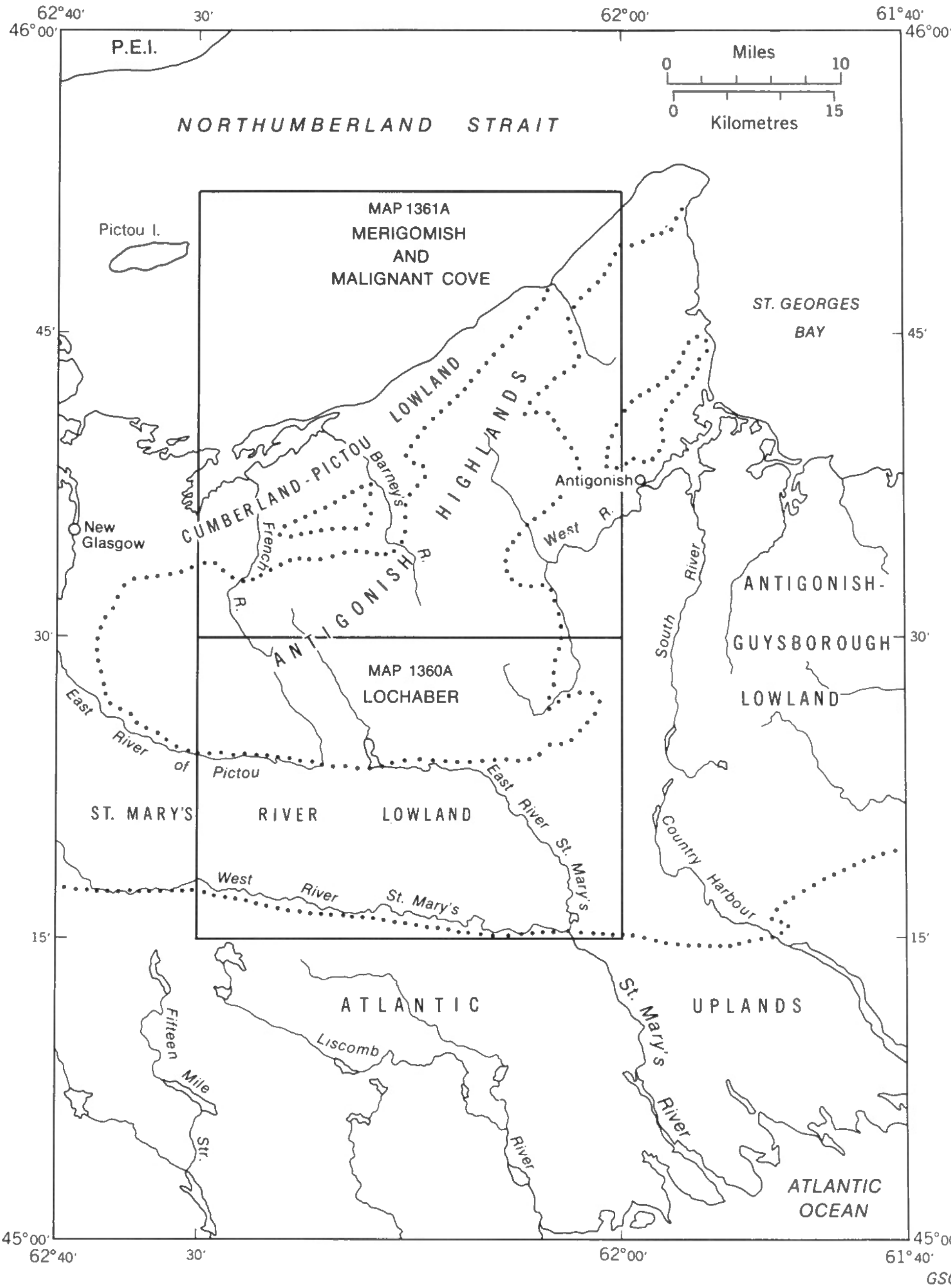

FIGURE 1. Physiographic divisions of northeastern Nova Scotia.

of the uplands is generally very flat, with the irregularities in topography due to differential erosion of the Meguma metasediments and Devonian granite. The northern boundary, marked by a steep hill, is along the West River St. Mary's fault.

The entire region has been subjected to continental glaciation and is now covered with glacial deposits. The thickest deposits are the unsorted gravel and sand found in kame terraces at the sides of the major stream valleys. Several kame terraces are found along the valley of Barneys River near Barneys River Station. Outwash deposits are common on the Cumberland–Pictou and Antigonish–Guysborough lowlands. A low esker crosses the road south of Lismore, and several glacial features suggestive of eskers occur north of Avondale Station. Sandy terraces are visible on the low hills east of the mouth of Knoydart Brook. The low hills on Merigomish Island and on the islands in Merigomish Harbour are probably drumlins. Along the coast of Northumberland Strait, indistinct striae with an eastward to northeastward orientation were observed. The distribution of Browns Mountain and Silurian boulders in gravel deposits near the coast suggests a southeastward to southwestward source. Glacial deposits on the Guysborough–Antigonish Lowland contain mainly Carboniferous rock fragments, but also contain a few rock types that come from the highlands. Glaciation was probably caused by a lobe of ice centred on the Antigonish Highlands, which formed glacial meltwater streams along the present major stream valleys.

The present coastline has several narrow, long beaches whose configurations are continually changed by severe storms. The bar at the east end of Merigomish Island, protected in 1965 by construction of a wall made of creosoted timber, was mostly destroyed by 1971. This wall replaced a lower wall made some forty years earlier. Merigomish Harbour, which is being filled by sediment from the rivers emptying into it, has extensive mud flats. The coastline is presently submergent, although a possible sea bench near Knoydart Brook indicates a former sea level about 10 feet higher than the present level.

Flood plains are developed along most of the major rivers, as seen at the mouths of Barneys and French rivers and along Ohio River. The north ends of Eden, Lochaber, and Two Mile lakes and all shores of Glenelg Lake are gradually being infilled.

Drainage

The streams of the map-area belong to one of three separate drainage systems that empty into Northumberland Strait, St. Georges Bay, and the Atlantic Ocean. The maturity of the streams is due mainly to the underlying bedrock.

Sutherland, French, and Barneys rivers, which flow northward into Merigomish Harbour, are all well graded with only a few minor rapids after they leave the highlands. The other minor streams emptying into Northumberland Strait, except for Knoydart and Baileys brooks, have short steep courses, usually with falls near the mouths.

Rights, Ohio, and James rivers and their tributaries have ungraded headwaters in the highlands where they flow over harder rocks, but are well graded where they flow across the Antigonish–Guysborough Lowland. These rivers drain into St. Georges Bay.

West River St. Mary's and East River St. Mary's form a well-developed stream system contained mainly within the St. Mary's River Lowland. These streams and rivers are poorly graded, and rapids and falls occur wherever they cross more resistant strata. The tributaries entering West River St. Mary's from the Atlantic Uplands all have falls near their mouths, but the St. Mary's River cuts across the uplands on its way to the Atlantic Ocean. St. Mary's River probably follows a glacial or preglacial channel, whereas the other streams have developed on glacial deposits and are still actively eroding their valleys.

Most of the larger streams formerly had dams to provide power for lumber mills. The only water-driven mill today is on Hemlock Brook with Mitchell Lake also dammed to provide adequate water reserve. Many of the numerous lakes in the West River St. Mary's Trough had small dams to assist in driving lumber on the streams. Several of the lakes in the region are due mainly to beaver dams. Many of the smaller streams dry up in the summer, but there may be appreciable water flow beneath the stream bed.

Acknowledgments

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C. W. Harper and A. J. Boucot identified may of the Silurian fossils and, along with W. S. McKerrow, discussed the Silurian geology with the author.

Scuba diving off Arisaig and Georgeville was undertaken with the help of D. Dobbin, G. A. Bartlett, and K. Ramey.

Chapter II

GENERAL GEOLOGY

The map-area is within the Appalachian Orogen, a system that extends from Newfoundland southwestward to Alabama. The orogen developed as an orthogeosyncline with thick lower and middle Paleozoic eugeosynclinal assemblages.

The southern two thirds of mainland Nova Scotia is underlain by lower Paleozoic sediments of the Meguma Group and by Devonian granite. The lower Paleozoic rocks of the Cobequid Mountains and the Antigonish Highlands lie to the north of the Meguma block. They are essentially mixed sedimentary–volcanic and igneous assemblages. Relatively undisturbed Lower Carboniferous to Triassic sediments unconformably overlie the older rocks in the northern half of the province.

The Antigonish Highlands are the most prominent feature of the map-area. The highlands are unconformably overlain by Carboniferous sediments on the northwest and east, and are in fault contact with Lower Carboniferous sediments on the south. A narrow strip of the Meguma block outcrops along the southern boundary.

The Antigonish Highlands consist of a folded and faulted pre-Silurian eugeosynclinal assemblage overlain by less disturbed Silurian–Devonian sediments. The interlayered volcanic and sedimentary rocks of the Ordovician and older Browns Mountain Group are separated into three divisions characterized by the predominance of acidic volcanics, laminated siltstone, and intermediate to basic volcanics. They were intruded by at least three plutonic assemblages: first, syenodiorite to granodiorite; then, diorite to gabbro; and later, granite. This complex is overlain locally by minor siltstone and wacke, and boulder-conglomerate. The Dunn Point Volcanics, mainly rhyolite and andesite, appear to underlie part of the Silurian Arisaig Group along the coast. In the Kenzieville syncline the basal Arisaig Group unconformably overlies the Browns Mountain Group, and is overlain conformably by the red Devonian Knoydart Formation.

The Paleozoic sequence underlying the Atlantic Uplands is mainly quartzite, phyllite, and minor schist of the Ordovician Meguma Group. These tightly folded and weakly metamorphosed rocks are intruded by Devonian biotite granite. Their northern limit is marked by the West River St. Mary's fault and its extension to the west. The present position of the Meguma Group is due to movement from the southwest, possibly continental drift.

The Carboniferous sediments are mostly nonmarine and were deposited in subsiding basins. The sediments have been only slightly deformed. In the Antigonish basin, the coarse

Horton clastics unconformably overlie the rocks of the highlands and are conformably to disconformably overlain by the marine Windsor Group. The Horton sediments of the St. Mary's River graben are unconformable on the Meguma Group and in fault contact with the highlands. The Carboniferous sequence on the northwest flank of the highlands is almost entirely nonmarine and has a thin marine Windsor section.

The Antigonish Highlands are bounded by several major faults, the Hollow, Browns Mountain, and Chedabucto faults. The Chedabucto fault and the West River St. Mary's fault delineate the St. Mary's River graben. Only the Chedabucto fault displays post-Hortonian movement.

Description of Formations (Antigonish Highlands) North of Chedabucto Fault

Cambro-Ordovician

Browns Mountain Group

Fletcher spent five summers, from 1882 to 1886, investigating the geology of the counties of Antigonish, Guysborough, and Pictou, which included the present field area (Fletcher and Faribault, 1887). He classified the Antigonish Highlands rocks as Pre-Cambrian (?) and Cambro-Silurian, both of which had a large portion of material of volcanic origin. The provisional *Pre-Cambrian* comprised the felsitic rocks of Georgeville, Doctors Brook, and Arisaig, the syenite, felsite, and allied rocks of Keppoch, East River St. Mary's, and Upper Barneys River, and the gneisses, schists, and syenites of Moose River, Blue Mountain, and Sutherland River. The Cambro-Silurian was said to be composed of "1. The lower flinty slates, quartzites and 'whin-like' rocks of James River and Eigg Mountain, 2. The soft reddish and olivaceous slates of Baxter's Brook and Brian Daly's Brook and 3. The reddish and grey sandstone, grit, and conglomerate of Bear's Brook." (op. cit.)

The Browns Mountain Group was regarded as Upper Cambrian and possibly Ordovician by Williams (1911), and subdivided into the James River, Baxters Brook, and Bears Brook formations. He did not completely understand the group, but commented on its complexity due to igneous intrusion and folding. Williams (1914) later considered the Bears Brook Formation to be younger than the Browns Mountain Group, which he redefined to consist of a lower greywacke–slate (James River Formation) and an upper red slate (Baxters Brook Formation) division.

Bell (1940, p. 6) stated that "the Brown's Mountain rocks are mainly greywacke with one zone consisting of andesitic flows associated with cherty quartzite and silicified, tuffaceous sediments" in the McLellan Mountain area near New Glasgow. These rocks were correlated on the basis of lithology with the rocks of the Arisaig area.

Maehl (1961) mapped the pre-Silurian rocks in northeast Pictou County as Browns Mountain Group undifferentiated overlain by a redefined Bear Brook Formation, and to the south subdivided them into the Charcoal and Sunnybrae formations.

The previous investigators observed only limited exposures of the Browns Mountain Group and, although their conclusions were valid for restricted areas, they may not be valid for the entire Antigonish Highlands.

The Browns Mountain Group is redefined in this report as a thick pre-Silurian, probably Cambro-Ordovician sequence of interbedded volcanic, pyroclastic, and sedimentary rocks that are the oldest exposed rocks in the Antigonish Highlands. The base is not exposed. They are unconformably overlain by the Silurian Arisaig Group, the Devonian Knoydart Formation, and Carboniferous sediments, and intruded by Cambrian (?), Ordovician, Devonian, and post-Devonian igneous rocks. The group is subdivided from oldest to youngest into the Keppoch, Baxter Brook, Brierly Brook, and Little Hollow formations, which grade abruptly into one another. The Baxter Brook and Brierly Brook formations appear to grade laterally and may be, in part, facies equivalents.

The best exposures are on Keppoch, Baxter, Brierly, and Doctors brooks, and James River. An approximate maximum thickness of 15,000 feet was interpolated from several incomplete sequences. Previous thickness estimates were given by Williams (1914, p. 52) as 5,500 ± (estimated) feet and by Maehl (1961, p. 26) as possibly more than 15,000 feet.

The fourfold division of the Browns Mountain Group into basal acid volcanics with minor sediments, succeeded by sediments and pyroclastics, then basic volcanics, pyroclastics, and minor sediments, and an uppermost siltstone–quartzite unit is repeated in other nearby Appalachian areas. In southeastern Cape Breton the Middle Cambrian Bourinot Group consists of basal lava flows and pyroclastics, a middle tuffaceous shale and quartzite unit, and an upper volcanic breccia and lava. It is overlain by grey quartzite and shale of the MacMullin Formation (Weeks, 1954, p. 31–53). The Bourinot has been assigned a middle Cambrian age on the basis of contained brachiopods and trilobites. The Cobequid Mountains, to the west of the Antigonish Highlands, are composed in part of a belt of Devonian (?) acidic to basic volcanics underlain by Silurian sediments and volcanics (Kelley, 1967a, p. 175). The Avalon Platform of Newfoundland includes three divisions of late Precambrian rocks: a basal volcanic sequence with minor sediments (Harbour Main and Love Cove groups) intruded by the Holyrood granite (574 m.y.), siliceous slate and greywacke (Conception and Connecting Point groups), and an upper sedimentary unit (Musgravetown, Hodgewater, and Cabot groups) that, in places, includes diverse volcanics (Bull Arm Formation) (Williams, 1969, p. 35–37). These Precambrian rocks are separated from the overlying Cambrian shale–limestone facies by the Random quartzite.

The similarities of these sequences, although of different ages, suggest a related depositional history.

Keppoch Formation. This formation, herein first defined, consists of intermediate to acidic volcanics and pyroclastics with interbedded sediments, and is the basal formation of the Browns Mountain Group. The name is taken from Keppoch Brook, a tributary of Beaver River near the south boundary of the Merigomish (11E/9) map-area. The best exposures are on Keppoch Brook and Garden and Moose rivers, and all three combine to make the type section.

The Keppoch Formation outcrops mainly in the southern half of the Antigonish Highlands. Frasers and MacIsaacs brooks have good exposures of the volcanic rocks and all rock types are found in most other streams. It is difficult to measure a thickness of the formation, but an approximate maximum of 5,200 feet is obtained from both Keppoch Brook and Garden River by assuming that the thicknesses between outcrops are in proportion to their measurements within. No previous estimates of thickness are known to the writer.

The formation consists of light grey to brownish grey and pale red, massive, and porphyritic leucodacite to rhyolite and minor breccia and tuff, light brown metasiltstone, medium grey quartzite, and minor black phyllite.

Table of Formations (north of Chedabucto fault)

ERA	America	PERIOD OR EPOCH	Europe	GROUP	FORMATION THICKNESS (feet)	LITHOLOGY
Cenozoic		Recent			0–10	Stream alluvium (sand, silt, and gravel), and beach sand
Cenozoic		Pleistocene			0–60	Glacial deposits; sand and gravel
				Unconformable contact		
PALEOZOIC	Pennsylvanian	Upper Carboniferous	Westphalian	Pictou	1,400+	Light grey, medium- to coarse-grained arenite and wacke and minor conglomerate
PALEOZOIC	Pennsylvanian	Upper Carboniferous	Westphalian	Cumberland	New Glasgow Conglomerate 650	Medium greyish red pebble- to cobble-conglomerate and interbedded medium- to coarse-grained wacke
PALEOZOIC	Pennsylvanian	Upper Carboniferous	Westphalian	The New Glasgow Conglomerate unconformably overlies the pre-Carboniferous		
PALEOZOIC	Pennsylvanian / Mississippian	Upper Carboniferous	Namurian	Canso	Lismore (northwest of Antigonish Highlands) 6,950	Greyish red and greenish grey wacke, siltstone, and conglomerate; greyish red and light grey mudstone, siltstone, and minor calcareous shale
PALEOZOIC	Mississippian	Upper Carboniferous	Namurian	Canso	(Antigonish basin) 120	Medium grey, fine-grained wacke, siltstone, and silty shale with calcareous layers; minor greyish red siltstone
PALEOZOIC	Mississippian	Lower Carboniferous	Viséan	Windsor	(northwest of Antigonish Highlands) 200	Medium grey argillaceous and oölitic limestone and minor calcareous shale, and medium grey-red mudstone and siltstone
PALEOZOIC	Mississippian	Lower Carboniferous	Viséan	Windsor	(Antigonish basin) 1,000–2,600	Light grey and greyish red mudstone and siltstone, medium grey calcareous shale and argillaceous limestone, minor gypsum, and anhydrite and red conglomerate
PALEOZOIC	Mississippian	Lower Carboniferous	Viséan	The Windsor Group disconformably overlies the Horton Group, and the Canso and Windsor unconformably overlie the pre-Carboniferous		
PALEOZOIC	Mississippian	Lower Carboniferous	Tournaisian	Horton	(near mouth of McArras Brook) 200	Greyish red, fine-grained micaceous wacke and siltstone, cobble-conglomerate and amygdaloidal basalt
PALEOZOIC	Mississippian	Lower Carboniferous	Tournaisian	Horton	Rights River (Antigonish basin) 5,500 ±	Greyish red boulder- to pebble-conglomerate and micaceous wacke. Grey mudstone and argillaceous limestone near base of section

PALEOZOIC	Devonian		The Horton Group unconformably overlies the pre-Carboniferous		
					Dark green, fine- to medium-grained diabase
			The diabase is in intrusive contact with all older rocks except the Arisaig Group and Knoydart Formation		
					Moderate red, medium- to coarse-grained granite
			The granite is in intrusive contact with the Baxter Brook and Brierly Brook formations		
		Gedinnian		Knoydart 900+	Greyish red mudstone, siltstone, and fine-grained wacke; greenish grey and greyish purple shale and argillite
	Devonian / Silurian	Pridoli	Arisaig	Stonehouse 1,375	Bluish grey, calcareous and non-calcareous wacke and siltstone, greenish grey mudstone, shale, and minor siltstone
	Silurian	Ludlow		32 Moydart 350	Red calcareous mudstone Greenish grey mudstone, wacke, and siltstone, minor fragmental limestone
		Ludlow / Wenlock		McAdam 560	Grey mudstone, wacke, shale, calcareous wacke, arenaceous limestone and dark grey wacke with septarian and phosphatic nodules
		Wenlock		French River 175+	Bluish grey, fine-grained wacke and mudstone
		Llandovery		Ross Brook 1,200–1,500	Dark grey mudstone and shale overlain by bluish grey, interbedded mudstone and wacke; minor calcareous beds and tuff laminae; basal black shale
		Llandovery		Beechhill Cove 300	Greenish and bluish grey well-bedded wacke and siltstone; minor shale and massive wacke
				Dunn Point Volcanics 300+	Red rhyolite and tuff, and dark green amygdaloidal andesite and volcanic breccia

PALEOZOIC	Ordovician	The Beechhill Cove is in unconformable contact with the Browns Mountain Group: The Arisaig Group and the Knoydart Formation are in fault contact with the Browns Mountain Group		
				Brownish grey, medium-grained hornblende granite; pale red leucogranite
		Granite is in intrusive contact with the Browns Mountain Group		
			Malignant Cove 350+	Greyish red pebble- to boulder-conglomerate and wacke
		The Malignant Cove is in unconformable contact with the Browns Mountain Group		
				Dark greenish grey to black diorite, hornblende diorite, and gabbro to diorite
		The diorite is in intrusive contact with the Baxter Brook and Brierly Brook formations		
				Light grey to pale red, medium-grained hornblende syenodiorite and granodiorite
		The syenodiorite and granodiorite are in intrusive contact with the Keppoch Formation and the granodiorite possibly intrudes the Brierly Brook Formation		
		Browns Mountain	Little Hollow 850−	Greyish red and dark grey siltstone and quartzite and minor ferruginous wacke
			Brierly Brook 5,800 ±	Dark purplish grey and greenish grey leucoandesite porphyry, lapilli crystal tuff, hornblende and amygdaloidal andesite. Purplish and dark grey agglomerate and breccia, lithic tuff and greywacke.
			Baxter Brook 2,600 ±	Medium greenish grey and light grey with minor reddish grey laminated tuffaceous siltstone, shale, and argillite. Medium greenish grey, fine-grained quartz-feldspar crystal tuff, shale, and silty shale.
	Cambrian		Keppoch	Light grey to brownish grey and pale red, massive and porphyritic leucodacite to rhyolite and minor breccia and tuff. Medium grey quartzite, light brown metasiltstone, and minor black phyllite

Table of Formations (south of Chedabucto fault)

ERA	PERIOD OR EPOCH	GROUP	FORMATION THICKNESS (feet)	LITHOLOGY
Ceno- zoic	Recent		0–25	Stream alluvium
	Pleistocene		0–60	Gravel and sand
Unconformity				
PALEOZOIC	Mississippian, Lower Carboniferous, Tournaisian	Horton	Strathlorne 2,500 ± Ainslie 2,500 ±	Greyish red and greenish grey mudstone and siltstone. Greyish red pebble- to boulder-conglomerate / Medium to dark grey siltstone, shale, and fine-grained quartz wacke. Minor black shale
			Craignish 2,200–4,300 ±	Light to medium grey, fine- to coarse-grained quartz and quartz-feldspar arenite, dark grey siltstone, and minor grit
Unconformity				
	Devonian			Light grey biotite and muscovite granite, minor moderate orange-pink granite
Intrusive Contact				
	Ordovician (?)	Meguma	Goldenville 2,300 ±	Greenish grey to medium grey quartzite, quartz wacke, and phyllite; minor greywacke and andalusite and staurolite schist

The flow rocks have an aphanitic quartz–feldspar–sericite groundmass that displays flow to semifluidal texture, some myrmekitic intergrowths with feldspar and a few quartz veinlets. The irregularly distributed phenocrysts are up to $\frac{1}{2}$ inch long and make up about 40 per cent of the rock. They are plagioclase (oligoclase to andesine) in subhedral to euhedral, polysynthetic and single twinned laths that are slightly sericitized (20 per cent); quartz in angular to rounded, clear to slightly strained grains, some of which are embayed (15 per cent); minor potassium feldspar (sanidine?) in nontwinned, subrounded, slightly sericitized grains; minor, highly altered, mafic minerals that were probably biotite, amphibole, and pyroxene; and scattered fragments of partly resorbed porphyritic volcanic rocks.

Tuff is slightly more altered and is about 55 per cent matrix and 45 per cent lapilli. The tuffaceous matrix is composed of clear, angular to subangular quartz, subangular to subrounded, slightly sericitized plagioclase and fresh to slightly sericitized potassium feldspar, a few leucoxene–hematite grains, and minor hematite dust. The lapilli are light coloured rhyolitic (?) and quartz–feldspar porphyry fragments.

The metasiltstone is, in part, faintly laminated and grades into argillite and fine-grained tuff. The metasiltstone is similar in mineral composition to the tuff. In many sections it is difficult to differentiate between the tuff and breccia, and interbedded metasiltstone and minor amounts of medium- to coarse-grained greywacke.

Quartzite varies from light grey to white on Moose River, and from light to medium grey on Garden River. It consists of about 90 per cent quartz and minor feldspar grains with an argillaceous matrix.

Dark grey to black, sheared and crenulated phyllite outcrops on Moose and Garden rivers where it is interbedded with porphyritic volcanics and metasiltstone. Thin sections display an augen-like texture, within a laminated shaly siltstone matrix. The phyllite was probably derived from an argillaceous metasiltstone.

The rocks of the Keppoch Formation are generally massive, except near fault zones where they are highly sheared and crenulated in a manner resembling schistosity. Specularite and quartz are common in the fractures, and rusty weathering pyrite cubes occur near the faults. Three intersection cleavages were observed in one outcrop near the fault along Moose River. The axial plane of a minor drag-fold and the cleavage intersect at an angle of 40 degrees in an outcrop of highly fractured and contorted siltstone and porphyritic volcanics on the headwaters of Garden River.

The massive volcanics break into angular fragments, and several outcrops have steeply dipping joints. The porphyritic volcanics commonly have narrow quartz veins.

On Keppoch, Beaver, and MacIsaacs brooks tuff and breccia are more common than elsewhere, and isolated thin andesite beds are interlayered with the acidic volcanics. Networks of specularite and calcite veinlets, and single quartz veins, are minor constituents of the breccia.

The attitudes recorded in the Keppoch Formation are almost all bedding of intercalated metasiltstone, although some are flow bands in the porphyritic flows.

The base of the formation is not exposed, and it is believed to be the oldest rock in the Antigonish Highlands. Minor amounts of basic volcanics and laminated siltstone are found within the Keppoch Formation, which appears to grade rapidly into the overlying Baxter Brook and Brierly Brook formations. Thus the formation top is placed at the base of an overlying continuous layer of either tuffaceous siltstone of the Baxter Brook Formation or andesitic volcanics of the Brierly Brook Formation. Windsor conglomerate and calcareous sediments unconformably overlie the Keppoch Formation near St. Joseph and northeast of Eden Lake. The unexposed Arisaig Group–Keppoch Formation contact south of Smith Lake is inferred to be an unconformity.

The hornblende syenodiorite and granodiorite is believed to intrude the Keppoch Formation. No contact metamorphism was observed nor are there any plutonic fragments in the adjacent volcanic rocks; thus the contact is probably not an unconformity. The plutonic bodies may be the intrusive equivalents of the flows and represent the site of the ancient volcanic conduits. The syenodiorite body at the northeast end of Eden Lake has been dated as 582 $\pm$ 32 m. y. (*see* p. 21), and the Keppoch Formation is interpreted as Early Cambrian or older.

The Keppoch Formation was probably deposited in a eugeosyncline with thicker flows nearer the volcanic centres and the pyroclastics deposited intermittently as laminae or thick accumulations throughout the area. The few sediments were derived from the early volcanics.

Baxter Brook Formation. The formation, herein defined, consists of laminated, fine-grained siltstone, shale, argillite, and tuff with minor interbedded andesite. It is exposed throughout the Antigonish Highlands, and the best exposures are on Baxter Brook, a tributary of Barneys River near the settlement of Marshy Hope.

Fletcher (1887, p. 22P) referred to one division of the Cambro-Silurian as the "soft slates of Baxter's and Brian Daly's Brooks" which he stated "consist largely of contemporaneous volcanic materials." No values were given for the thickness of these sections. Williams (1914, p. 52) listed an estimated thickness of 500$\pm$ feet for the Baxters Brook. Maehl (1961, p. 26) estimated the lower Browns Mountain Group (equivalent to the Baxter Brook and Brierly Brook formations), to be at least 10,000 feet thick in eastern Pictou County. The exposures on James River, Baxter, Campbell, Middle, and Powers brooks, a tributary of Brierly Brook, were measured by the author and the results extrapolated to give a maximum thickness of approximately 2,600 feet for the Baxter Brook Formation.

The most common rocks of the Baxter Brook Formation are faintly laminated, tuffaceous, fine-grained siltstone, shale, and argillite that are medium greenish grey and light grey; some are reddish grey. There are minor amounts of interbedded, medium greenish grey, fine-grained greywacke, fine-grained quartz-feldspar crystal tuff, shale, and silty shale.

The siltstone consists primarily of subangular to angular quartz grains from 0.02 to 0.08 mm in diameter in an argillaceous matrix. Detrital muscovite is rare. Quartz is generally strained and contains numerous bubble inclusions. The smaller quartz grains are generally more angular and include shard-like grains that appear to be of pyroclastic origin. The sericite and chlorite probably were derived from feldspar and argillaceous material. In the coarser varieties the silt-to-matrix ratio is about 5 to 1, which decreases sharply in the shale and argillite. In some of the coarse-grained siltstone there is a strong alignment of the silt grains parallel with bedding. The bedding is defined by the relative amounts of argillaceous and silt-sized material and changes in matrix composition, and often results in colour laminations. Pronounced colour laminations are caused by limonite among angular grains from 0.02 to 0.10 mm on Baxter Brook; by pyrite among 0.025 to 0.050 mm quartz grains in an extremely fine grained argillaceous matrix on Camerons Brook; and by carbonaceous (?) material on James River and Brierly Brook. Other accessories include calcite in veinlets, pyrite cubes, and rare magnetite grains. The finer grained sediments grade into tuffaceous rocks composed almost entirely of angular fragments of quartz and feldspar up to 0.16 mm in diameter. A few hand specimens were believed to be quartzite. However, no recrystallization was evident in thin section, and their mineralogical composition was nearly identical to the tuffaceous siltstone.

The siltstone occurs in massive beds from 2 to 6 inches thick or in faintly to markedly laminated sequences. Cleavage, where present, parallels laminations in a few outcrops. Minor crenulations were observed in the laminated siltstone near faults, and all rocks types are generally highly fractured in the fault zone. The fractured rocks contain quartz veins up to 4 inches wide and narrower calcite veinlets. Calcite veinlets are also found in slightly fractured rocks, remote from an apparent fault zone.

Top determinations indicate a variety of age relationships. On James River, for example, laminated siltstone overlies fine-grained greywacke and is overlain by leucoandesite in one outcrop, overlies andesite in another, and is interbedded with greywacke in a third. However, the general indication is that, although minor basic flows and greywacke are interbedded with the Baxter Brook Formation, most are part of the Brierly Brook Formation and overlie the Baxter Brook Formation.

The contact with the underlying Keppoch Formation is gradational, and the base of the lowest laminated siltstone bed is arbitrarily chosen as the base of the Baxter Brook Formation. Lateral and vertical gradation into the Brierly Brook Formation makes it more difficult to define and locate this contact. As there are minor thin andesite flows within the Baxter Brook Formation, the contact with the overlying Brierly Brook Formation is placed at the base of the lowest flow in a continuous volcanic section.

On Powers Brook, east of Brierly Brook, the attitudes of the siltstone with black carbonaceous (?) laminations suggest the presence of plunging synclines and anticlines. On Sutherland River several small folds, 1 foot to 4 feet across with a plunge of 15 degrees, were seen in a highly fractured outcrop.

The mineral composition, particularly the quartz grains, suggests that the sedimentary rocks were derived mainly from the siliceous volcanics of the Keppoch Formation and the syenodiorite and granodiorite intrusives. The interbedded volcanics are related to the volcanism associated with the Keppoch and Brierly Brook formations, and the greywacke and coarser sediments appear to have been derived during periods of increased volcanic activity.

The Baxter Brook Formation is overlain by the lower Silurian Beechhill Cove Formation, intruded by granite dated as upper Ordovician, and is younger than the Keppoch Formation and syenodioritic intrusives. It is, therefore, pre-upper Ordovician and post-lower Cambrian.

Brierly Brook Formation. The third new formation name proposed for the Browns Mountain Group is the Brierly Brook Formation. It consists of intermediate to basic volcanics and associated tuff, breccia, and greywacke, with minor, interbedded, laminated argillite. The name is taken from Brierly Brook, a small brook flowing south from the Antigonish Highlands near the town of Antigonish.

The Brierly Brook Formation is exposed in all parts of the Antigonish Highlands. The best exposures are on Brierly Brook, and other good exposures occur on Sutherland River, Black Brook, and Barneys River. An estimated maximum thickness of 5,800 feet is based on examination of several incomplete outcrop sections.

A number of extremely variable rock types are found in this formation: dark purplish grey and greenish grey leucoandesite porphyry, lapilli crystal tuff, amygdaloidal andesite, and hornblende andesite are the most common; purplish and dark greenish grey andesitic agglomerate and breccia, lithic tuff, and greywacke with mainly igneous rock fragments are widely distributed; and there are minor local occurrences of dark grey dacite and greenish grey, laminated argillite.

Petrographic examination revealed a similar mineral composition in most rocks. The feldspar is predominantly euhedral to anhedral plagioclase crystals altered to kaolin and sericite with a composition of sodic andesine. No zoned feldspar was observed, but polysynthetic and single twinned laths are common. The composition of the fine-grained plagioclase crystals in the matrix was not determined. A few unaltered grains of orthoclase were observed in the tuffaceous rocks. The mafic minerals are almost entirely altered to chlorite, but in a few thin sections rare hornblende, and clinopyroxene (pigeonite?) in prismatic grains now altered to muscovite, leucoxene, and chlorite were identified. Minor amounts of iron oxide, pyrite, and silica are the only common accessories.

Flow structure is visible in the groundmass and is indicated by aligned plagioclase laths in most porphyritic andesite thin sections. In two thin sections the rock has irregular flow layers with differing composition, some characterized by euhedral plagioclase laths parallel to the flow and others with partly resorbed, flow-banded volcanic clasts. One thin section has numerous amygdule-like masses of chlorite that may be altered olivine. The composition is about 40 to 50 per cent porphyroblasts; the rest is finer grained matrix.

The andesitic volcanics in a few sequences grade into slightly more acidic, fine-grained varieties. These flows are mappable as a separate unit south of Barneys River, but individual flows are seen throughout the map-area. A small amount of presumed Brierly Brook Formation enclosed in a fault slice on Iron Brook consists of dark grey andesite, medium greyish red porphyritic rhyolite, and a small syenitic intrusive stock. This is the most acidic variety found in the Brierly Brook Formation and is probably a very young flow. The examined thin sections appear to be either dacite or, less commonly, possibly trachyandesite. The dacite has a fine-grained diabasic texture and consists of plagioclase laths with a composition of about oligoclase, a few of which are zoned; smaller amounts of potassium feldspar, probably orthoclase; from 5 to 10 per cent quartz in separate grains and in narrow (0.08 mm) veinlets; chlorite formed from the alteration of pyroxene (?); minor hematite and pyrite; and a few needles of tremolite (?) in the quartz.

The tuffaceous rocks contain from 55 to 65 per cent lapilli to ash fragments. The fragments are commonly fractured and consist of twinned plagioclase grains, siliceous volcanic material, intermediate volcanic material, and a few quartz grains in a fine-grained matrix, which, in places, shows flow texture composed of chlorite, iron oxide, and plagioclase. The greywacke has a similar composition, except that intermediate volcanic fragments are more common and no flow structure occurs in the matrix. The argillite is composed of angular quartz grains in an argillaceous matrix, and is similar to that found in the Baxter Brook Formation.

Structure within the Brierly Brook Formation is delineated mainly by the sediments. The volcanics are generally massive and attitudes are indicated only by flow lines. Many outcrops are highly fractured and have associated narrow quartz veinlets, pyrite cubes, and a few specularite veinlets in the basic volcanics.

An increase in the amount of fracturing and intense shearing is observed in all major fault zones. The volcanics generally have a chloritic sheen on the fracture surfaces and serpentine veinlets are rare. The andesite porphyry on Callaghan Brook and Beaver River display cataclastic texture, due to the fault on Beaver River and perhaps related to the emplacement of the granite on Callaghan Brook.

The formation has a gradational contact with the underlying Baxter Brook and Keppoch formations. The base of the section is placed at the bottom of the lowest andesite flow in a predominantly volcanic section. The exposures on James River and South Rights River suggest that parts of the Brierly Brook and Baxter Brook formations are interbedded. There are several examples of andesite interlayered with laminated, fine-grained, tuffaceous siltstone. Single andesite flows that are too thin to differentiate are included in the Baxter Brook Formation. The Little Hollow Formation conformably to disconformably overlies it on Iron Brook and East Doctors Brook. The contacts with the younger Malignant Cove Conglomerate and the Silurian Arisaig Formation have been interpreted as unconformities.

Contact metamorphism has affected most of the rocks near the Ordovician granite and, to a lesser degree, those near the Devonian granite. There are numerous narrow ($\frac{1}{2}$- to 2-inch) aplite dykes and networks of quartz veinlets that are related to the adjacent granite bodies near Brora and Gunn lakes, Barneys River, Ohio River, and Georgeville. The intruded andesitic lava has been metamorphosed to amphibolite hornfels at the contact on Black Brook and near Laggan. The fabric of the amphibolite hornfels grades from hornfelsic to granoblastic with strongly sheared zones. It consists of 55 to 60 per cent fresh to strongly altered (sericitized and saussuritized) plagioclase with some polysynthetic twinning; 35 to 40 per cent amphibole (hornblende or actinolite (?)) in euhedral to anhedral, fresh to altered grains; and magnetite, apatite, chlorite, leucoxene, pyrite, and sphene as accessories. Minor amounts of volcanic fragments were assimilated by the Gunn Lake and Barneys River plutons. Several small roof pendants of volcanic material occur in the granite on the headwaters of Barneys River. A small amount of siliceous hornfels on McIver Brook is not near any known igneous body.

The Brierly Brook Formation represents part of an eugeosynclinal assemblage developed during a period of intense volcanic activity. The volcanic rocks probably issued from several volcanic rocks centred in three areas where volcanic rocks and dioritic intrusives are now found: Upper Barneys River, eastern Browns Mountain, and Cape George, near Georgeville.

The Brierly Brook Formation is unconformably overlain by fossiliferous basal Silurian rocks along French River, is intruded by Devonian granite on James River, upper Ordovician granite on Beaver River, and appears unaffected by the Cambrian (?) syenodiorite of Eden Lake (*see* p. 21). The Brierly Brook Formation which generally overlies the Baxter Brook Formation is, therefore, assumed to be Lower to Middle Ordovician.

Little Hollow Formation. This is the name proposed for a sequence of fine-grained arenaceous sediments at the top of the Browns Mountain Group. The name Little Hollow has been applied to the valley of Iron Brook (from the time of Fletcher's survey of the area in 1886 until the present). The best exposures are on Iron Brook, a tributary of Doctors Brook, and it is designated as the type section.

There are also a few exposures on East Doctors Brook, and the Nova Scotia Department of Mines drilled two holes on Iron Brook. The thickness as estimated on Iron Brook is about 850 feet.

Most exposures are greyish red and light to dark grey siltstone, fine-grained wacke and quartzite, and minor, greyish purple, ferruginous wacke.

The siltstone and wacke are composed mainly of angular to subangular quartz grains from 0.05 to 0.2 mm in diameter. The quartz shows deformation lamellae, numerous bubble trains, and strained extinction. The edges of many grains are extremely pointed, and these may be tuffaceous fragments. Quartz veinlets are minor, late, and narrow (0.2 mm). Lineation of the quartz grains is not apparent, although accessories such as muscovite may be concentrated in discontinous lamellae. Chlorite occurs in minor amounts and seems to be secondary after detrital pyroxene. A few siliceous rock fragments found in the wacke are probably derived from siliceous volcanics. A small amount of interstitial calcite occurs, but the groundmass is mainly kaolinized. Hematite and pyrite are minor accessories in the wacke.

The ferruginous wacke consists principally of subangular to angular quartz fragments that also show deformation lamellae and strained extinction and have numerous bubble inclusions. Most are about 0.1 mm across, but larger aggregates and a few smaller grains were seen in all sections. The cement is almost entirely hematite with only minor amounts of calcite and kaolinized groundmass. There are a few small (0.1 mm) rounded grains of hematite, some with quartz nucleii, that probably are of oölitic origin.

The quartzite consists of subrounded to subangular quartz grains about 0.2 mm in diameter. The grains are full of bubbles, and only some of them are recrystallized. Narrow late quartz veinlets and minor interstitial calcite occur. The only accessory observed was chlorite, apparently altered from pyroxene.

The exposures on Iron Brook are steeply dipping and this suggests that they are the south limb of a syncline. Attitudes were determined with difficulty, and only one top determination was made. The basal contact was not observed, although the outcrops nearest the contact suggest an unconformable contact with the Baxter Brook Formation and a conformable to unconformable contact with the Brierly Brook Formation. It is in fault contact with a slice of Brierly Brook rock to the north. The Little Hollow Formation is disconformably overlain by the Beechhill Cove Formation of the Arisaig Group.

The rocks of the Little Hollow Formation were affected by minor metamorphism, as indicated by the recrystallized quartzite, and the lack of metamorphism in the ferruginous wacke.

Much of the quartz of this formation is of volcanic, and probably tuffaceous origin. A purely tuffaceous origin is ruled out because of the scarcity of rock fragments and the essentially monomineralic composition of the formation. Most of the Browns Mountain volcanics and associated intrusives nearby are of intermediate composition, except for the porphyritic rhyolite in the fault slice immediately to the north. The Baxter Brook Formation of East Doctors Brook, as elsewhere, contains angular quartz fragments of probable pyroclastic origin. The rocks of the Little Hollow Formation were derived from a regolith developed on the older Browns Mountain Group rocks, with a few added quartz grains of primary pyroclastic origin. These sediments were deposited on the flank of the developing Antigonish Highlands.

Williams (1914, p. 55) reported on fossils found in the "iron ore" and "schistose micaceous sandstone" on East Doctors Brook that were identified as *Obolus* (*Lingulobus*) *spissa* and *Lingulella* (?) and correlated the "iron ore" and the fossils with the Lower Ordovician of Belle Isle, Newfoundland.

Recent collections made on Iron Brook yielded only indeterminable brachiopods, and a single sample from East Doctors Brook had organic (trilobite?) remains, but no identification was possible.

The Little Hollow Formation is interpreted as Ordovician, probably Lower to Middle Ordovician.

Malignant Cove Formation

The Malignant Cove Formation consists of greyish red pebble- to boulder-conglomerate and wacke. Williams (1914, p. 58) used the name for the "coarse conglomerates and grits" that outcrop near Malignant Cove. The only exposures are along Malignant Brook, for about a half mile south of its mouth, although Bell (1940, p. 7) regarded the lithologically similar Stewart Brook Formation of Pictou County as provisionally correlatable with it.

Attitudes observed in the wacke lenses suggest a thickness of about 250 feet, contrasted with Williams (1914, p. 58) statement that "the observed thickness of these sediments is about 20$\pm$ feet, but the original thickness was probably much greater."

Greyish red, silicified pebble-conglomerate, grading into boulder-conglomerate and locally into granule-conglomerate, is the most common rock type. The rounded to subangular clasts are mainly volcanic, of andesitic and dacitic composition, with some pink quartz and greywacke. The degree of silicification of the rock and the angularity of the predominantly volcanic fragments in one or two outcrops have resulted in conglomerate resembling a volcanic breccia. The coarse-grained wacke consists of more angular fragments, also derived from volcanic terrain, and occurs in narrow lenses. The wacke rarely grades into siltstone.

There are a few narrow quartz veinlets, and parts of the sequence are calcareous. Several narrow diabase dykes intrude the Malignant Cove Formation. The dykes and the quartz veins have produced narrow altered zones in the sediments.

The sediments dip at angles from 60 degrees to vertical, but generally the bedding in the conglomerate is indeterminable. The beds are right-side-up with tops to the north, including a single, apparently overturned bed that dips 60 degrees to the south. The wacke along the bedding planes is sheared in several instances, and the shearing is also evident in thin section.

The Malignant Cove Formation at one location is in nonconformable contact with dark green amygdaloidal andesite of the Brierly Brook Formation. Andesite and minor dacite outcrop upstream in Malignant Brook and to the east, but the contact with the Malignant Cove Formation is exposed only once. The contact is interpreted as an unconformity. The silicified sediments are overlain, probably unconformably, by minor amounts of poorly consolidated conglomerate of similar mineralogical composition.

The Malignant Cove Formation is interpreted as a small outwash deposit of terrestrial, essentially fluviatile sediments with limited transport that were derived from, and deposited on the Browns Mountain Group. Deposition may be related to possible uplift accompanying intrusion of the Ordovician granite. The formation could be the same age as the Arisaig Group, but the apparent absence of fragments younger than Browns Mountain Group suggests an older age. The interpretation of minor overlying conglomerate as Carboniferous, and the greater degree of silicification of the Malignant Cove relative to the Carboniferous Horton conglomerate, indicate a pre-Carboniferous age. Thus a tenuous age of Middle to Late Ordovician is proposed. If some of the volcanic clasts were derived from the Dunn Point Volcanics, the age would be latest Ordovician or earliest Silurian, but probably older than the Beechhill Cove.

Intrusive Rocks

Three phases of Cambro-Ordovician intrusive activity are associated with the Browns Mountain Group. The contacts of these intrusive rocks and the volcanic–sedimentary assemblage were not observed, and the age relationships suggested by present outcrops are open to other interpretations. The intrusive phases are probably related to the volcanic activity and are, therefore, intrusive into volcanics in one location and overlain by similar, but younger volcanics elsewhere. Volcanics of the same age may be intruded by one pluton and overlie similar, but older intrusives elsewhere.

Syenodiorite and Granodiorite. The oldest intrusive rocks are light grey to pale red, medium-grained hornblende syenodiorite and granodiorite that outcrop near Eden, Smith, and Haggard lakes in Lochaber map-area.

The Eden Lake outcrops are probably one pluton that is partly nonconformably overlain by Brierly Brook volcanics and therefore resembles two separate bodies. The Eden Lake syenodiorite pluton varies from medium to coarse grained and in hand specimen is composed of grey feldspar, pink feldspar, quartz, hornblende, and minor epidote and pyrite. Colour variation, from light grey to pinkish grey, is accompanied by a decrease in the relative amount of quartz. The outcrops are generally highly fractured. The small granitic veins intruding the adjacent basic volcanics are believed to be related to younger granitic rocks.

Thin sections show a hypidiomorphic-granular texture and a composition of 70 to 80 per cent twinned and zoned, fresh to strongly sericitized plagioclase about An_{25} (oligoclase) and minor orthoclase; 10 to 15 per cent light to dark green hornblende partly altered to chlorite; 5 to 15 per cent fractured and strained quartz; minor epidote, and brown biotite largely altered to chlorite, and traces of sphene and fresh needles of apatite. Cataclastic texture is well developed in some specimens.

The Smith Lake pluton is associated with other igneous rocks varying from massive, medium pinkish grey syenite (?) porphyry to medium greyish purple felsite (latite?), and it is difficult to separate the porphyritic volcanics from the intrusive rocks in some outcrops. The syenodiorite–granodiorite is believed to be an intrusive phase related to the Keppoch Formation that is generally younger than the extrusives.

The Eden Lake body was radiometrically dated by the K-Ar method using clean, dark green hornblende with trace impurities of quartz and mica (Wanless *et al.*, 1967, p. 25). The results are as follows:

Sample No.	%K	Ar^{40}/K^{40}	$\%Ar^{40}$	Age x 10^6 m.y.
K-Ar 1283	0.605	0.0399	86	582 ± 32

The date of 582 ± 32 m.y. indicates an Early Cambrian or Late Precambrian age if the proposed time scale of the Geological Society of London (1964) is used. If this age is accepted, it indicates an early Cambrian or late Precambrian period of volcanism and related intrusive activity. A similar syenodiorite body in the Coxheath Hills, near Sydney, N.S., dated as 584 ± 28 m.y. (Wanless *et al.*, 1967, p. 129) intrudes a folded sequence of volcanics and sediments, previously defined as pre-Middle Cambrian (Bell and Goranson, 1938), and now regarded as early Cambrian or late Precambrian. The intrusives of Eden, Smith, and Haggard lakes and the Coxheath Hills are assumed by the author to be Lower Cambrian.

Dioritic Rocks. Dark greenish grey to black diorite, hornblende diorite, and intrusive bodies that vary from diorite to gabbro are found throughout the entire Antigonish Highlands, usually in association with the basic volcanics of the Brierly Brook Formation. The surface area of these bodies ranges from about ¼ square mile to 4 square miles.

Most of these intrusions produce positive aeromagnetic anomalies, as shown on the Merigomish sheet (Geol. Surv. Can. Map 1775 G). Aeromagnetic maps of the Lochaber map-area and the southwest corner of the Merigomish map-area, prepared by the Nova Scotia Department of Mines, indicate several positive anomalies correlative with the dioritic bodies. On all these maps there are positive anomalies that do not have correlative surface geological features, suggesting that the causative geological features are at depth.

The dioritic varieties are dark green, medium greenish grey, dark grey, and rarely, mottled greenish grey and black, medium to fine grained, with porphyritic phases common in the larger bodies. The feldspar and mafic minerals, generally highly altered to chlorite, and minor pyrite are recognizable in most hand specimens. The feldspar phenocrysts appear to be plagioclase in most samples. Identifiable hornblende phenocrysts, some up to 5 cm long, are found near the quarry at Georgeville. Very minor foliation of the platy minerals, notably biotite, was observed in the larger intrusives northeast of Malignant Cove.

Most thin sections display hypidiomorphic-granular texture, however, identification of the highly altered feldspar laths and mafic minerals was not always possible. Feldspar, which comprises about one half of the thin sections, was determined to be from An_{15} to An_{35}, oligoclase, and rarely, andesine. The plagioclase is highly altered to sericite, and a few zoned grains were observed. There are minor amounts of less altered interstitial feldspar in some sections, and it was generally identified as orthoclase. Quartz grains, approximating less than 2 per cent, were visible in two sections.

Thirty to forty per cent of the sections is composed of amphibole and its alteration products. Hornblende, the predominant amphibole, occurs as two types, one primary and the other secondary; the latter is found in minor amounts. Actinolite occurs as the reaction product from pyroxene, probably augite. Chlorite and biotite replace the amphiboles, and some of the biotite is replaced by chlorite.

The pyroxene content, although generally less than 10 per cent, approaches 30 per cent in the gabbroic rocks where it is the main mafic mineral. Most was identified as clinopyroxene, probably augite, although pigeonite was found in four sections and hypersthene in one. The pyroxene is altered to amphibole (actinolite, where identifiable) and to chlorite.

Pyrite and pyrrhotite are common accessory minerals in most sections, and apatite, sphene, ilmenite, and olivine altered to serpentine, were present in trace amounts in a few thin sections. One outcrop contained minor allanite in a biotite vein.

Thin sections from the dioritic bodies near the Browns Mountain Fault have minor calcite veinlets.

The spatial relationship of these intrusives to the basic volcanics of the Brierly Brook Formation, their comparative mineralogy, including the presence of pigeonite, and their apparent similar ages suggest that most bodies are the intrusive equivalents of the volcanic rocks.

A dark hornblende concentrate was obtained from medium green, medium-grained micaceous diorite near the headwaters of West Barneys River. This diorite and the adjacent basic volcanic rocks are cut by aplite dykes related to a nearby granite stock. The 411 ±20 m.y. K-Ar age for the diorite represents a minimum age for the diorite and the volcanics owing to probable updating by the granite (Wanless *et al.*, 1967, p. 126).

Sample No.	%K	Ar^{40}/K^{40}	$\%Ar^{40}$	Age x 10^6m.y.
K-Ar 1305	0.55	0.0269	80	411 ±20

The dioritic rocks are, therefore, assumed to be Lower to Middle Ordovician and intruded during deposition of the entire Brierly Brook Formation, with a few small bodies intruded at the close of volcanic activity. The dioritic rocks have previously been regarded as Precambrian (Fletcher, 1892, p. 8P), Lower Ordovician (Geol. Surv. Can. Map 910A) and Lower and/or Middle Devonian (Nova Scotia Dept. Mines, Geological Map of Nova Scotia, 1965).

Granitic Rocks. Brownish grey, medium-grained hornblende granite to syenite is exposed in the southern portion of the Antigonish Highlands in several small stocks near Upper Barneys River, Brora Lake, Beaver River, and west of Eden Lake. The pale red granodiorite to granite bodies exposed near Gunn Lake, Ohio River, and Georgeville, on Cape George, are probably related to the granite–syenite, although minor bodies may be related to the Cambrian syenodiorite and granodiorite.

The granite–syenite is light brownish grey, pale red or medium grey, medium to coarse grained, with visible hornblende or biotite. The Upper Barneys River stock contains several large inclusions of basic volcanic material and, near the contact with the intruded volcanics, hornblende crystal aggregations are up to 5 inches long. Several outcrops, in particular those along Beaver River, are moderately sheared. The interior of the Brora Lake intrusive changes abruptly from pale red granite to grey granodiorite. The granodiorite is included with the similar Cambrian rocks.

Feldspar comprises 50 to 70 per cent of the thin sections examined. Orthoclase and microcline predominate with lesser amounts of albite–oligoclase. Most feldspar is moderately to highly altered to sericite, although fresh albite reaction rims were found in three sections.

Exsolution of the feldspars is demonstrated by numerous perthitic intergrowths. Quartz content ranges from 2 to about 25 per cent. Moderate straining is evident in all thin sections, with no increase toward the border of the plutons. The mafic minerals comprise about 5 to 15 per cent, mainly varying proportions of hornblende and biotite. The hornblende is generally green and partly altered to chlorite. The Upper Barneys River body displays poikiloblastic hornblende, and the hornblende in the Beaver River body is fractured. The biotite, which is also altered to chlorite, displays bending of the biotite cleavage flakes. Minor accessories include pyrite, epidote, and fibrous stilpnomelane.

Relatively clean concentrate of slightly altered olive-green biotite with 5 per cent hornblende contamination was obtained from pale red, medium-grained biotite granite on Beaver River. A K-Ar age determination on this sample yielded a date of 432 ± 18 m.y., suggesting latest Ordovician or early Silurian age (Wanless *et al.*, 1967, p. 126).

Sample No.	%K	Ar^{40}/K^{40}	$\%Ar^{40}$	Age x 10^6m.y.
K-Ar 1291	6.07	0.0284	97	432 ± 18

The stock cuts Browns Mountain volcanic and sedimentary rocks, and cobbles of similar granite occur in Lower Carboniferous (Horton) conglomerate to the east.

The granodiorite to granite is pale reddish brown to light greyish pink, medium to coarse grained and, in places, has a rusty weathered surface due to contained pyrite blebs. The rocks are composed almost entirely of feldspar, including considerable plagioclase, and quartz. The Gunn Lake and Ohio River intrusives are too deeply weathered to obtain a fresh sample for an age determination.

The rocks of the Gunn Lake stock are slightly cataclastic, allotriomorphic to hypidiomorphic, granular, and medium to coarse grained. The feldspar content is either 60 to 70 per cent perthitic intergrowths or 60 to 70 per cent mainly plagioclase. The anhedral potassium feldspar is partly altered to kaolinite and has fractures filled with secondary quartz, fresh plagioclase, and minor iron oxide (magnetite?). The plagioclase has prominent polysynthetic and single twinning and is slightly to strongly sericitized and saussuritized. Some of the plagioclase grains are fractured, bent, and strained. Plagioclase determinations ranged from An_{30} to An_{10}, that is, from oligoclase to albite. Quartz, which comprises from 20 to 35 per cent of most thin sections, occurs as equidimensional, angular to subrounded or interstitial grains. It displays undulatory extinction and is strongly fractured. Accessory minerals include minor sericite–muscovite, iron oxide, interstitial carbonate, and sphene. The rock may have originally been a granite that was strongly granulated and later recrystallized. The Ohio River intrusive consists of about 30 per cent potassium feldspar, mainly orthoclase; 40 per cent sodic plagioclase, twinned and some slightly zoned; and 25 per cent quartz. The accessories include about 2 per cent chlorite–biotite and traces of leucoxene and iron oxide. This quartz–monzonite to granite body is relatively fresh compared to the Gunn Lake body, however, the plagioclase and potassium feldspar are, respectively, strongly and slightly kaolinized.

A greyish pink to pinkish grey granodiorite pluton intrudes the Baxter Brook Formation on the coast near Georgeville. Several narrow (less than 3 feet) dykes cut the sediments and, in one instance, the main pluton. The medium- to coarse-grained rock consists of about 70 per cent plagioclase (albite–oligoclase) and orthoclase, partly as perthite; 25 per cent milky to colourless quartz; minor muscovite and chlorite and scattered traces of pyrite and chalcopyrite. The pegmatite dykes contain up to 10 per cent green microcline, in crystals up to 4 inches long, associated with disseminated pyrite, chalcopyrite, and radioactive crystolite. The main pluton has a few quartz grains with muscovite-filled fractures and other minor evidence of cataclasis.

The basic volcanics of the Brierly Brook Formation are strongly metamorphosed to amphibolite hornfels and are, in part, fractured at the contact with the Gunn Lake and Ohio River stocks. Hornfels was also developed at the contact of the Georgeville stock. No recognizable fragments from these stocks were observed in any younger sedimentary rocks, although cobbles and boulders are common in glacial deposits. Their metamorphic aureole, cataclastic texture, and similarity to the Beaver River stock support a suggested Ordovician age. The Ordovician intrusives in the northern Appalachian indicate widespread Taconic igneous activity (Lyons and Faul, 1968, p. 309), and these plutons were probably intruded during the Taconic Orogeny.

Dunn Point Volcanics

The Dunn Point Volcanics are defined as consisting of red rhyolite and tuff underlain by dark green amygdaloidal andesite and volcanic breccia, and unconformably overlying the Browns Mountain rocks. Dunn Point, a small point about a half mile west of the mouth of Doctors Brook, displays good exposures of both rhyolite and andesite. The volcanics are exposed along the shore from Arisaig Point to Malignant Cove. All rock types are present in the type section between Arisaig Point and the mouth of Doctors Brook.

Individual sections 50 to 60 feet thick have been measured, but an accurate estimate of total thickness is not possible due to the lack of continuity of any horizons. The volcanics are overlain by the Beechhill Cove Formation. A very rough estimate is about 100 feet for the rhyolite and associated tuff and 200 feet for the andesite and associated rock types. Williams, (1914, p. 34) stated, "At the base of the Silurian is an old rhyolite flow, probably about 200 feet in thickness." He did not estimate the thickness of the andesite. No other thickness estimates have been reported.

The andesite is generally exposed to the seaward and is overlain toward the land by the rhyolite. There are several outcrops which indicate that the andesite overlies the rhyolite, and east of Doctors Brook a banded rhyolite flow is enclosed by two andesite flows, each about 6 feet thick.

The most common rock is very dark green or red amygdaloidal andesite, with vesicular phases, that outcrops as individual wedge-shaped flows up to 30 feet thick. The vesicles are filled with quartz and chlorite; there are prominent quartz veins. These flows are interbedded with red and green lapilli tuff agglomerate and volcanic breccia. The flows display spheroidal weathering, which probably developed from columnar jointing. There are several interbedded layers of reddish and black shale.

A distinct laterite zone was developed at the top of many flows. The laterite zone is underlain by spheroidal andesite, a zone of columnar jointing, and then relatively unaltered andesite. The laterite surfaces are channelled locally, and the bases of the overlying andesite flows, in places, contain small blocks of laterite. A few laterite beds have a sharp contact with the underlying unweathered andesite, unlike the normal gradational contact, suggesting that they were transported before deposition.

The andesite consists of plagioclase (andesine) and chlorite phenocrysts in an andesine–quartz groundmass. The plagioclase is partly epidotized, and the chlorite has developed from pyroxene, mainly enstatite.

The rhyolite forms prominent outcrops, such as at Arisaig pier and Frenchmans Barn. The rhyolite is typically porphyritic and has distinct flow banding in shades of red, yellow, green, and blue. Well-developed parting, parallel to the flow banding, locally resembles cleavage. Quartz veins are common. Several beds of spotted red tuff with white feldspar phenocrysts are interbedded with the rhyolite flows. The surfaces of the individual flows have also been deeply weathered and converted to laterite. The rhyolite is overlain gradationally by a thin cobble-conglomerate, a few feet thick, which in turn is overlain by red and green shaly pebble- and granule-conglomerate. These subangular, poorly sorted conglomerates are lateritic and were transported but a short distance.

The volcanics were deposited subaerially on an old land surface, probably composed of the Browns Mountain Group. The volcanic activity began with the extrusion of andesitic flows, which in many cases were deeply weathered before deposition of succeeding flows. Rhyolitic extrusions gradually succeeded the more basic flows so that some interlayering occurred.

The rhyolite is disconformably overlain by Beechhill Cove sediments and minor tuff laminations are found as high as the lower Ross Brook Formation, suggesting continued volcanic activity into the lower Silurian. Fullager and Bottino (1968) analyzed twelve whole rock samples from the Dunn Point Volcanics for rubidium, strontium, and strontium isotope composition. The visual best-fit isochron plot using their data displays minor scattering of some points. One andesite sample was excluded from the calculation due to its low radiogenic ^{87}Sr content. They obtained an age of 430 ± 15 m.y. for the Dunn Point Volcanics, which is interpreted as the maximum probable age of the Arisaig Group. The age of the volcanics is uppermost Ordovician, however, it must be pointed out that the presence of the tuff beds in the Ross Brook Formation indicates volcanic activity in the lower Silurian. The maximum age of the Silurian–Ordovician contact may thus be slightly greater than 430 m.y.

Silurian

Arisaig Group

Gesner (1836), in a publication entitled *Remarks on the Geology and Mineralogy of Nova Scotia*, referred to greywacke slate containing shells extending to Arisaig pier. Later (1845), he presented a geological map of Nova Scotia that showed a Silurian group composed of fossiliferous clay slate, and greywacke. Dawson's extensive writings on Nova Scotia geology included several references to the Arisaig section, and generally gave its age as Silurian (1845, 1850, 1860, 1881, 1891). Further study of the rocks was made by Honeyman (1859, 1860, 1864, 1867, 1870, 1874, 1878, 1890), who proposed a fourfold subdivision, and also compared the Arisaig fauna with the British Silurian fauna. Dawson and Honeyman recognized that the fauna had a closer affinity to European than to North American fauna. Fletcher, who was carrying out systematic 1-mile mapping of Nova Scotia, gave a detailed description of the Silurian rocks at Arisaig (1887, p. 37–41) and less explicit descriptions of other Silurian exposures. He accepted Honeyman's subdivision, however, he made only passing reference to fossils having been collected.

Paleontology of the Arisaig rocks, particularly the Ostracoda, was studied by Hall (1860) and Jones (1890, 1891).

Ami began his study of the Arisaig section by "... arranging the collections of Arisaig fossils already in the possession of the Geological Survey Department" (1900b, p. 179A). He undertook field investigations and proposed a division into the Arisaig, McAdam, Moydart, and Stonehouse formations. Although he listed the fossils, he did not define the formations, but did state that the formations were based on paleontological as well as lithological characteristics.

Twenhofel spent the summer of 1908 examining the Arisaig section and made over 200 paleontological collections, from which 140 to 160 species, chiefly brachiopods, were identified by Schuchert (Twenhofel, 1909). He established forty lithological zones, grouped into five subdivisions. These zones were well described, and the type fossils for each zone were listed. The formational boundaries are accepted by later workers, although they have changed the nomenclature.

Williams (1914) studied the Arisaig–Antigonish area (about 115 square miles) under the supervision of Professor Schuchert who, with Professor Twenhofel, visited him in the field. His work gave a description of the local geology, although little use was made of fossils other than in the coastal sections. The Silurian section was named the Arisaig Series, which was composed of five divisions (Beechhill Cove, Ross Brook, McAdam, Moydart, and Stonehouse formations) subdivided into twelve zones with designated guide fossils. Williams interpreted the Stonehouse–Knoydart boundary as a marked erosional unconformity equivalent to the Silurian–Devonian boundary.

McLearn (1924) described the Silurian fauna from Arisaig in considerable detail, and subdivided the five formations into fifteen lettered zones on the basis of lithology and fossils.

Jones (1926) collected graptolites from the basal Ross Brook black shale which he correlated with the Upper Llandovery shelly facies.

Copeland (1960,1964) has investigated Ostracoda from the Stonehouse Formation of the Arisaig Group and proposed a possible zonation of the strata based on ostracods. A post-Ludlow (Downtonian) correlation was suggested.

Maehl (1960) wrote a Ph.D. thesis at Massachusetts Institute of Technology on the Silurian of Pictou County, Nova Scotia. He recognized and named the French River Formation which overlies the Ross Brook.

The most intensive study of the geology of the Arisaig area was undertaken by Boucot *et al.* (1965). It contains numerous detailed maps. They proposed a new subdivision of the Arisaig Group by redefining the French River Formation to include part of the lower McAdam Formation, introducing the Doctors Brook Formation corresponding to most of the lower McAdam Formation, and renaming the remaining upper part the McAdam Brook Formation. These two new formations were recognizable after detailed examination of the type sections near Arisaig, but were not mappable at the scale used in the present study.

Harper (1964, 1973) completed an extensive study of the brachiopods and studied many of the writer's collections. He reassigned many of the brachiopod holotypes (or hypotypes). Berry (1967) wrote on the graptolites from the McAdam Formation, Legault (1968) examined the conodonts and fish remains from the Stonehouse Formation, and Bambach (1969) studied the middle to upper Arisaig pelecypods. The Silurian terminology used in *Correlation of North American Silurian Rocks* (Berry and Boucot, 1970) is followed in this report.

The Arisaig Group is exposed along the coast of Northumberland Strait near Arisaig and inland as far as Hollow fault. This nearly complete section includes the type section of all formations except the French River Formation. The middle parts of French and Barneys rivers are underlain by Arisaig strata which have eroded to form the Kenzieville trough. The type section of the French River Formation is exposed on the nose of a plunging syncline on French River. Minor Arisaig rocks, probably Beechhill Cove, are found near the mouth of Iron Brook and east of Marshy Hope. Lower Arisaig Group sediments with possible Beechhill Cove correlation are found northeast of Blue Mountain and south of Gunn Lake. The Silurian exposures, west and northwest of Eden Lake, and west of Lochaber Lake, are shown as Arisaig Group (undivided) and both contain lithologies and fossils common to the middle and upper Arisaig Group. Maehl (1960, p. 16, 91–104) regarded the lithology of the southern exposures to be sufficiently different from that of the coastal and Kenzieville exposures to propose two new formations, the Glencoe Brook and Kerrowgare. The author regards these differences as more apparent than real, and prefers to retain the normal nomenclature, while observing that the southern exposures represent a slightly more siliceous facies.

Extensive fossil collections were made from most Silurian exposures, however, only those required for correlation were studied. Details of some of these collections are given in the main report, but most are listed in the Appendix. Thus several fossil locations indicated on

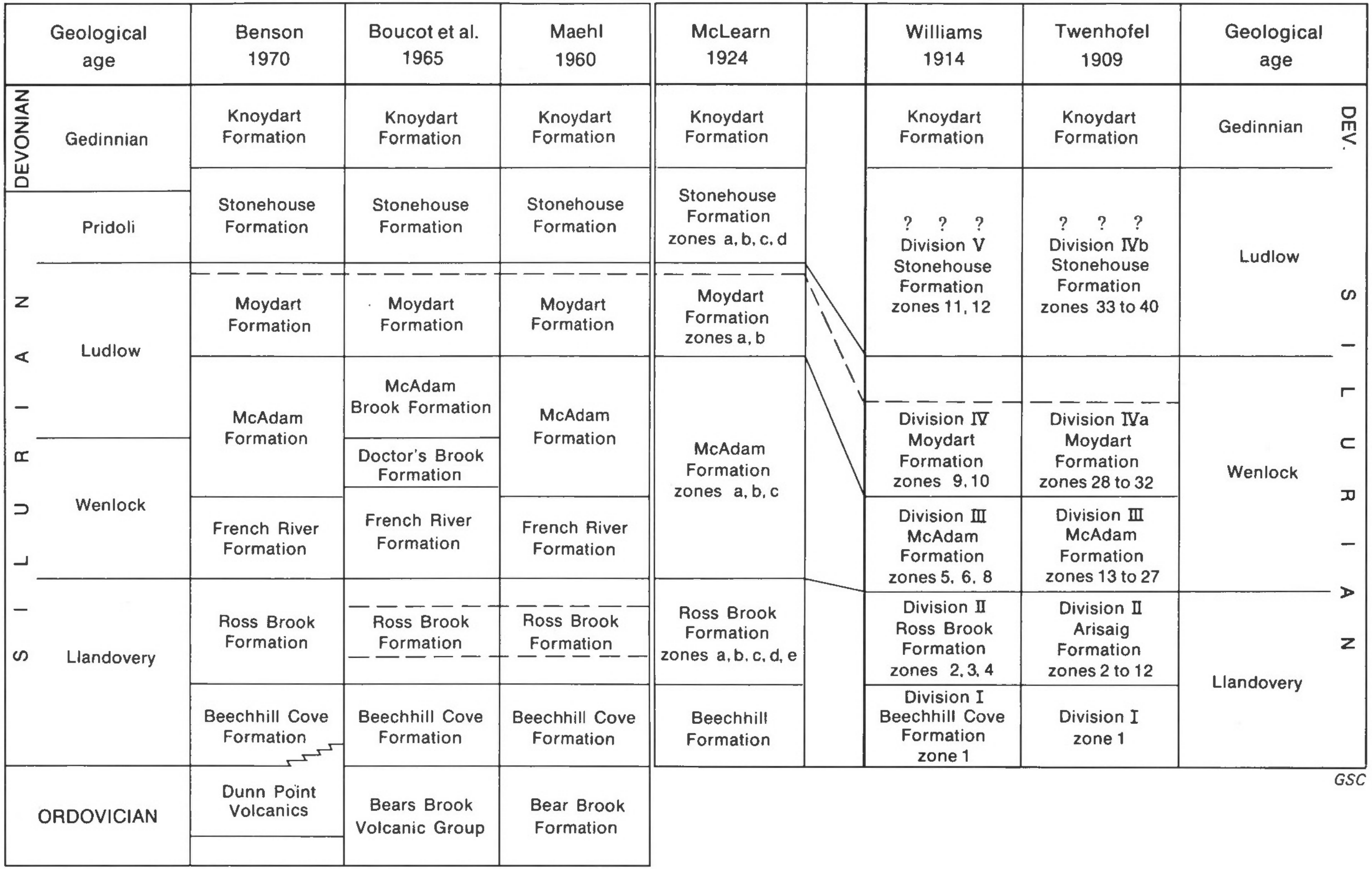

FIGURE 2. Development of the Arisaig Group subdivisions and relative geological age.

the map are not included in the fossil list. More extensive discussions of fossils are found in other recent works, in particular, Bambach (1969), Copeland (1964), Harper (1973), Legault (1968), Maehl (1961), and McLearn (1924).

The present study follows the subdivision proposed by Maehl (1960) for the Kenzieville trough area, which differs from that of previous workers by the addition of the French River Formation. The Stonehouse Formation is accepted as being post-Ludlow and is assigned a Pridoli age (Berdan *et al.*, 1969, p. 2167). Figure 2 shows the changes in nomenclature and assigned geological age that have been made in the last sixty years.

Beechhill Cove Formation. The Beechhill Cove Formation is composed of basal Silurian greenish and bluish grey wacke and siltstone that are overlain by Ross Brook black shale. The name was proposed by Williams (1914, p. 63) for Twenhofel's (1909) Division I. The type section is exposed along the shore at Beechhill Cove about 1½ miles northeast of Arisaig. Extensive outcrops are also found nearby along the coast, on Doctors Brook, and inland on both sides of the French River and Barneys River valleys. Minor exposures occur along Iron Brook, near Marshy Hope, and northeast of Blue Mountain.

There are about 300 feet of strata at the type section, 225 feet on Doctors Brook, and 240 feet on Wallace Brook. Twenhofel (1909) proposed a maximum thickness of 160 feet as measured at the type section, Williams (1914, p. 63) used a figure of 200 feet for the section on Doctors Brook, and McLearn (1924, p. 9) proposed a thickness from 160 to 200 feet. The amount of outcrop exposed along the coast of Northumberland Strait varies with successive winter storms.

The Beechhill Cove Formation consists essentially of greenish and bluish grey, well-bedded, fine-grained wacke and siltstone with lesser amounts of shale and more massive wacke. Most rocks have a light brownish grey weathered surface.

The fine-grained wacke and siltstone form resistant beds from about one inch to one foot thick. They are composed of 30 to 70 per cent subangular quartz grains, and 10 to 25 per cent subangular to subrounded, weathered feldspar grains in a clay matrix with minor interstitial chlorite and mica. No carbonate was observed. The shale has a similar composition with a greater clay ratio and grades into argillaceous siltstone. The more massive wacke occurs in beds from 6 inches to 2 feet thick and has less clay matrix. Conglomerate is exposed near the base of several outcrop sections: thin (about 3 feet thick) pebble- to cobble-conglomerate on Doctors Brook; angular pebble-conglomerate near the Arisaig pier; quartz-pebble conglomerate on East French River; and granule-conglomerate on Iron Brook. Near the coast the clasts are mainly volcanic, but in the Kenzieville trough quartz predominates. The more massive wacke beds away from Arisaig also contain a greater proportion of quartz. Quartzite is exposed near Marshy Hope and north of Kenzieville. A few thin beds of crosslaminated fine-grained wacke with appreciable fossil content fill probable channels.

The Beechhill Cove Formation, which is composed of competent strata, and the underlying rocks appear to have reacted to tectonic forces as a single block. Several folds are outlined by the outcrop pattern, particularly near Kenzieville, but the rocks do not appear to be highly deformed. The Beechhill Cove Formation rocks on Middle and Wallace brooks are described as massive, and the wacke and siltstone are not fractured, although the formation is tightly folded. The dip of the strata averages about 70 degrees near the coast and 45 degrees inland.

The basal contact with the underlying volcanics is exposed on Wallace Brook and at extreme low tide at Beechhill Cove. The basal sediments are generally a thin pebble- to cobble-conglomerate. The overlying strata are parallel or subparallel to the volcanics. The contact, where observed, is interpreted as a disconformity. The outcrops nearest the contact in the Kenzieville trough suggest that the contact is part of a regional unconformity.

The contact with the overlying Ross Brook Formation is exposed in the type section where a sharp break in lithologies between the parallel Beechhill Cove siltstone–wacke and the younger black shale is taken to indicate a disconformity. The contact is not exposed in the Kenzieville trough, but adjacent outcrops on the French River show the same rapid variation in lithology and suggest a disconformity.

Following a period of erosion, the Beechhill Cove Formation was deposited on the surface of underlying Dunn Point Volcanics and Browns Mountain rocks. The thin conglomerate beds are postulated as channel deposits which were overlain by marine sand, silt, and mud which had been transported but a short distance, as evidenced from the subangular quartz and feldspar grains. The argillaceous matrix of the strata and the absence of coarse material suggest a low, nearby source, with little opportunity for sorting before deposition. The brachiopod fossils and the sedimentary structures indicate a shallow marine environment. The slightly more siliceous sediments to the south are probably due to their provenance, in part, from the siliceous volcanics of the Keppoch Formation. A source area to the southeast of Arisaig is interpreted from current indications; in the Kenzieville trough no interpretation of a source area was made.

Fossil collections included brachiopods and corals. The brachiopod fauna, which suggest a lower Llandovery correlation, include the following common species: *Mendacella arisaigensis*, *Leptostrophia beechhillensis*, and *Cryptothyrella beechhillensis* (*see* fossil collections list in Appendix).

Ross Brook Formation. This formation is composed of a thin basal black shale that grades upward into interbedded dark grey mudstone and shale, and thence in the upper portion into bluish grey mudstone and shale with increasingly prominent fine-grained wacke and siltstone beds. The formation was named by Williams (1914, p. 64) for a small brook just west of Arisaig village. The composite type section consists of a basal portion at Beechhill Cove, a nearly continuous section along the coast westward from Arisaig, and further exposures along Arisaig Brook. Unfortunately, the Arisaig Group coastal exposures occur in a series of fault slices, and parts of the Ross Brook Formation are missing. A more complete section outcrops along French River and Wallace Brook.

The Ross Brook Formation is also exposed in Doctors Brook and several other small brooks near the coast, and in the Kenzieville trough. Ross Brook rocks were also recognized northeast of Blue Mountain and south of Gunn Lake where they were mapped as part of the Arisaig (undivided).

The type section near Arisaig was measured by Twenhofel (1909, p. 148) as 833 feet. Boucot *et al.* (1965, p. 46), who recognized that the shore section is incomplete, proposed a thickness of 1,050 to 1,300 feet for Arisaig Group. Maehl (1960, p. 45) observed a nearly complete section 1,200 feet thick along French River. The present report accepts the figure of 1,050 to 1,300 feet for the Arisaig locality and proposes a thickness of 1,200 to 1,500 feet for the French River and Wallace Brook localities. The higher value includes about 180 feet of strata represented by a covered interval.

Twenhofel (1909, p. 149, 150), Williams (1914, p. 65), and McLearn (1924, p. 9) divided the Ross Brook Formation into several zones based on faunal differences. Maehl (1960, p. 45–50) and Boucot *et al.* (1965, p. 44–50) recognized three lithologic units: the lower, middle, and upper members. These members do not have distinct boundaries, but are arbitrarily defined on the presence of beds of a minimum thickness. The members are valid concepts in discussing the lithology, but cannot be applied equally over the entire area. For example, the designation of the presence of siltstone beds greater than 6 inches thick for the upper member will vary with respect to provenance. Thus the terms upper, middle, and lower are used only in a relative sense in this report.

The lower Ross Brook Formation is exposed at Beechhill Cove and consists of dark grey to black carbonaceous shale overlain by feldspathic laminated shale, with varying silt content. The composition of one specimen of dark grey silty shale is about 40 per cent clay matrix and 60 per cent silt grading upward to medium-grained silt. Identifiable minerals include subangular quartz, muscovite, chlorite, highly altered feldspar, and pyrite. About twenty medium grey, thin (less than 6 inches thick) tuff layers displaying graded bedding are interlayered with the silty shale. The black shale beds, which are prominent in this section, often contain graptolites.

In the Kenzieville trough the lower Ross Brook Formation is medium grey to medium greenish grey mudstone, in which there are a few very thin (less than 2 inches thick) tuff beds. No black shale beds were observed, but dark grey to black mudstone was uncovered in the centre of the trough in a new road-cut. The rocks in the trough are possibly younger than the lower Ross Brook along the coast.

The middle Ross Brook Formation is characterized by bluish grey mudstone and shale with interbeds of very fine grained more resistant wacke and minor siltstone. The wacke and siltstone beds are from 0.5 inch to 6 inches thick and increase upwards in thickness and frequency until they make up about 15 per cent of the section. Fossils are more common in the wacke and siltstone beds, generally near the bottom.

The mudstone consists of about 70 per cent matrix, 10 to 15 per cent each of quartz and altered feldspar, and minor muscovite and chlorite.

The shale composition is assumed to be lower in quartz but is similar otherwise. The wacke and siltstone are made up of about 50 per cent subangular quartz grains, 20 per cent altered feldspar, 25 per cent argillaceous matrix, and minor muscovite and iron oxide. Some of the wacke and siltstone is calcareous.

The upper Ross Brook Formation is also composed of bluish grey mudstone and shale with interbedded very fine grained wacke and siltstone. It varies from about 15 per cent resistant beds to a high of about 70 per cent. Most sections have about equal amounts of mudstone–shale and wacke–siltstone. Some of the wacke layers are calcareous and grade into an arenaceous limestone. These calcareous layers commonly have a prominent basal concentration of brachiopod shells. The mineralogical composition is similar to that of rocks of the middle Ross Brook.

Bedding laminations are readily seen in the mudstone and shale of the lower and middle Ross Brook, but are less pronounced toward the top. The wacke and siltstone beds are typically massive with a few faint crosslaminations. Bedding directions are indicated by the alignment of fossil shells and occasionally by muscovite flakes.

The Ross Brook Formation is mainly a relatively incompetent shale–mudstone sequence. Associated with the major folds and faults are numerous small folds and faults. The dip averages about 50 degrees near Arisaig and 30 degrees in the Kenzieville trough. Two fracture sets were observed in several outcrops on Doctors Brook.

The Ross Brook Formation is conformably overlain by the French River Formation, as indicated in outcrops on Arisaig Brook and French River. The abrupt colour change from the darker Ross Brook to the overlying French River is readily observed and this conformable contact is confirmed at most locations.

A sequence of thin black shale beds occurs at the base of the Ross Brook Formation at Arisaig, and on Sam Cameron Brook in Hopewell map-area (Benson, 1967a, p. 17). These rocks may have been deposited in a restricted basin, such as a lagoon, thus a great change in depositional environment was not required. Nearby volcanic activity is indicated by the tuff beds in the lower Ross Brook. The increase in siltstone–wacke content toward the top of the formation is suggestive of more rapid erosion of the source area, probably due to slight uplift. The fossil brachiopods and the sedimentary textures indicate a shallow-water marine environment. The Ross Brook Formation is postulated to have been deposited in a nearshore shallow marine environment that received most of its sediment from the slightly elevated Browns Mountain complex. The extrusive activity that resulted in the Dunn Point Volcanics terminated during Ross Brook deposition and also contributed minor material.

The lower Ross Brook Formation is assigned an age at the lower-middle Llandovery boundary (lower Silurian) on the basis of its graptolite assemblage (Boucot *et al.*, 1965, p. 53). No fossils were found in the lower part of the middle Ross Brook. The brachiopods in the remaining middle and upper Ross Brook, which correlate with the upper Llandovery, include *Eocoelia hemisphaerica*, *Protochonetes tenuistriatus*, and *Plagiorhyncha* aff. *glassi*. The trilobites *Phacops marklandensis* McLearn, and *Dalmanites weaveri* (Salter) confirm this correlation (*see* fossil collections list in the Appendix). Palynomorphs from the upper Ross Brook correlate with the late Llandovery of the Belgian Ardennes (Cramer, 1970).

French River Formation. This formation consists of a thin sequence of bluish grey, fine-grained wacke and mudstone. It was first recognized and defined by Maehl (1961, p. 51), who applied the term to rocks overlying the Ross Brook Formation on French River about a half mile south of Route 4. The type section is exposed in the nose of a plunging syncline for about 2,000 feet along French River. The upper contact with the overlapping McAdam Formation is not exposed on French River.

The French River Formation outcrops in Doctors Brook and Arisaig Brook, where it was formerly regarded as part of the McAdam Formation, but is faulted out of the shore section. A single outcrop, lithologically similar to this formation, was observed west of Lochaber Lake.

Boucot *et al.* (1965, p. 54) extended the French River Formation to include more of the McAdam Formation, including the "iron ore bed." The "iron ore" bed is included in the McAdam Formation in this report.

Maehl (1961, p. 51) measured a thickness of 175 feet at the type section, where no upper contact was observed. Boucot *et al.* (1965, p. 56) suggested a thickness of 280 feet for their extended formation. The thickness in the Kenzieville trough is proposed as a minimum of 175 feet and as an interpreted maximum of 200 feet. This compares with an estimated thickness of 225 feet near Arisaig.

The French River Formation consists of interbedded, bluish grey, fine-grained wacke and siltstone grading to massive mudstone. The wacke and siltstone increase upward in proportion to the mudstone to a maximum value of about 60 per cent. The mudstone appears to have irregular bedding, which is difficult to determine because of closely spaced fractures. There are elongated concretions composed of black noncalcareous shale near the base of the section on French River, and of mudstone similar to the host rock near the top. The mudstone near Arisaig grades into a shale through the development of a crude fissility because of alignment of mica plates. Outcrops weather grey to olive-grey with minor limonitic staining. Fossils are plentiful, particularly in the upper beds.

The siltstone and wacke are composed of about 40 per cent clay matrix, 25 per cent each of angular quartz and altered feldspar, and minor mica (muscovite) and opaque (pyrite, leucoxene) minerals. The mudstone is assumed to have a similar mineralogical composition with a predominant clay matrix fraction.

Most of the French River beds near Arisaig were folded and fractured by movement along the Hollow fault. The rocks are generally moderately dipping (average 55 degrees), highly fractured, and display minor folds, and in much of Doctors Brook they are sheared. The type section, although fractured, is relatively undisturbed and dips about 15 degrees.

The upper contact with the conformably overlying McAdam Formation is placed in a gradational sequence at the point where the amount of wacke and siltstone begins to decrease. This point is about 25 feet below the "iron ore" bed in the McAdam Formation on Arisaig Brook. Where the "iron ore" bed is not exposed, the contact is very difficult to identify because of the similarity between some mudstone and wacke beds.

The depositional environment of the French River Formation was similar to that of the Ross Brook, that is, shallow-water marine with a nearby source area of igneous or metamorphic rocks. There was probably slight uplift of the source area during deposition of the upper part of the formation.

Harper (1964, p. 23) stated that most brachiopods from the French River Formation have extremely long ranges, however, *Marklandella* and *Plagiorhyncha* are of Llandovery or Wenlock age. The stratigraphic position of the French River Formation indicates a post-upper Llandovery pre-Ludlow age. The graptolite *Monograptus* aff. *distans* found in Doctors Brook reaches greatest diversity in the late Llandovery, but ranges into the Wenlock (Boucot *et al.*, 1965, p. 59). A Wenlock age is assigned to the French River Formation.

Extensive fossil collections were made at the type section, but as the specimens have not yet been examined, the reports of Boucot *et al.* (1965), Harper (1964, 1973), and Maehl (1961) must be referred to for information on the French River paleontology.

McAdam Formation. This formation consists of grey mudstone, calcareous wacke, arenaceous limestone, and dark grey wacke with septarian and phosphatic nodules. A thin ferruginous wacke, the "iron ore" bed is found near the base. Ami (1900b, p. 180A) used the name for rocks exposed along the coast and in McAdam Brook. Twenhofel (1909, p. 152–154) and Williams (1914, p. 66) defined the limits of the McAdam Formation mainly on a faunal basis and provided good lithologic descriptions. McLearn (1924, p. 11, 12) stressed the paleontology of the rocks. Maehl (1961, p. 54–56) recognized a lower and upper member with different lithologic characteristics. Boucot *et al.* (1965, p. 60–72) named the redefined lower member the Doctors Brook Formation and the upper member the McAdam Brook Formation.

A composite type section for the McAdam Formation is obtained from a basal and lower portion on Arisaig Brook, a lower to upper section on the shore near McAdam Brook and in the brook itself. There are also numerous exposures on Doctors Brook and the French River syncline.

Early thickness estimates by Twenhofel (1909, p. 153), Williams (1914, p. 67), and McLearn (1924, p. 11) were all about 1,100 feet. The difference in thickness between the shore and Arisaig Brook sections was ascribed to shortening through faulting on Arisaig Brook. Maehl (1961, p. 55) proposed a minimum thickness of 660 feet for the French River syncline area. The combined Doctors Brook and McAdam Brook formations were estimated to total about 560 feet by Boucot *et al.* (1965, p. 61). Bambach (pers. com. 1967) has demonstrated the repetition of beds in the shore section. This report proposes a thickness of about 240 feet from the shore section plus 320 feet for Arisaig and Ross brooks, for a total of 560 feet. An estimated thickness on the French River syncline at the west end of the Kenzieville trough ranges from 500 to 700 feet.

The basal part of the McAdam is completely exposed only on Arisaig Brook, where it consists of massive grey mudstone and wacke with a $2\frac{1}{2}$-foot bed of fossiliferous ferruginous wacke. The ferruginous wacke (called oölitic iron ore by previous authors) consists of fine-grained quartz grains with a coating of hematite cemented by a hematite matrix, with minor oölitic grains. The ferruginous wacke also outcrops on the south flank of the French River syncline. The lower McAdam consists of interbedded, massive grey mudstone up to 1 foot thick, well-bedded bluish grey wacke and siltstone up to 6 inches thick, and calcareous wacke grading into argillaceous and arenaceous limestone. Coquinite layers are prominently exposed in the shore section, where they occur as lenses or channel deposits cut in the mudstone. Calcareous beds are rare in the French River syncline. The massive mudstone, in a few instances, grades into faintly laminated shale. Phosphatic nodules, some cored by brachiopod fragments, are found in dark grey mudstone and shale along the shore and in Doctors Brook.

The wacke and siltstone beds consist of 60 to 70 per cent fine-grained sand to silt-sized fragments of rounded quartz, and minor altered feldspar and mica. The clay matrix is predominantly sericite. The mudstone to shale consists of about 30 per cent silt-sized fragments, and a matrix of muscovite, chlorite, and unidentified clay particles. The matrix of rocks from the Arisaig area contains minor calcite. The limestone layers contain up to 60 per cent carbonate as cement and as fossil fragments.

The lowest 50 feet of the upper McAdam Formation consists of dark grey to black, fissile, laminated shale and mudstone with minor thin (less than 1 inch) siltstone interbeds. This lithology grades upward into equal amounts of grey shale and siltstone (in beds up to 3 inches thick) near the top of the formation. Calcareous siltstone is found in all but the lowest portion. Calcareous and septarian nodules, some with cores of shell fragments, are common throughout. Well-developed cone in cone structures are found in the shore exposures. The uppermost beds consist of greenish grey siltstone and grey shale. Mineralogical composition is similar to the lower McAdam.

The McAdam Formation, in particular the shore section (average dip is 50 degrees), displays numerous small faults and folds, and fracture cleavage is well developed in the mudstone and shale. The outcrops in Doctors Brook are highly sheared due to their proximity to Hollow fault. In the French River syncline less cleavage was observed, and the average dip is about 40 degrees.

The McAdam Formation grades upward into the predominantly greenish grey Moydart Formation. The contact of the shore and McAdam Brook sections is placed below the first greenish grey siltstone bed, over 1 foot thick, which is also the point where the greenish grey beds become the dominant lithology. Elsewhere, the contact was not observed, but there appears to be an abrupt change from the grey mudstone siltstone assemblage to the greenish grey Moydart siltstone beds.

The sediments of the McAdam Formation were probably derived from the Browns Mountain rocks, and deposited in a shallow marine environment. The rounded quartz grains of the ferruginous wacke were probably caused by reworking at the margin of the basin. The predominance of mudstone, the scour and channels, and calcareous sediments all indicate shallow water. The dark grey to black shale of the upper McAdam indicates a local environmental change such as would be expected at the margin of the sea. The increasing predominance of siltstone toward the top of the section and the continued presence of brachiopods restricted to shallow marine environment suggest an increased supply of sediments, probably through uplift of the source area. Current directions from the northeast are indicated. Detailed study of the pelecypods indicates a gradational change from lagoon-centred flocculent muds to shallow-water cohesive silts in the upper McAdam (Levinton and Bambach, 1969, p. 1134).

Correlation is difficult because of the long range of the brachiopods such as *Isorthis*, *Salopina*, and *Protochonetes*. *Monograptis* cf. *Monograptis distans*, found in an isolated outcrop on Doctors Brook, is assigned a Llandovery to early Wenlock age (Harper, 1964, p. 24). The black shale at the base of the upper McAdam contains *Monograptis rilagiio*, *Mono-*

graptis variano, and *Monograptis wandalensis* (*see* fossil collections list in the Appendix) which indicate an early or middle Ludlow age (Berry, 1967, p. 965–969). The McAdam Formation is, therefore, regarded as upper Ludlow to middle Wenlock.

Moydart Formation. The type section of the Moydart Formation is exposed along the Arisaig shore at Moydart Point. The name was first used by Ami (1900b, p. 180A) and later defined by Twenhofel (1909, p. 155). It consists of greenish grey mudstone, wacke, and siltstone with minor fragmental limestone, overlain by red calcareous mudstone ("Red Stratum"). The definition of this formation has not changed from Twenhofel's report.

The Moydart is also well exposed in McAdam and Arisaig brooks. Less complete sections occur on Doctors Brook and on the north limb of the French River syncline. Moydart lithology is present on Kerrowgare road near Normans Brook, and west of Lochaber Lake.

Twenhofel (1909, p. 155) measured the thickness of the type section as 379 feet, although he omitted zone 29 from his description. Williams (1914, p. 69) and McLearn (1924, p. 12) gave thicknesses of 282 feet and about 380 feet, respectively. Maehl (1961, p. 61) proposed a value of 450 feet for the French River syncline. Boucot *et al.* (1965, p. 73) determined an apparent thickness of 392 feet (360 feet plus 32 feet for the "Red Stratum") for the shore section, 150 feet plus for McAdam Brook, and 560 feet for Arisaig Brook. The Arisaig Brook section thickness is exaggerated by repetition of beds by faulting, whereas an incomplete section was observed in McAdam Brook. Thicknesses of 350 feet for the greenish grey beds and 32 feet for the "Red Stratum" were measured along the shore by the author, and a minimum thickness of 420 feet was interpreted for the north limb of the French River syncline.

The Moydart Formation is characterized by its distinctive greenish grey colour and by the "Red Stratum" at the top of the section. It is about 65 per cent mudstone, 30 per cent siltstone and wacke, and 5 per cent limestone. The mudstone is more arenaceous and more resistant than older Arisaig Group mudstone. It generally contains at least 70 per cent fine silt and commonly grades into argillaceous siltstone. The mineralogical composition is about 50 per cent subangular quartz, 10 per cent mica, 10 per cent altered feldspar, minor opaque minerals (hematite and leucoxene), and 25 per cent clay matrix. Carbonate is present in only a few of the more arenaceous beds. The mica, principally muscovite with subordinate chlorite, when aligned on the bedding surfaces, imparts a slight fissility to some exposures. Large slump rolls were observed at Arisaig in the lower mudstone beds. The siltstone is composed of about 50 per cent subangular quartz, 20 per cent altered feldspar, 10 per cent mica and chlorite, minor opaque minerals, and up to 10 per cent each of calcite and clay matrix. The wacke has a similar composition. Siltstone is more common than wacke in the shore sections, but less common in the French River syncline. The siltstone–wacke beds are usually from 2 inches to 1 foot thick at Arisaig, with beds up to 3 feet thick inland. There are several thin (less than 2 inches) beds of arenaceous limestone with about 50 per cent interstitial calcite, 25 per cent subangular quartz, 10 per cent each of mica and chlorite, and 5 per cent altered feldspar. The siltstone, wacke, and arenaceous limestone layers tend to have sharp basal contacts and either gradational or sharp upper contacts. Some upper contacts have well-developed ripple-marks. Small-scale crossbedding is common in most wacke and siltstone beds. Shelly limestone beds and lenses up to 6 inches thick fill channels in the siltstone and mudstone.

The "Red Stratum" at the type section is mainly moderate red, greyish red to dusky red calcareous mudstone with mottled grey spots. Most of the mudstone is almost a silty marl. A general lithological stratigraphic section of the "Red Stratum" is as follows: 0 to 5 feet, basal moderate red arenaceous mudstone interbedded with calcareous mudstone with minor greenish grey ferruginous layers; 5 to 10 feet, greyish red-purple calcareous mudstone with ellipsoidal (2 by 6 inches) calcareous nodules; 10 to 25 feet, moderate red and mottled moderate red and greyish green calcareous mudstone; 25 to 30 feet, greyish red-purple, moderate red, and greyish green calcareous mudstone with small calcareous nodules; 30 to 32 feet, greyish green calcareous mudstone, at the top.

The Moydart exposures along the coast have an average dip of 50 degrees, are generally undisturbed, and contain only a few minor vertical folds. The upper part of the formation displays many small faults and folds. Elsewhere, the Moydart has fewer small-scale folds and faults, probably because the beds are more competent. The sections are incomplete due to repetition or omission of beds by faulting.

The upper contact is placed at the top of the "Red Stratum" which is conformably overlain by beds of the Stonehouse Formation. Some of the beds of the Stonehouse are greenish grey and these beds may be confused with the Moydart Formation in isolated outcrops where the "Red Stratum" is not exposed.

The shallow-water marine environment continued during deposition of the Moydart, as evidenced from the small-scale crossbedding, scour, limestone beds, and predominantly shelly fossil fauna. The "Red Stratum" was probably deposited either in a short-lived lagoon or as an alluvial deposit due to increased supply of sediment (Dineley, 1963, p. 524).

The Moydart Formation has an abundant brachiopod and pelecypod fauna with crinoids locally prominent. The brachiopods include *Salopina submedia*, *Protochonetes novascoticus*, *Howellella moydartensis*, *Hyattidina northumberlandensis*, "*Camarotoechia*" *moydartensis*, *Sphaerirhynchia saffordi*, and *Rhynchospirina acadiae* (*see* fossil collections list in the Appendix). The last three are restricted to the Moydart Formation (Harper, 1964). A few phosphatic shell fragments were found in the lower part of the "Red Stratum."

The Moydart is assigned a Ludlow age on the basis of its stratigraphic position.

Silurian and Devonian

Stonehouse Formation

The Stonehouse Formation, consisting mainly of bluish grey calcareous and noncalcareous wacke and siltstone, is best exposed at the type section southwest of Arisaig from Moydart Point to about a half mile southwest. It was named by Ami (1900b, p. 180A) and was first described in detail by Twenhofel (1909, p. 156–158), both of whom regarded the shore section to be the complete formation. McLearn (1924, p. 13) recognized younger beds on Stonehouse Brook (MacEachern Brook) and that the top of the Stonehouse was not exposed at the shore. Copeland (1964, p. 5) stated that the uppermost 225 feet of the Stonehouse is not exposed. The exposures on MacEachern and McAdam brooks are the youngest beds and are included in the type section.

The Stonehouse Formation is also exposed on Vamey Brook, in the French River syncline, and at Lochaber Lake.

Twenhofel (1909, p. 156) measured a thickness of 1,075 feet for the shore section. McLearn (1924, p. 13) included the unexposed upper beds in his estimate of 1,275 feet. Later thickness estimates for the type section include Copeland's (1964, p. 5) of about 1,500 feet and the Boucot *et al.* (1965, p. 82) approximate total of 1,350 feet. This report accepts an approximate value of 1,375 feet at Arisaig, assuming 1,075 feet exposed in the shore section and an estimated 300 feet of partly exposed beds on MacEachern and McAdam brooks. Outcrops on both sides of Lochaber Lake suggest a possible Stonehouse Formation thickness of 1,100 feet, but a minimum of only 700 feet is proposed for the French River syncline.

The Stonehouse Formation can best be described by three informal lithologic subdivisions. The lowest approximately 100 feet is really a transition zone and is composed mainly of greenish grey calcareous mudstone, shale, and siltstone with minor wacke and shelly argillaceous limestone in beds from 1 inch to 1 foot thick. The middle 500 feet is mainly bluish grey calcareous wacke and siltstone with minor mudstone and shale and restricted greenish grey beds. The wacke and siltstone are often finely bedded with prominent cross-bedding and ripple-marks, and are in layers from 1 inch to 2 feet thick. There are a few thin calcareous shelly beds and mudstone layers. The uppermost unit (about 750 feet) has more varied lithology and consists of bluish grey calcareous wacke, greyish red and grey slightly calcareous shale and wacke, and increasing amounts of grey and greyish red shale, siltstone, and wacke toward the top. The siltstone and wacke are 60 per cent angular quartz, 20 per cent altered feldspar, 10 per cent calcite, and 10 per cent matrix. Some quartz-rich siltstone with very little clay matrix was observed. The mudstone and shale horizons are about 20 per cent subrounded quartz and altered feldspar, 10 per cent muscovite, up to 10 per cent calcite, and the remainder is clay matrix. Fossils are found in most rock types, but are most common in thin siltstone layers and in massive calcareous wacke beds. The calcareous beds have medium dark grey to light brownish grey weathered surfaces.

The beds at the Stonehouse type section have a nearly constant dip of about 40 degrees to the southwest. Several small faults were observed, but none has appreciable dislocation. Major faults appear to have removed the lower beds from the McAdam Brook section, and to cut the beds west of Arisaig Brook. Overturned beds and dips up to 80 degrees near Hollow fault indicate more deformation in this area than the uplift and tilting postulated for the type section. On both sides of Lochaber Lake the beds dip up to 85 degrees and display more prominent cleavage, probably due to folding.

The contact zone of the Stonehouse Formation with the Horton (Carboniferous) basalt is exposed in a sea cliff near the mouth of McArras Brook. The contact is often obscured by mud and could be interpreted as a fault or an unconformity. This report favours a fault contact. The only observed contact is on the headwaters of McAdam Brook, 3,200 feet southeast of Highway 45. Greenish grey calcareous siltstone with brachiopod, crinoid, and pelecypod fossils grades into typical greyish red Knoydart mudstone and siltstone. The contact is placed at the top of the highest greenish grey siltstone bed with brachiopod fossils. Thus small single outcrops where the contact is not exposed could be placed in the wrong formation.

The Stonehouse Formation was deposited in normal marine shallow-water environment similar to that prevalent during deposition of most of the Arisaig Group. The red beds and limited brachiopod fauna toward the top of the formation indicate a probable shallowing of the depositional area before the subaerial deposition of the Knoydart Formation.

The Stonehouse Formation has a distinctive fossil fauna. Copeland (1964, p. 5), who was able to delineate three ostracod zones, obtained fifteen species and subspecies of eight genera from the type section. These lower, intermediate, and upper zones are designated by *Londinia arisaigenis*, *Aparchites? sinuatas* (Hall), and *Neobeyrichia* (*Nodibeyrichia*) *pustulosa* (Hall). Harper (1973) included the following brachiopods among those restricted to the Stonehouse Formation: *McLearnites mertoni*, *Protochonetes stonehousensis*, *Delthyris* (*Quadrifarius*) *rugaecosta*, "*Camarotoechia*" *planorugosa* "*Camarotoechia*" *glomerosa*, *Rhynchospirina sinuata*, and *Atrypa* cf. *A. gedinniana* (*see* fossil collections list in the Appendix).

Copeland (1964, p. 7) assigned a post-Ludlow age to the Stonehouse. The ostracods were correlated with European Downtonian fauna. Harper (1964, p. 26) considered it to be Gedinnian and part Skala, on the basis of brachiopod evidence. Boucot *et al.* (1965, p. 90) regarded the Stonehouse as post-Ludlow, of Skala and lower Gedinnian age. Berdan *et al.* (1969) gave the age as Pridoli (uppermost Silurian) and lower Gedinnian, which terminology is used in this report.

Devonian

Knoydart Formation

The term Knoydart Formation was applied by Ami (1901, p. 301) to the Devonian red beds exposed on McArras Brook that he regarded as "a bit of the Old Red Sandstone of Europe." A thick section is also exposed to the southwest on Knoydart Brook, the name taken for the formation.

The Knoydart Formation is exposed southwestward from Knoydart Brook to Baileys Brook and a single outcrop was found in the French River syncline. Extensive exposures are found near Lochaber Lake. The diamond-drill hole on the west side of Lochaber Lake penetrated assumed Windsor limestone in an area interpreted as Knoydart.

Fletcher measured the Knoydart section on McArras Brook as 683 feet as reported by Ami (1901, p. 301), who suggested a minimum thickness of 1,000 feet. The detailed section examined and described by Fletcher is the only section where accurate measurements can be made. The McArras Brook section may have an approximate thickness of 1,150 feet, which is extrapolated from the measured section and isolated outcrops. A more conservative estimate is a minimum thickness of 900 feet. The fairly poor section on Hurlbert Brook is interpreted as having a possible thickness of 1,800 feet. No estimate was made for the French River syncline.

The Knoydart Formation consists essentially of greyish red mudstone, siltstone, and fine-grained wacke. The only apparent lithologic differentiation is a slight trend toward a less argillaceous matrix in the middle and upper parts of the formation.

The Knoydart Formation on McArras and Knoydart brooks consists of about 35 per cent medium greyish red siltstone and mudstone; 30 per cent moderate red, slightly calcareous, very fine grained wacke and siltstone; 17 per cent medium reddish grey, fine-grained wacke; 15 per cent medium greenish grey, fine-grained wacke and siltstone; 2 per cent medium greyish red calcareous siltstone and mudstone with calcareous nodules; and minor thin beds of medium greyish red quartz–arenite, granule-conglomerate, and greywacke of possible tuffaceous origin. Grey beds from $\frac{1}{16}$ to $\frac{1}{2}$ inch thick are distributed throughout the sections, and narrow ($\frac{1}{4}$-inch) beds of paler red are common. The normal bedding surfaces are faint. The wacke beds are generally from 4 to 6 inches thick and the siltstone beds are slightly less, although $\frac{1}{16}$-inch laminae of wacke and siltstone occur throughout the section. Crossbedding, ripple-marks, shallow scour marks, graded bedding, and animal trails and burrows are common. The beds are commonly fractured and the fractures and veinlets are filled with quartz. The conglomerate clasts are mainly intraformational, with predominantly mudstone clasts. Several narrow (less than 6 feet wide) diabase dykes intrude the sediments on Knoydart Brook and the headwaters of McArras Brook. The outcrops are cut by local faults that have produced minor displacements, generally of less than 20 feet.

The Lochaber Lake section, as represented on Hurlbert Brook, consists of about 40 per cent medium greyish red, slightly calcareous, fine-grained wacke, siltstone, and silty shale; 35 per cent dark greyish red, slightly calcareous, fine-grained wacke and siltstone; 15 per cent dark greyish red silty shale; 5 per cent greenish grey, highly indurated shale; and 5 per cent dark greyish red, silty, indurated shale. No conglomerate, greywacke, nor diabase dykes were observed, but all other characteristics of the McArras and Knoydart brooks sections are present. In a fractured silty shale outcrop with incipient slaty cleavage, the fractures are filled with specularite and chlorite.

Fish plates occur in several wacke and in one greywacke bed on McArras Brook. No fossil remains were found in the Knoydart rocks near Lochaber Lake.

The siltstone and wacke consist of about 80 per cent subangular to subrounded quartz and subordinate feldspar grains, and minor amounts of muscovite, chlorite, rock fragments, and calcite. The red colour is due to both hematite coating of individual mineral grains, and to silt to fine-grained sand-sized particles of hematite.

Outcrops in both areas have generally well-developed cleavage that dips more steeply than the bedding. The beds of McArras and Knoydart brooks dip from 15 to 60 degrees with an average of 35 degrees. On Hurlbert Brook the average bedding dip is 45 degrees and the cleavage measured about 70 degrees in most outcrops. No increase in cleavage near the local faults was noted, but appreciable cleavage development appears to be related to the Hollow fault. The Knoydart is overlain unconformably by Carboniferous sediments and its youngest (?) beds were not observed.

The similarities in rock type and mineralogy between the Knoydart Formation and Arisaig Group suggest a similar source area which is proposed to be the Antigonish Highlands. The Knoydart section has been compared with the Downtonian and Dittonian (lower Old Red Sandstone) of England and Wales (Denison, 1956; Dineley, 1962). The absence of typical marine invertebrates and the sedimentary structures are compatible with a freshwater, probably fluviatile, deltaic origin. The Stonehouse Formation is interpreted as a coastal or deltaic shallow marine deposit which, as the water became more shallow or the deposits thickened, gave way to the nonmarine deltaic Knoydart red beds. This sequence was shown in a series of paleogeography and lithofacies maps by Boucot (1970, p. 477–483).

Although fish plates were observed at four outcrops on McArras Brook up to a quarter mile south of Route 45, only one collection was made. Ostracoderm and placoderm fishes, ostracods, and plants have been reported from this formation (Dineley, 1962, p. 135–139).

Ami (1901, p. 309) reported that A. S. Woodward had identified *Onchus murchisoni* Agassiz, *Pteraspis* sp. cf. *Pteraspis crouchii*, *Psammosteus* sp. cf. *Psammosteus anglicus* Traquair, *Cephalaspis* sp. and *Ichthyoidichnites acadiensis* nobis from McArras Brook which he correlated with the Lower Devonian (Old Red Sandstone). *Pteraspis whitei* Denison correlates with the base of the Dittonian (Denison, 1955). Dineley (1962, p. 138-139) reported on finding upper Downtonian fish 650 to 700 feet from the base of the Knoydart, and Dittonian ostracoderm fish higher in the section. He identified *Traquairaspis symondsi* (Lankester), cephalaspid fragments, anaspid scales, and *Onchus murchisoni* Agassiz in a later paper (Dineley, 1964). Berdan (1969, p. 2176) recognized the Knoydart as Gedinnian, although the uppermost beds were not observed.

Intrusive Rocks

Granite. A small granite stock intrudes Browns Mountain Group rocks near James River. The intruded volcanic and sedimentary rocks, particularly near the western contact, are highly sheared. The stock is composed of moderate red, fine- to medium-grained feldspar granite. On James River the granite is finer grained near the contact and highly fractured along the entire river. The same fine-grained phase is found near the western contact, but the fracturing is more restricted.

Thin sections show the granite to be composed mainly of highly altered, pale red feldspar and milky to colourless quartz, commonly in myrmekitic intergrowth, and minor chlorite derived from biotite and hornblende. Zoned plagioclase crystals are present, but most feldspar, except for a few phenocrysts, is too highly sericitized to permit identification. Some albite was identified, and if it is the predominate feldspar, the rock should be regarded as granodiorite. The mafic minerals are almost completely replaced by chlorite, and no estimate of the relative amounts of biotite and hornblende was made. The granite is intruded by several narrow diabase dykes. Contact effects are restricted to a narrow zone, less than 1 foot wide, in which the feldspar grains are pinkish grey and less highly sericitized.

The intruded rocks are pre-Silurian, and similar granite is noted as pebbles in Lower Carboniferous sediments to the south. Fairbairn *et al.* (1960, p. 403) determined the age of the James River pluton by Sr-Rb analysis of the feldspar to be 370 m.y. The Acadian Orogeny has been dated throughout the northern Appalachians (Lyons and Faul, 1968, p. 309–310) and intrusive activity is thought to be mainly restricted to early Devonian. The James River granite may have been intruded during the early stages of the Acadian Orogeny and to have cooled slowly at depth, as indicated by the myrmekite. During later stages of the orogeny it was uplifted and exposed through erosion.

Diabase. Diabase dykes from 2 to 10 feet thick intrude many of the pre-Carboniferous rocks in the Antigonish Highlands. Good examples may be seen on the coast northeast from Malignant Cove, at the falls below Gunn Lake, on James River, south of Avondale Station, and on the headwaters of Black Brook. A small stock near College Grant and dykes on Knoydart Brook intrude the Knoydart Formation. These diabase bodies are grouped under one heading as Devonian and earlier (?) and more than one period of intrusion is probably represented.

The diabase is greenish black to dark greenish grey with minor greyish green patches. Most outcrops are medium to fine grained, except at the contact where they are fine grained. Diabasic texture was observed in most hand specimens.

A thin section of a typical diabase reveals a subophitic, medium- to fine-grained, partly porphyritic rock that is slightly to strongly altered. It is composed of about 60 per cent euhedral plagioclase grains whose identity is masked by sericitization or saussuritization. Plagioclase from one thin section has a composition of about An_{21} (oligoclase). Pyroxene (augite) and chlorite total about 30 per cent. The pyroxene is anhedral to subhedral, fresh to highly altered, and interstitial between the plagioclase laths. The chlorite, usually more plentiful than the pyroxene, displays light to dark green pleochroism and is also interstitial between plagioclase, usually as massive-looking aggregates. Accessory minerals include clear anhedral epidote, twinned carbonate, iron oxide, and pyrite. A single thin section contains minor micrographic potassium feldspar and quartz intergrowths, and another thin section, brown translucent and opaque varieties of leucoxene.

An isolated outcrop on Ohio River of very fine grained porphyritic diabase contains about 20 per cent light green chlorite (penninite) that occurs as aggregates, some having outlines and fractures similar to olivine; about 60 per cent strongly altered plagioclase; 10 per cent light brown cryptocrystalline groundmass (palagonite?); and minor leucoxene, iron oxide, pyrite, and sphene. This outcrop may be an altered volcanic rock.

The College Grant stock is subophitic altered diabase composed of 60 per cent plagioclase with polysynthetic and single twinning, 30 per cent interstitial chlorite, probably secondary after pyroxene, and minor leucoxene, magnetite, and hematite.

The diabase dykes intrude the Devonian granite on James River, the Devonian Knoydart Formation, the Silurian Arisaig Group, the Ordovician hornblende granite and granodiorite, and the Cambro-Ordovician Browns Mountain Group. Some of the dykes may be related to the Ordovician diorite bodies, and some are similar to the post-Silurian and post-Devonian dykes. They may be related to only one event; if so, this event would possibly be the igneous activity at the start of the Carboniferous which resulted in the extrusion of basic volcanics.

Lower Carboniferous (and Upper Devonian?)

Horton Group

The Horton Group, as defined by Bell (1929, p. 30–45), consists of the Horton Bluff and the Cheverie formations along the Avon River. Murray (1955, p. 16) described three conformable formations, the Craignish, Strathlorne, and Ainslie in southwest Cape Breton Island; these names were used by Kelley (1958, p. 177). The threefold division is applicable to the Hopewell map-area (Benson, 1967a, p. 22–23) and to the St. Mary's River graben, but it does not apply to the flanks of the Antigonish Highlands.

Recent work on the correlation of the Horton Group in Nova Scotia has depended mainly on palynology. Indeed, the palynology studies of Barss, McGregor, and Hacquebard are the main basis for all revision of the Carboniferous–Devonian stratigraphy (Barss, 1967; Barss and Hacquebard, 1967; Hacquebard, 1971; McGregor, 1971; Belt, 1965) (*see also* Fig. 4).

The Rights River Formation of the Horton Group, as defined in this report, is a predominately wacke–sharpstone conglomerate sequence that unconformably overlies Lower Devonian and older rocks of the Antigonish Highlands. The name is taken from Rights River, a stream in the northeast corner of Merigomish map-area.

Murray (1960, p. 69–75) used the name Rights River Formation for a thick wedge of red sharpstone conglomerate in eastern Cape George. He described several outcrop areas in detail and correlated the Rights River with some part of the Ainslie Formation, but did not define the formation.

The type section of the Rights River Formation is exposed on Rights River where about 5,000 feet of strata is present. Murray (1960, p. 74) estimated a thickness of 2,500 feet underlain by an unstated thickness of the Graham Brook Member. Good exposures are also found on South Rights River, Brierly Brook, the headwaters of Malignant Brook, along the shore west of McArras Brook, and north of Lochaber Lake.

The Rights River Formation is characterized by poorly sorted, angular to subangular pebble- to boulder-conglomerate with varying amounts of interbedded, medium- to coarse-grained wacke. The rocks are usually greyish red to dark reddish brown with minor greenish grey lenses and layers. A 20-foot, brownish grey, fractured mudstone section that overlies the Browns Mountain Group on a tributary of Brierly Brook is interpreted as a possible residual soil profile. Black, sheared argillaceous limestone and grey mudstone are interbedded with the lower portion of the section on Rights River, east and northeast of North Grant. The overlying conglomerate and wacke beds are, in part, slightly calcareous.

The outcrops near Big Marsh suggest that the Rights River conglomerate is unconformably overlain by Windsor limestone. A diamond-drill hole near Big Marsh School penetrated 167 feet of conglomerate below the Windsor Formation (Nova Scotia Dept. Mines, 1949; Huppi, 1953).

The section at the mouth of McArras Brook totals about 1,200 feet. The lower half consists of red and greyish red pebble- to boulder-conglomerate up to 30 feet thick with interlayered, dark green and dusky red, amygdaloidal basalt up to 15 feet thick, and medium grey-red, fine-grained wacke. The wacke generally overlies and underlies the basalt. The conglomerate clasts include Browns Mountain and Arisaig lithologies and greyish red wacke from the underlying Devonian Knoydart Formation. Sandstone dykes about 1 inch wide are common in the upper part of the basalt flows. The upper half of the section consists of interbedded wacke and conglomerate.

East of the Antigonish Highlands, clasts in the conglomerate are granite, granodiorite, and Browns Mountain volcanics and sediments. The relative amounts of each type of clast depend on the distance from the source area of each rock type. The clasts are commonly coated with red iron oxide. The conglomerate matrix is grit with large amounts of red iron oxide and some clay minerals. The wacke is medium reddish grey to grey, micaceous, poorly sorted, and grades into granule-conglomerate.

The Rights River conglomerate is generally massive, although an apparent upward decrease in clast size is seen in some exposures. The interbedded wacke displays crossbedding, ripple-marks, channelling, and minor graded bedding. The beds dip from 10 to 50 degrees with most attitudes between 20 and 30 degrees. The argillaceous limestone outcrops are highly sheared. The McArras Brook section is transected by one steeply dipping fault.

The contacts of the Rights River Formation are observed only near the margin of the depositional basin where a thinner section is present. At Brierly Brook the conglomerate unconformably overlies the Browns Mountain Group and is disconformably to unconformably overlain by the Windsor limestone. At McArras Brook it unconformably overlies the Devonian Knoydart Formation and is disconformably overlain by the Windsor Group. The basal unconformity is suggested in most stream sections near the margin of the basin. The contact with the Windsor on Rights River, which is near the centre of the basin, is conformable.

The Rights River Formation is interpreted as an alluvial fan deposited in a relatively restricted valley. It thins sharply from Rights River to the edge of the basin on Brierly Brook. The source area was either nearby or almost underlying rocks of the Antigonish Highlands which were intermittently uplifted early in the Carboniferous. The Windsor Group is transgressive over the Horton Group.

A few plant fragments were found in the conglomerate and wacke beds, and spore samples were obtained from several grey wacke beds on Rights River. Sample 7395 contains spores that are common to the previously studied Horton collections (*see* fossil collections list in Appendix). The other three samples contain spore assemblages that are possibly older than the Horton Bluff of the type section. At the mouth of McInnis Brook on Cape George, Upper Devonian spores have been identified from Horton rocks (Benson, 1970a; McGregor 1971). It appears that Bell's type section of the Horton on the Avon River is missing the lowermost Horton strata, and the Rights River conglomerate section is stratigraphically equivalent to the type Horton Bluff and Cheverie plus a lower interval. The Rights River Formation is of possible latest Devonian and Lower Carboniferous (Tournaisian) age.

Windsor Group

The Windsor "Series" was first precisely described by Bell (1929, p. 45), who subdivided the type section near Windsor, Nova Scotia, into five faunal subzones, A, B, C, D, and E on brachiopod and coral evidence. Mamet (1970, p. 3) reviewed the previous stratigraphic work and concluded that the foraminifera fauna and algal flora indicate that the Windsor Group is late Viséan to early Namurian, in contrast to the previously suggested Early or Middle Viséan to Late Viséan. The Windsor fauna, like the Horton fauna, very clearly show an European affinity and are thus more easily regarded as Lower Carboniferous than Mississippian. Both North American and European period names are used in the Table of Formations, but only the European terms (Lower and Upper Carboniferous) are used elsewhere in this report.

Distinctive limestone horizons that can be easily recognized in most sections are present in the Windsor subzones. Schenk (1967, p. 239; 1969, p. 1040) regarded some of these units as time transgressive, however, Mamet (1970) concluded that the microfauna confirmed the chrono-stratigraphic value of the brachiopod–coral assemblages. Figure 3 indicates the age

Subzone	Horizon	Lithological characteristics of subzone carbonate (limestone) bed. Type Section (Bell, 1958)	Substage	Foraminiferal zones	Zone (Mamet, 1970)	Zone (based on conodonts) (Globensky, 1967)
			Early Namurian	19		
				18		
				17	E (Schizodus)	E
			Late Viséan	16s	D (Giant ripple)	
F		Gigantoproductus		16i	C (Third algal) (Small algal)	
E	E_1	Schizodus (dolomitic, oolitic)		15	B (first & second oolitic) A?	
D	D_3	Yellow earthy				
	D_2	Bituminous, oolitic		14		
	D_1	Giant ripple, algal				
	C_3	Columnar, algal	Middle Viséan	13		
	C_2	Minor columnar and domal algal		12		
	C_1	Small algal, crystalline				
	B_3	Second oolitic				A ?
	B_2	First oolitic	Early Viséan	11		
	B_1	Quarry, thick fossiliferous				
	A_2	Canary, yellow to red nodular		10		
	A_1	Basal sandy laminated				
				9		

GSC

FIGURE 3. Correlation of Windsor subzones.

proposed by several authors for these limestones. Mamet (op. cit., p. 19) regarded Bell's F subzone as a time-equivalent of the E and recommended discarding the term.

Windsor strata are exposed in scattered outcrops in the Antigonish basin and near Big Marsh, in a well-exposed but incomplete section on the coast west of McArras Brook, and in three restricted areas, northeast of Eden Lake, near Baileys Brook, and in the valley of the Hollow fault near Doctors Brook.

Sage (1954, p. 51–53) measured 670 feet of Windsor strata above the D_2 limestone on West River of Antigonish, and 1,907 feet for the entire Windsor on Pomquet River 6 miles farther east. The total thickness for the A, B, and C subzones in other parts of the Antigonish basin range from 800 to 1,500 feet. These figures, added to the value from West River, give an approximate total thickness of 1,500 to 2,100 feet for the Antigonish basin. Near St. Joseph, a thickness of 1,000 feet of Windsor overlying the Browns Mountain Group was estimated from scattered outcrops, and an additional possible 1,600 feet of clastic sediments and gypsum–anhydrite. The 2,600-foot total represents a maximum value, and the figure of 1,500 to 2,100 feet is proposed as a more valid thickness. The Windsor section west of McArras Brook was measured by Pohl (1930, p. 93) as 1,600 feet, however, he included some of the overlying Lismore Formation and 300 feet of strata regarded in this report as Rights River. The interpreted thickness from measured outcrops is 200 feet.

The Windsor Group is composed of marine and minor continental sediments, with interbedded evaporite sequences. In the Antigonish basin it consists of light grey and greyish red mudstone and siltstone, and medium grey calcareous shale and limestone with minor gypsum and anhydrite. On Brierly Brook and Rights River about 20 feet of dark grey to black, argillaceous, laminated limestone disconformably overlies the Rights River Formation. This limestone, correlated with the A_1 basal sandy limestone of the type section, is overlain by red and medium brownish grey calcareous mudstone and siltstone, with interbedded gypsum and anhydrite. South of Brierly Brook the evaporites are exposed in cliff faces up to 60 feet high. The calcareous beds in the southern part of the basin correlate mainly with D and E subzones. Small outcrops of D_3 (?) yellow dolomitic limestone and grey laminated argillaceous limestone appear to overlie the Rights River Formation. Along West River the interbedded, medium greyish red siltstone and mudstone with minor calcareous layers, dark grey argillaceous limestone, and marly gypsum are typical of the upper Windsor. Gypsum is exposed near Salt Springs and several salt springs are found near the river's edge. Near Glen Road and south of Ohio similar sections of fossiliferous black argillaceous and crystalline limestone beds from 5 to 15 feet thick are interbedded with calcareous and noncalcareous, medium greyish red siltstone and fine-grained wacke. The limestones, particularly the fragmental layers, possess a weak to strong petroliferous odour. These beds are all correlated with subzone E. A similar argillaceous limestone, mudstone, and siltstone sequence, found northeast of Lochaber Lake and near Hillcrest, is also regarded as correlative with the E subzone. The shore section consists of approximately 100 feet of medium grey-red, fine-grained wacke and siltstone overlain by 20 feet of mudstone and siltstone, 6 feet of dark grey siltstone with 2-inch beds of argillaceous limestone, and 15 feet of medium grey limestone with numerous oölitic beds. On Knoydart Brook, 150 feet of moderate greyish red calcareous wacke conformably overlies Rights River conglomerate and is overlain by 20 feet of medium grey, fine-grained oölitic limestone with petroliferous odour. The limestone on the shore is regarded by Mamet (1970, p. 74) as latest Viséan, zone 16, and by the author as probably D_2. The Windsor section near Big Marsh is a small basin with arenaceous laminated A_1 limestone, with minor breccia conformably overlying Rights River conglomerate at the edges. The outcrop in the middle of the basin is moderate brownish grey calcareous wacke, mudstone, and minor granule-conglomerate with interbedded grey fragmental and lithographic limestone. A drillhole near the centre of the basin revealed a more complex section (Huppi, 1953).

The Windsor sediments do not generally display many bedding structures except ripple-marks. The siltstone, in places, fills minor channels in the underlying beds, and graded bedding is found in the granule-conglomerate and wacke. The beds are generally relatively flat lying with almost all dips less than 30 degrees. Northeast of Lochaber Lake dips of up to 75 degrees were measured near the evaporite beds, where diapiric uplift has probably occurred.

The Windsor Group overlies the Horton Group disconformably to unconformably, the Knoydart Formation, Arisaig Group, and Browns Mountain Group unconformably, and is bounded by faults near Doctors Brook. The upper contact with the overlying Canso is con-

Drillhole section near Big Marsh (from Huppi, 1953)

Lithology	Approximate thickness (feet) of unit	Approximate thickness (feet) above base
Dark grey crystalline to dense limestone with some red clay streams and basal (2-foot) limestone and siltstone breccia	37	529
Greyish red calcareous micaceous siltstone	8	492
Light grey to white fine-grained dense limestone with minor shaly partings	23	484
Greyish red and green shale and siltstone, in part slightly calcareous with narrow (2-inch) gypsum veins	262	461
Dense coarsely crystalline anhydrite with disseminated gypsum crystals	57	199
Greyish red and green siltstone with anhydrite, gypsum, and shale lenses	33	142
Light grey, highly contorted gypsum	6	109
Dark grey shale with gypsum streaks	14	103
Grey dense limestone	41	89
Grey, laminated argillaceous limestone. Bedding dips from 0 degree to 45 degrees	48	
Boulder-conglomerate (Rights River)	167	

formable near McArras Brook and assumed to be conformable in the Antigonish basin. The upper boundary is probably time transgressive, as E limestone is not present near McArras Brook.

The marine Windsor Group of the map-area was deposited under three paleoenvironments: open marine carbonate platform, oölitic and algal bank, and shallow marine restricted (lagoonal), dependent on the oscillations of the Windsor sea (Mamet, 1970, p. 20). The Antigonish Highlands appear to have remained a positive arch at this time. The cyclic nature of the Windsor sea begins with transgression during deposition of zone A. Further transgression resulted in the maximum extent of the Windsor sea during deposition of zone B. The cyclic fluctuations continued with lesser transgressions during C, D, and E deposition. The development of marginal oölitic and algal banks resulted in the formation of supersaturated lagoonal flats where dolomite and evaporites were deposited. Each succeeding transgression brought more brine to these flats. The cyclic transgressive nature of the Windsor sea coupled with probable isostatic readjustment of the Antigonish Highlands resulted in A, B, and D limestones resting unconformably on pre-Windsor rocks.

Most Windsor carbonate beds are fossiliferous, except the basal A_1 and A_2 limestones. Few collections were made in the map-area, although good fossil descriptions are available in other reports (Bell, 1929; Globensky, 1967; Mamet, 1970; and Sage, 1954).

The Windsor Group has been recognized as Lower Carboniferous (early to late Viséan) (Bell, 1958; Belt, 1964; Sage, 1954). More recent studies by Mamet (1970) and Globensky (1967) narrow the age limits of the Windsor. Mamet regarded it as late Viséan and earliest Namurian. However, spore studies indicate an age no younger than Tournaisian for the Horton, which the Windsor overlies disconformably. It is probable that the Windsor, in particular the A subzone, is middle Viséan and possibly early Viséan.

Upper Carboniferous

The commonly used Upper Carboniferous stratigraphic units, Canso, Riversdale, Cumberland, and Pictou groups, were actually defined as time-stratigraphic units by Bell (1944, p. 5–21). Through usage they came to be regarded as rock-stratigraphic units. Their descrip-

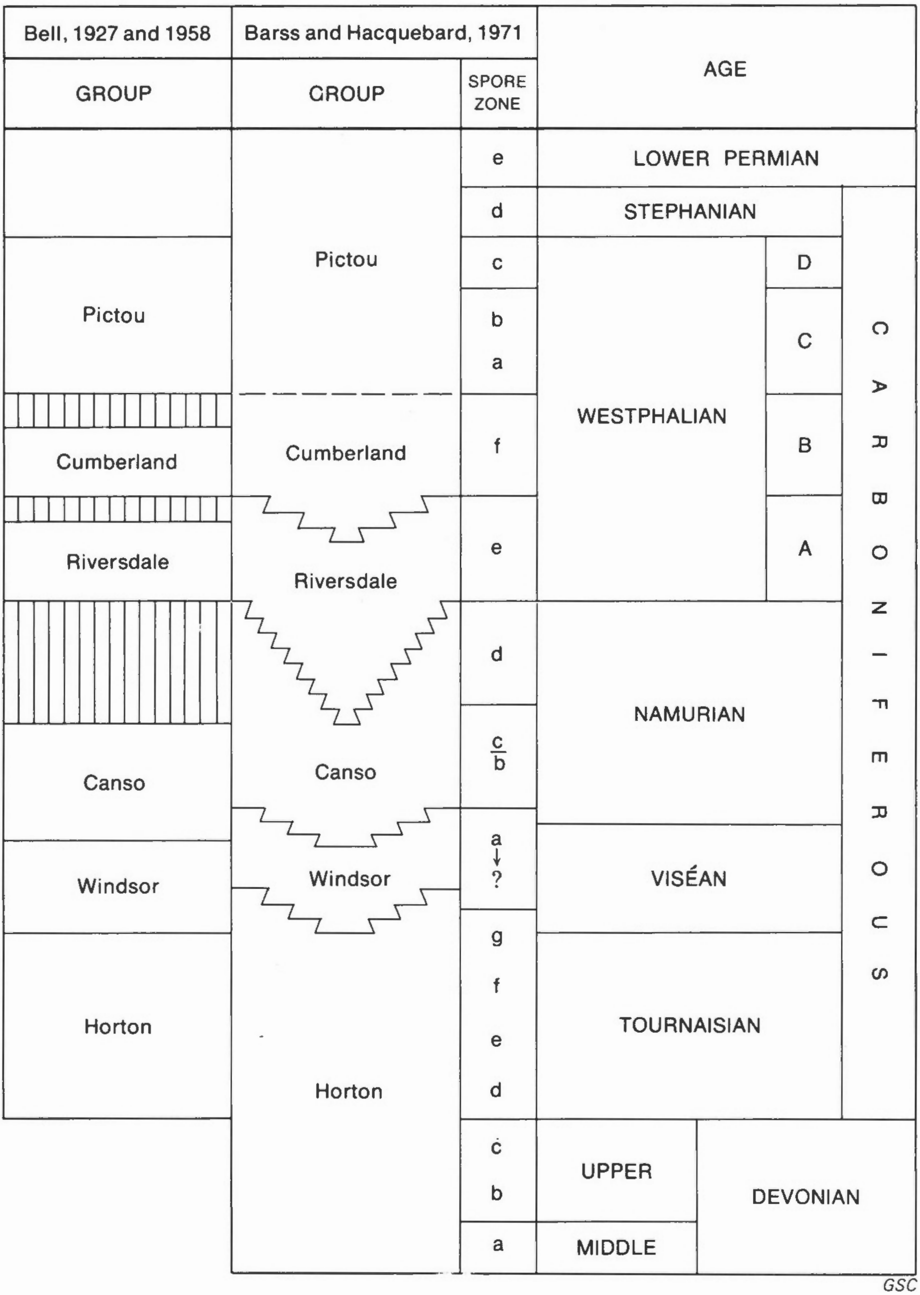

FIGURE 4. Stratigraphic subdivisions and age of Upper Paleozoic rocks in eastern Canada (Hacquebard, 1971).

tions have been inadequate, but rather than introduce new terms, it is preferable to accept these terms as redefined by Kelley (1967b) and van de Poll (1970). Belt (1964, 1965) focussed attention on the problems of Upper Carboniferous terminology and proposed the Mabou Group and an informal "coarse fluvial facies" to include all Upper Carboniferous units. Further field and palynological studies have indicated that the "coarse fluvial facies cannot be regarded as a valid litho-stratigraphic unit, but rather appears to be a highly variable, multi-provenant sequence, of more or less time-transgressive strata" (van de Poll, 1970, p. 29). The stratigraphic limits of the Mabou Group are also time transgressive (Hacquebard, 1971), hence the term Mabou Group is not used in this report as it is little improvement over the original Canso Group, and preference must be given to older, well-established terms.

The Carboniferous spore zones are shown in Figure 4. A more detailed discussion is presented by Hacquebard (1971).

Canso Group

The Canso Group was defined (Bell, 1944, p. 5) as red and grey shale that overlies marine Windsor or its nonmarine equivalent in age. The type section is along the eastern shore of the Strait of Canso. The Canso Group in the map-area consists of greyish red and greenish grey wacke, siltstone, and conglomerate, and greyish red and light grey mudstone, siltstone, and minor calcareous shale. The lower boundary is placed at the top of the youngest marine limestone of the Windsor Group. Bell (1926, p. 162C–166C) continued the use of the name Lismore Formation (Williams, 1914, p. 33) for the Canso rocks northwest of the Antigonish Highlands. The red Canso strata east of the Antigonish Highlands were named the Pomquet Formation (Rostoker, 1960) and the grey beds, the Hastings Formation. This report retains the use of the term Lismore Formation. The limited exposures to the east are referred to as Canso Group.

The type section of the Lismore Formation is exposed along the coast from Lismore to east of Knoydart Brook. However, this section does not contain the younger Canso rocks exposed on the coast near Merigomish, in French River, and in Hogan Brook. Bell (1926, p. 163c) measured a thickness of 2,817 feet from the underlying Windsor limestone to Lismore, 3,920 feet in Hogan (Huggan) Brook, and 1,290 feet under Merigomish Harbour, for a total of 8,025 feet. Present field work resulted in an estimate of 2,350 feet for the shore section and an additional 4,600 feet in Hogan Brook, French River, and under Merigomish Harbour, for a total thickness of approximately 6,950 feet. The few Canso outcrops in the Antigonish basin at the eastern edge of the map-area suggest a minimum thickness of about 120 feet.

Lismore sections are also exposed along the south shore of Merigomish Harbour, and in Knoydart, Vamey, Baileys, Smith, and Hogan brooks, and Barneys and French rivers. As the Canso is not resistant, almost all outcrops are on the coast or in the stream valleys.

The eastern Canso Group outcrops are part of a more extensive section that underlies part of the Antigonish basin. They consist of nearly flat lying, light to dark grey, very fine grained wacke, siltstone, and silty shale with interbedded calcareous layers about 6 inches thick. The calcareous layers weather light brownish grey which contrasts with the normal dark grey weathered surface. Minor greyish red siltstone is found in the grey sequence, and a thin greyish red micaceous siltstone appears to conformably overlie the Windsor limestone.

The Lismore Formation comprises greyish red wacke, siltstone, and shale with minor granule-conglomerate; greyish red and grey mudstone, siltstone, and calcareous shale; and grey wacke and siltstone. These lithologies are present throughout most of the section, although certain associations are more common in different parts of it. The following generalized outcrop descriptions from the shore section between Lismore and the Windsor limestone indicate a slight coarsening of grain size upward:

Light grey and greyish red, fine-grained wacke.

Medium greyish red siltstone and mudstone.

Light grey and greyish red, crossbedded, fine-grained wacke and calcareous shale.

Variegated grey and greyish red siltstone and fine-grained wacke.

Medium greyish red wacke; light grey, medium-grained wacke and cobble-conglomerate with calcareous concretions; and medium greyish red, fine-grained wacke.

Medium greyish red grading to medium grey offshore, calcareous siltstone.

Medium greyish red, flaggy, fine-grained wacke and siltstone, mudstone, and claystone.

Greyish red siltstone, mudstone, and claystone with malachite-stained fossil plant fragments.

Medium greyish red and medium grey, fine-grained wacke with numerous spores and fossil plant fragments.

On Hogan Brook and French River similar sections, representative of the middle and upper Canso strata, consist of medium greyish red siltstone and very fine grained wacke with minor light greenish grey beds and medium red granule-conglomerate, grading upward into medium greyish red and light grey, fine-grained wacke with interbedded calcareous wacke and granule-conglomerate and mottled mudstone. East of Egerton and Sutherlands River these beds are overlain by light grey and greyish red, calcareous pebble- to cobble-conglomerate.

The Lismore rocks display crossbedding, minor channelling, graded bedding, and ripple-marks, all of which show that these gently dipping beds are right-side-up. On Hogan Brook and French River fracturing of some beds indicates local faults. No increase in fracturing was attributed to the proximity to the trace of Hollow fault. The basal contact with the Windsor Group appears conformable, but it overlies the older Paleozoic rocks with pronounced unconformity. The fault scarp extension of Hollow fault was present during deposition of the Lismore, but a few minor fractured zones are the only indication of later movement. The upper contact with the Pictou is interpreted as a disconformity, and with the New Glasgow Conglomerate, as a disconformity or unconformity.

The Lismore rocks are regarded as a transgressive fluvial sequence derived from the Antigonish Highlands, possibly, in part, from Lower Carboniferous and Devonian rocks. The calcareous beds of the Lismore Group and Antigonish basin indicate a temporary lacustrine environment.

The age of the Canso, based primarily on palynology, is Namurian. The transgressive nature of the group and of the overlying strata permit a basal age as old as Upper Viséan in subsection and an upper limit from middle to upper Namurian.

Cumberland Group

The term Cumberland series was introduced by Bell in the Springhill area and was also used in the Pictou coalfield (1940, p. 16) "to designate strata that lie either unconformably or disconformably above the Boss Point of the Riversdale series and unconformably below the Pictou series." It was correlated with the Westphalian B flora of Europe.

The Cumberland strata in the map-area consist entirely of a poorly sorted conglomerate and wacke sequence regarded as correlative with the New Glasgow Conglomerate. In the New Glasgow area to the west it is a coarse boulder-conglomerate with lenticular beds of red sandstone and shale (Bell, 1940, p. 18).

The type section was designated as New Glasgow and its environs on Fraser Mountain. The conglomerate is a minimum of 2,600 feet thick at New Glasgow and thins eastward to an estimated 2,000 feet east of Fraser Mountain.

The New Glasgow Conglomerate outcrops near Sutherlands River and on Quarry Island and adjacent areas in Merigomish Harbour. Bell (1940, p. 20) estimated a thickness of 325 feet for the conglomerate on Quarry Island. Present work suggests that 650 feet of New Glasgow Conglomerate overlies the Lismore near Sutherlands River and about 300 feet, near Quarry Island.

The conglomerate consists of medium greyish red, poorly stratified and indurated pebble- to cobble-conglomerate, with 4- to 6-inch-thick beds and lenses of medium- to coarse-grained wacke, and minor, light to medium grey sections, with some carbonaceous remains. The red conglomerate consists of red greywacke and wacke clasts in a very coarse grained sand to granule matrix. The grey conglomerate consists of light to medium grey quartz wacke clasts in a medium-grained sand matrix. On the shore north of Egerton, light grey calcareous pebble-conglomerate and wacke conformably overlie light olive-grey wacke of the Lismore Formation. These beds can be interpreted either as an intraformational conglomerate or an eastward extension of the New Glasgow Conglomerate. The conglomerate dips from 15 to 30 degrees near Sutherlands River and from 10 to 20 degrees at the coast. The steeper dips probably reflect the higher angle of deposition nearer the highland.

The southern beds unconformably overlie the slightly fractured Lismore Formation, suggesting movement along Hollow fault before deposition of the New Glasgow Conglomerate.

The conglomerate and coarse sediments are interpreted as local conglomerate deposits that were formed following local vertical movements of the Browns Mountain Block.

Spore samples Bo 126, 132, and 133 were obtained just below the New Glasgow Conglomerate and were correlated with spore zone d of the Canso–Riversdale or younger. Similar correlations were obtained from spore samples collected on Sutherland River west of the map-area. The New Glasgow Conglomerate is, therefore, post-Namurian, and may be as young as Westphalian B.

Pictou Group

Bell (1926, p. 171c) included the New Glasgow Conglomerate in the Pictou series but later (1944, p. 29) redefined the Pictou Group as mainly Westphalian C and D, with possible Westphalian B, due to its transgressive nature. The type section in the Tatamagouche syncline along West Branch River John is 7,350 feet thick. The Pictou Group consists of interbedded dusky red sandstone, grey arenite, dusky red shale and mudstone, and minor grey shale. The coal-bearing strata in Pictou county designated as the Stellarton series were divided into a lower predominantly red sandstone and shale division and an upper predominantly grey shale and sandstone coal-bearing division.

The Pictou Group outcrops on Merigomish Island and on Kings Head. The thickness is estimated at a minimum of 1,400 feet. The Pictou Group also outcrops on Pictou Island, about 12 miles northwest of Merigomish Island.

The main rock types are light to medium grey, very coarse grained arenite and wacke in beds averaging about 1 foot thick that usually display current crossbeds. The strata are composed of poorly sorted, angular grains with a few subrounded grains in some quartz-rich and lithic strata. The mineralogy of the arenite is essentially 50 per cent quartz, 30 per cent feldspar, 10 to 15 per cent rock fragments, 2 per cent mica, and 1 to 2 per cent organic remains concentrated on the bedding planes. There are a few beds of granule- to pebble-conglomerate up to 3 feet thick, some of which contain minor calcareous pebbles. Large fossil tree trunks, 6 to 8 feet long and 1 to 2 feet in diameter, are found among more common small fragments.

Several narrow carbonaceous layers, less than 6 inches thick, could be considered low-rank coal; a 3-foot-thick seam at Coal Point contains pyritized plant remains.

The beds dip from 10 to 25 degrees to the north and all top determinations indicate that they are right-side-up. Observed primary structures include current bedding, ripple-marks, slump rolls, and, in places, poorly graded bedding. Neither top nor bottom contact was observed, but the bottom contact is inferred as a disconformity.

The Pictou Group is of fluvial origin and was derived from older Carboniferous rocks to the south. The sediments in the Merigomish map-area were deposited at the edge of the Cumberland basin and probably contain limited lacustrine horizons, such as the coal bed at Coal Point.

The Pictou Group in the Merigomish Island to Fraser Mountain (New Glasgow map-area) region is correlated with spore zones a to c by Barss and Hacquebard (1967, p. 277–280), that is, Westphalian C and D. The spores from Pictou Island are Westphalian D, or even Stephanian.

Cenozoic

Pleistocene

Most of the bedrock north of the Chedabucto fault is covered with glacial deposits. The glacial rivers in the highlands apparently followed the same valleys as the present major streams. Well-developed kame terraces are visible along Barneys and French rivers and adjacent to the highlands east of these streams. The terraces near Barneys River Station are composed of coarse sand and gravel, and those southeast of the mouth of Knoydart Brook contain some fine sand. The Carboniferous plains are covered with thick deposits of gravel outwash, whereas the highlands are covered with from 2 to 25 feet of glacial drift. Four gravel deposits, each more than 25 feet thick, were examined and the source of the larger than pebble-sized fragments was determined as follows: East Branch Doctors Brook, entirely wacke, greywacke, volcanics, and intrusives from Browns Mountain Group; coast west of Malignant Cove, Silurian wacke, Carboniferous wacke and siltstone, Browns Mountain intrusives, sediments, and volcanics; south of Arisaig Brook, 60 per cent Carboniferous siltstone and wacke, 20 per cent Browns Mountain wacke, greywacke, and laminated siltstone, 10 per cent Silurian wacke and minor Silurian fossiliferous siltstone, Ordovician intrusives and volcanics, and Carboniferous pebble-conglomerate; near Salt Springs, 60 per cent Carboniferous wacke and siltstone, and 40 per cent Browns Mountain sediments and volcanics with minor intrusives.

Recent

The present stream system is actively eroding. Fine-grained sediments are deposited by the streams at their mouths. The north ends of Eden Lake and Lochaber Lake are being rapidly filled in by a combination of stream sediment and plant growth. Considerable silt is being added to Merigomish Harbour by Barneys, French, and Sutherland rivers. The other streams, which empty directly into Northumberland Strait, have supplied additional sediment which is transported by long shore currents and deposited on sandy or rocky beaches. Pebbles on the beaches of Merigomish Island have been identified as Moydart and Stonehouse fossiliferous fragments and as Silurian rhyolite similar to that exposed at Arisaig pier. At present the Maritime seacoast is submergent, due mainly to the response of the earth's crust to the postglacial rise of the sea over the Scotia shelf (Grant, 1970, p. 687).

A peat bog on the west side of James River was mostly drained and removed during construction of the new highway (Route 4). It developed in a depression in the underlying Windsor Formation, which was apparently veneered with glacial deposits. Peatbogs near Canso developed by small lakes growing over with sedge fern and becoming partly eroded, then becoming wetter and forming a *sphagnum fiseum* bog (Osvald, 1970, p. 167). The same sequence is postulated for this bog.

Description of Formations South of Chedabucto Fault

Ordovician

Meguma Group

The Meguma Group had long been recognized as the oldest rocks of mainland Nova Scotia before Ami (1900a) named the Halifax Formation and Woodman (1904) named the Meguma series and Goldenville Formation. The Meguma Group consists of a basal Goldenville greywacke conglomerate, schist, slate, and argillite sequence overlain by the Halifax slate with minor siltstone and argillite. The age of the entire Meguma has not yet been resolved, but Halifax rocks near Wolfville contain earlymost Ordovician graptolite fossils (Bulman, 1960). Graptolite branches found near Tangier (27 miles south-southwest of the map-area) in Meguma rocks that are regarded as Goldenville, or possibly Halifax, were assigned a Canadian (Arenigian–Lower Ordovician) or, less likely, a Silurian age (Poole, 1971). Detrital muscovite concentrated from nearby Goldenville rocks was dated as 496 ± 20 m.y. and 476 ± 19 m.y. (Poole, 1971), that is, Late Cambrian to Early Ordovician. No Halifax Formation is exposed in the map-area, although it is exposed to the east, west, and south.

Goldenville Formation. A thin Goldenville section is exposed in most north-flowing tributaries of West River St. Mary's, in St. Mary's River, and in a few scattered interstream outcrops. The thickness of the exposed Goldenville has been estimated at 18,500 feet along the shore of Liverpool Bay and on Sissiboo River (Taylor, 1969, p. 9), 17,670 feet above an unknown base in the Fifteen Mile Stream district south of the Hopewell map-area (Woodman, 1904, p. 16), and 2,400 feet in Hopewell map-area (Benson, 1967a, p. 11). The thickness in the Lochaber map-area is estimated at 2,300 feet on Chisholm and Palmer brooks and St. Mary's River.

The Goldenville lithology of the Lochaber map-area is not representative of the much thicker complete section. The formation comprises greenish grey to medium grey quartzite, quartz wacke, phyllite, and quartz–mica schist, with minor greywacke and subgreywacke and andalusite and staurolite schist developed near the granite contacts.

The quartzite is fine to medium grained and occurs in sections from 5 to 25 feet thick interbedded and gradational with quartz wacke and phyllite beds from 1 to 5 feet thick. The quartz wacke also varies from fine to medium grained and grades into greywacke, and quartz–mica schist, particularly near the granite bodies. The phyllite, which is dark purplish grey to medium grey, has gneissic lenses near the granite. Most outcrops display narrow (1-inch) granitic veins, up to 6-inch quartz veins, and occasional gneissic knots about $\frac{1}{2}$ inch across. The schistosity of the quartz–mica schist is generally parallel to the bedding, and the quartz veins are also often parallel. The mica schist and phyllite contain small (1 mm to 2 mm) andalusite and garnet crystals. Several granite outcrops contain xenoliths of quartz–mica schist. On Kelly Brook there is an increase in quartz veins near the granite contact, and a quartz muscovite hornfels was formed at the contact, yet the mica schist 5 feet from the contact displays no appreciable increase in metamorphic effect. A good discussion of the metamorphism of the Meguma Group was published by Taylor and Schiller (1966).

The outcrops and waste dumps around Little Liscomb Lake gold mine were carefully examined for indications of gold mineralization. The quartzite and quartz wacke appeared no different from those elsewhere; no gold was found. Similar observations were made at Crows Nest gold mine and Cochrane Hill gold mine just south of the map-area east of St. Mary's River.

The quartzite has a recrystallized submosaic texture consisting of 60 per cent recrystallized quartz, 30 per cent slightly sericitized plagioclase, mostly untwinned but with minor polysynthetic twinning; and 10 per cent fine-grained muscovite, chlorite, sericite, opaque minerals (pyrite, magnetite), and matrix; all are cut by numerous quartz veins. The quartz wacke and quartz–mica schist have similar mineral content, but the relative amounts differ with more quartz and less feldspar and mica in the wacke. The quartz–mica schist consists of 45 to 50 per cent strained, slightly attenuated recrystallized quartz; 30 per cent calcic, untwinned, and altered plagioclase; 15 to 20 per cent muscovite; and minor chlorite, garnet (almandine), and highly altered potassium feldspar. On St. Mary's River this schist grades into a staurolite–garnet–biotite schist with a porphyroblastic foliated texture that consists of 45 per cent sericite–quartz matrix with strongly oriented muscovite; 30 per cent light to dark reddish brown, strongly oriented porphyroblastic biotite with minor poikiloblastic quartz and zircon; 20 per cent euhedral crystals of staurolite with inclusions of quartz, garnet, iron oxide, and biotite. The strongly foliated phyllite consists of fine-grained quartz, oriented biotite and muscovite flakes, and accessory magnetite and leucoxene, sphene, chlorite, tourmaline, and apatite.

The Goldenville outcrops show a consistent east–west strike dipping steeply to the north. However, a good outcrop section on McQuarrie Brook exposes two well-developed folds across a width of 25 feet, and several drag-folds with nearly horizontal plunge. Considerable fracturing is seen in most outcrops. The quartzite on Churn Brook has well-developed fault planes and contorted quartz veins that are attributed to differential movement. No top or bottom determinations were made, although bedding planes were observed in some wacke outcrops.

The Goldenville was intruded by the Devonian granite and unconformably overlain by the Horton conglomerate. East of St. Mary's River it appears to be in fault contact with the Horton.

The Goldenville Formation is interpreted as a flysch-like continental margin, possibly a continental terrace or continental rise deposit, that was probably derived from a southerly source area (Schenk, 1970). The age is regarded as lower Ordovician, although it may be as old as Cambrian.

Devonian

Intrusive Rocks

Granite. The exposure of granite near Hattie Lake in the southwest corner of the map-area is an extension of a larger body to the south and west (Benson, 1967a, p. 21). The two smaller bodies just south of West River St. Mary's are probably part of the Hattie Lake body.

The granite outcrops generally weather a light brownish grey, but the fresh surface varies from pinkish grey to medium light grey. The granite is medium to coarse grained with easily identifiable pink feldspar, grey quartz, biotite, and muscovite. Several outcrops, notably in the two smaller bodies, are foliated due to alignment of the minerals.

Thin sections of the Hattie Lake granite display a coarse-grained, allotriomorphic, slightly cataclastic texture consisting of 35 per cent anhedral orthoclase and twinned microcline; 35 per cent strained and granulated quartz; 25 per cent subhedral to euhedral, fractured and strained plagioclase laths that are partly kaolinized; 5 per cent fresh, bent and strained, reddish brown biotite and colourless muscovite; and minor apatite. The Goldenville rocks just south of the West River St. Mary's fault are intruded by dark green hornblende diorite which is itself cut by several narrow (6-inch) granitic dykes. The slightly cataclastic quartz hornblende diorite is composed of 60 per cent fractured and strained, fresh, polysynthetic twinned plagioclase laths; 20 per cent interstitial strained quartz; 17 per cent light to medium brown, partly chloritized hornblende; 3 per cent biotite strongly altered to chlorite and minor sphene.

The granite bodies have inclusions of quartz–mica schist (Goldenville). Granite pegmatite dykes intruding the quartz–mica schist have chilled borders. The granite is overlain unconformably by Lower Carboniferous Horton Group sediments. Fairbairn (1960, p. 408) reported numerous K-Ar biotite and muscovite ages from Nova Scotia, including a value of 380 m.y. for granite in Liscomb Game Sanctuary from the same body as the Hattie Lake granite. A Devonian age for this granite is accepted, and it was intruded during the late stages of the Acadian Orogeny.

Lower Carboniferous

Horton Group

The Horton Group in the St. Mary's River graben is divisible into three lithographic units, the Craignish, Strathlorne, and Ainslie formations. Kelley (1967b, p. 20) found it difficult to separate the Strathlorne and Ainslie formations in the Baddeck and Whycocomagh map-areas, due mainly to lateral facies changes. He suggested combining them into a Strathlorne–Ainslie Formation and using the names Strathlorne and Ainslie members for regional usage on Cape Breton Island. The Strathlorne and Ainslie beds are not in contact in the Lochaber map-area and are mapped separately, although the Strathlorne is, in part, a fine-grained facies equivalent of the Ainslie. These three units were also recognized in the Hopewell map-area (Benson, 1967a, p. 22–28) and were described as informal units a, b, and c.

The Horton Group sediments were derived from Meguma Group rocks and Devonian granite to the south, and deposited in the developing Carboniferous basin. The relatively clean Craignish was deposited following intrusion of the Devonian granite and uplift of Meguma rocks and granite along the West River St. Mary's fault. As the block of Meguma rocks was eroded, the sediments became finer grained and the Strathlorne was deposited near the far side of the basin. Continuing minor uplift along the fault, particularly to the east, resulted in subaerial deposition of the Ainslie red beds. The small outlier of Ainslie near Denver was possibly due to uplift directly to the south. Following deposition the Chedabucto fault developed the St. Mary's River graben through left-lateral strike-slip and minor dip-slip movement.

Craignish Formation. The Craignish Formation type section along Southwest Mabou River consists of 5,130 feet of medium- to coarse-grained, grey arkosic sandstone with minor amounts of siltstone, and red conglomerate with interbeds of red arkosic grit, sandstone, and siltstone (Murray, 1960, p. 12).

About 2,000 feet of Craignish (unit "a") is exposed in Hopewell map-area (Benson, 1967a, p. 23). In Lochaber map-area an estimated maximum thickness of 4,300 feet is present on McDonald and Sutherland brooks, but the folded strata on Cross Brook are a minimum of 2,200 feet thick.

The best exposures of the Craignish are on East River St. Mary's between Rocky Mountain and Willowdale, on Cross and McDonald brooks, and in the barrens south of Eden Lake.

This formation consists of light to medium grey, coarse- to fine-grained quartz–arenite and quartz-feldspar arenite interbedded with dark grey siltstone, quartz wacke, and quartz-feldspar wacke (grit), and minor granule-conglomerate, shale, and mudstone. The arenite beds are the most resistant and form prominent outcrops that result in an erroneous impression of the relative amounts of arenite and siltstone. On East River St. Mary's near Willowdale the arenite is the major constituent, whereas in the barrens south of Eden Lake five arenite sections, each about 20 feet thick, were separated by covered sections from 75 to 250 feet thick underlain by siltstone. The quartz–arenite and quartz-feldspar arenite occur in massive beds with indistinct bedding about 6 inches thick and, in places, some beds are as thin as $\frac{1}{4}$ inch. The colour is usually light grey, although a greyish brown colour due to hematite staining and a white and light grey speckled effect due to kaolinization of the feldspars are common. The arenite grades compositionally into wacke by addition of fine-grained argillaceous matrix and mica and in grain size into granule-conglomerate. The granules consist of quartzite, mica schist, quartz, and black slate, which are all found in the Meguma Group. Large plant fragments (*Lepidodendropsis*) are found in the arenite, smaller remains in the wacke, and spores in the fine-grained wacke and siltstone. Quartz veins and fracture fillings (up to 1 inch wide) occur in most arenite exposures. The siltstone is medium to dark grey and grades into both wacke and arenite. Laminated beds and crossbedded sections 2 to 4 inches thick are equally distributed with more massive sections. The composition of the Craignish is more argillaceous toward the block of Meguma sediments and also toward the top of the section, where minor reddish grey greywacke and mudstone beds occur.

A typical quartz-arenite thin section consists of more than 80 per cent subangular quartz grains from 0.3 to 0.6 mm, about 5 per cent each cataclastic and interstitial quartz cement, less than 5 per cent untwinned sericitized feldspar, and traces of muscovite and quartz schist fragments. The quartz-feldspar arenite is similar, except that feldspar comprises up to 20 per cent of the rock. The fine-grained wacke consists of 60 per cent clear, rounded to subangular, equidimensional quartz grains, less than 10 per cent strained chlorite, and minor zoisite, leucoxene, and biotite. The siltstone and silty shale consist of fine silt clasts in a sericitic matrix with laminations accented by carbonaceous material.

The beds are generally massive with indistinct bedding that is more distinct where carbonaceous material and mica plates occur on the bedding planes. Both normal and torrential crossbeds are found in the wacke, arenite, and siltstone beds. Graded bedding and ripple-marks are less common.

The Craignish beds are commonly folded and all beds, except the more massive arenite and wacke, display drag-folds, evidence of slippage, and minor fracturing. As the beds were deposited in an elongated basin, there is a consistency in attitude with two thirds of the outcrops striking between 50 and 90 degrees and greater than two thirds dipping more than 60 degrees.

The basal contact was not observed, but it is assumed to be unconformable on the older Meguma sediments and Devonian granite. Near the Meguma massif the Craignish grades upward into the mainly red Ainslie, whereas farther away the grain size decreases and it is overlain by the Strathlorne. Much of the Craignish is in direct contact with the Antigonish Highlands rocks along the Chedabucto fault.

The Craignish Formation of the Lochaber map-area is correlated with the type section on lithologic, stratigraphic, and palynological evidence. Most spore collections were correlated with the Horton Bluff Formation (Tournaisian) as defined by Bell (1929, p. 30–45) (*see* fossil collections list in Appendix). Several collections on McDonald Brook were provisionally regarded as older than Horton Bluff, and some of the Craignish to the east on West River St. Mary's is possibly as old as Horton Bluff. This suggests an offlap succession for the Craignish, which grades upward and shoreward into the red Ainslie. The Craignish is totally Lower Carboniferous where exposed, but subsurface sections may be as old as the basal Rights River.

Strathlorne Formation. Murray (1960, p. 15) defined 1,050 feet of black, fissile shale, grey, thinly bedded siltstone, and grey, green, and buff very fine and fine sandstone exposed along Southwest Mabou River as the type section of the Strathlorne Formation. He stressed the entirely nonred character of the beds.

The Strathlorne beds (unit "b") in Hopewell map-area were estimated to be 3,000 feet thick (Benson, 1967a, p. 23), and the less extensive strata in Lochaber map-area are 2,500 feet thick. The few exposures are on tributaries of East River of Pictou and along the railway near the western edge of the map-area. In the small area east of Lochaber Lake and north of the Chedabucto fault only two small outcrops were observed, and the area could also be part of the Craignish Formation.

The Strathlorne Formation consists of interbedded, medium to dark grey siltstone, shale, and fine-grained quartz wacke with minor black carbonaceous shale. The siltstone is micaceous with common shaly partings and carbonate- and quartz-filled fractures. The siltstone grades into silty shale and shale and, occasionally, into fine-grained quartz wacke. Laminae and lenses of contrasting rock types are found in most exposures. The mica imparts a sheen to almost all bedding surfaces; pyrite is common in the carbonate and quartz fracture filling and also occurs in some of the carbonaceous shale.

Similar medium grey quartz wacke, silty shale, and laminated shale beds with a single dark grey limestone outcrop occur east of Lochaber Lake. All outcrops are sheared and most are tightly folded.

The mineral composition of the siltstone and wacke is similar to the Craignish, except for a greater amount of carbonaceous material in some thin sections.

Each of the measured dips was at least 45 degrees; most were between 70 and 85 degrees. The entire formation is fractured and drag-folds are common. The fracturing increases toward the Chedabucto fault which forms the northern boundary. The Strathlorne–Craignish contact is gradational and is placed above the highest medium- to coarse-grained arenite bed.

No fossil samples were collected from the Strathlorne, which is correlated with the type section on lithologic and stratigraphic grounds. It is regarded as Lower Carboniferous.

Ainslie Formation. At the type section on Southwest Mabou River the Ainslie Formation consists of 1,820 feet of red and nonred, fine- to coarse-grained clastic beds (Murray, 1960, p.16).

About 1,700 feet of Ainslie (unit "c") is exposed to the west (Benson, 1967a, p. 23). The best exposures in the map-area are along West River St. Mary's and Cross Brook. A shallow, synclinal basin of Ainslie overlies the Craignish near Denver.

The Ainslie Formation consists of greyish red and greenish grey micaceous mudstone and siltstone, medium grey and brownish grey, fine-grained micaceous quartz wacke and laminated siltstone with locally important light to medium grey and greyish red pebble- to boulder-conglomerate and greywacke. The various lithologies and colours grade very rapidly into one another. Almost all bedding planes display detrital mica typical of the Horton. The outlier near Denver is a finer grained sequence consisting of medium grey, fine-grained wacke and mudstone, reddish brown siltstone, mudstone, and fine-grained wacke and minor mottled reddish and greenish grey outcrops. Minor fossil plant remains are found in the grey beds and in scattered narrow black carbonaceous shale lenses. The pebble- to cobble-conglomerate and greywacke that are more common nearer the Meguma block consist of subrounded to subangular quartz, quartzite, schist and, in places, granite clasts in an unsorted matrix. The

Ainslie beds east of McDonald Brook are better sorted and contain few argillaceous beds, indicating that they may be from lower in the section.

A granule-conglomerate to wacke thin section is composed of 20 per cent strained quartz, 25 per cent cataclastic quartz, 20 per cent highly altered plagioclase (oligoclase to andesine), 5 per cent microcline, 10 per cent lithic fragments (quartzite, granite), 10 per cent biotite with minor muscovite, and less than 5 per cent chlorite. There is fair to poor sorting of subangular grains cemented by a silt–sericite mélange, indicating an immature sediment. Identifiable minerals in the finer grained sediments were similar, and the red colour was derived from iron-stained clay minerals and minor hematite.

The siltstone and wacke beds are generally crossbedded, and ripple-marks are common in the red beds. A typical sequence consists of interbedded, light grey to reddish grey micaceous wacke, greyish red mudstone, greenish grey pebble-conglomerate, greywacke, and mudstone. The wacke and greywacke, although crossbedded, break into flagstones from 1 to 8 inches thick, in many places with ripple-marked surfaces; the other beds are more massive. The conglomerate, commonly a channel filling, grades upward into a wacke or greywacke. The basal contact with the underlying mudstone is sharp. Several small local faults were interpreted as due to slump. Fractures are better developed to the east and near Denver. The majority of dips are less than 30 degrees; few are more than 50 degrees. The strike varies greatly.

The Ainslie Formation was derived from the Meguma Group and Devonian intrusive rocks and deposited as deltaic deposits at the margin of the Carboniferous basin. The basinward equivalent of the Ainslie was first the Craignish and toward the end of Horton deposition, the Strathlorne. These coarse sediments were continually being formed due to intermittent uplift along the West River St. Mary's fault. This uplift continued longer to the east where the upper beds have been eroded to leave lower Ainslie and Strathlorne beds (*see* Fig. 2). West of McDonald Brook the Ainslie is unconformable on the granite and Meguma rocks, and the present dip probably differs little from the depositional dip. The outlier near Denver is an erosional remnant of a more extensive Ainslie section that was deposited farther out in the basin due to the greater uplift to the south. The folds in the Ainslie formed during readjustment and movement of the Meguma block toward the end of Ainslie deposition.

The Ainslie Formation is correlated with the Cheverie Formation and, on palynological evidence, is as low as the Horton Bluff. The lithology is comparable with the type section. The Ainslie is regarded as a time-transgressive middle to upper Tournaisian formation.

Cenozoic

Pleistocene

The barrens south of Eden Lake where glacial striae were measured are almost devoid of glacial overburden, in contrast with the thick drift deposits elsewhere. The valleys of West River St. Mary's and East River St. Mary's appear to have been glacial meltwater channels, and kame terraces are common. The valley of West River St. Mary's near Caledonia is filled with glacial outwash deposits.

Recent

Glenelg Lake is being rapidly filled in with stream alluvium and vegetation in the same manner as Eden and Lochaber lakes. The topographic maps compiled from 1945 airphotos show that the three lakes were much larger than at present.

Chapter III

STRUCTURAL GEOLOGY

The map-area consists of four structural units: the Cambro-Ordovician sedimentary–volcanic–igneous complex; overlain by the Siluro-Devonian volcanic–marine sequence; relatively undisturbed Carboniferous sedimentary rocks; and the Meguma metamorphic rocks intruded by Devonian granite that served as the source area for the Carboniferous graben. Each unit presents a different structural picture. The present distribution of each unit depends largely on bounding faults, most of which are extended outside the map-areas (Fig. 5).

Previous studies (Neale *et al.*, 1961) included the map-area in the Canadian Appalachians subdivided into the following structural units: rocks folded only during late Paleozoic (Carboniferous cover): Taconic and/or Acadian folded rocks faulted and locally folded during late Paleozoic (Antigonish Highlands); cratonic cover on Paleozoic folded zones (Pictou Group); and rocks folded only in Acadian (Meguma). Deformation within the area has been more complex, and the present study shows that further work is needed to undertake a thorough structural analysis.

Faults

The Antigonish Highlands is a horst bounded by Hollow fault on the northwest and Chedabucto fault on the south. Hollow fault is an extension of the Cobequid fault that separates pre-Carboniferous rocks of the Cobequid Mountains from the Carboniferous rocks to the south. The transcurrent movement of the Cobequid fault was predominantly right-lateral with unknown total displacement (Eisbacher, 1969, p. 1103) that occurred during the late Upper Carboniferous. Eisbacher's work does not disprove the assumed vertical crustal movement that produced the Carboniferous sediments, but emphasizes the postdepositional strike-slip component.

The Hollow fault line scarp can be easily traced northeastward across the map-area. Intensive fracturing associated with the fault is visible in most outcrops along Doctors Brook and in all pre-Carboniferous rocks near the fault trace. A small slice of Windsor Group rocks is caught between associated faults at the coast, but outcrops of the Lismore and New Glasgow formations unconformably overlie the pre-Carboniferous with no apparent dislocation. A small area of Baxter Brook Formation near Sutherlands River is highly sheared, indicating that the fault was active there. The Silurian outcrop distribution on both sides of Hollow fault supports the proposed right-lateral movement on the Cobequid fault. Downthrow to the northwest probably occurred in lowermost Carboniferous. Hollow fault is more properly a

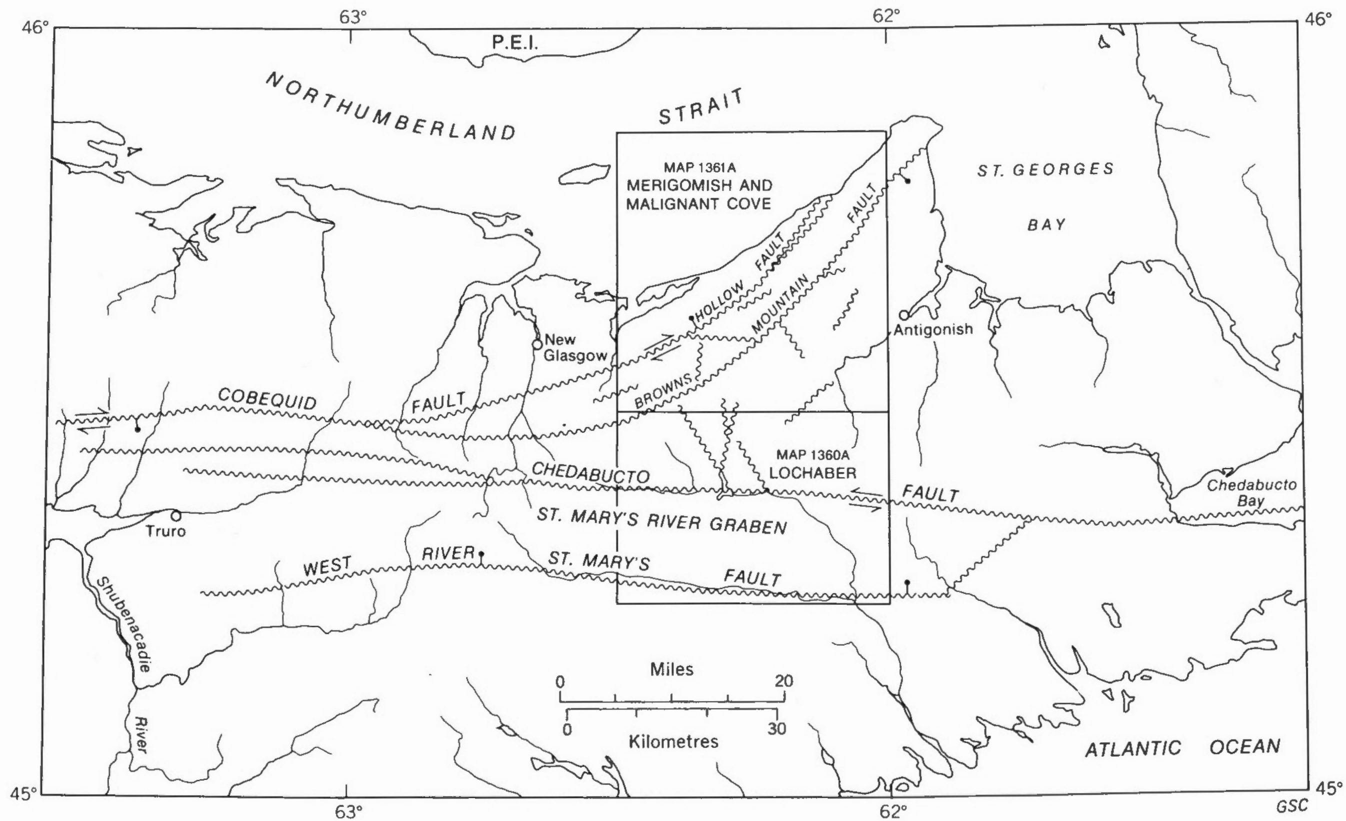

FIGURE 5. Major faults in northeastern Nova Scotia.

fault zone, as there are several branches near Doctors Brook; Marshy Hope fault, the fault near the headwaters of Baileys Brook, and several other small faults are probably offshoots of the main fault. Major movement along Hollow fault was post-Lower Carboniferous and pre-uppermost Carboniferous, as is also postulated for the Cobequid fault (Eisbacher, 1969).

The Chedabucto fault is easily traced by highly sheared rocks in East River of Pictou, McKay Brook, and east of Lochaber Lake. Several drag-folds were developed in the Strathlorne outcrops near the fault. It can be extended westward to the Truro area where Triassic sediments are also affected (Stevenson, 1958), and eastward into offshore Chedabucto Bay where assumed Cretaceous sediments are deformed along the extension of the fault (King and MacLean, 1970, p. 2008). The main movement along this fault is believed to have occurred contemporaneously with that along Hollow fault, but with additional movement in post-Upper Carboniferous–pre-Cretaceous time, with minor later readjustment. From outcrop information on Big Brook (Hopewell map-area), the movement is interpreted as left-lateral strike-slip, with minor vertical movement.

The Browns Mountain fault can be followed through several fracture zones on Browns Mountain and probably extends westward into Hopewell map-area. No strike-slip component was measured. The relative uplift to the north was apparent only at the northeast part of the fault, although similar movement could have occurred along its entire length. The oldest undisturbed rocks are the Rights River Formation; thus movement along the fault probably occurred in the Devonian.

These three major faults and several well-delineated smaller faults shown in Figure 5 are regarded as a distinct fault system.

There has been no appreciable movement along the West River St. Mary's fault since deposition of the Craignish Formation. Vertical movement along this fault was associated with the Devonian Acadian Orogeny. The resultant uplift elevated the source area for most Horton rocks in the St. Mary's River graben. The Meguma Group rocks and the Devonian granite near the fault are fractured, but the Ainslie is undisturbed.

The Arisaig rocks, particularly those along the coast, are generally fractured and cut by several faults. A series of faults with vertical displacement of a few feet have repeated parts of the McAdam Formation along the coast and give an erroneous impression of a thicker section. Vertical movement is apparent in other faults cutting the Arisaig, which suggests that these faults are a result of readjustment of the uplifted Siluro-Devonian rocks that were brought upward with the Browns Mountain block. The Arisaig Brook section has two well-developed fracture sets.

The overlying Carboniferous sediments have local faults with minor displacement of a few inches to 10 feet. These faults cannot usually be traced from one outcrop to the next. They are associated with the late Paleozoic (Upper Carboniferous) disturbance.

Folds

All sedimentary and volcanic units except the youngest Upper Carboniferous rocks are folded to varying degrees.

The absence of top indications in many Browns Mountain Group outcrops precludes identification of folds, and the scarcity of outcrop in other areas is equally disadvantageous. The rapid lateral variation in rock type makes it difficult to use horizon markers. On South Rights River the outcrops of the Brierly Brook and Baxter Brook formations have nearly consistent attitudes, yet the repetition of a laminated siltstone and tuff horizon suggests a tightly folded contact. A similar laminated siltstone on Power Brook and South Rights River suggests the presence of a syncline and an anticline. These folded sequences can be interpreted only if the Brierly Brook is the younger. Elsewhere, similar laminated siltstone and tuff beds are repeated several times in a single section without any indication of folding. Undoubtedly, these rocks are folded, but the folds indicated on the map may not be the true representation. Possible folds are also indicated on Iron Brook, Camerons Brook, Beaver River, Keppoch Brook, Baxter Brook, and Middle River by changes in attitude without apparent repetition of a diagnostic bed. The grey dacite flows are the best indicator of folds where a single persistent flow occurs. Thus the folds in the Arisaig Group near Middle and Wallace brooks are partly traced in the dacite. The outcrops of Beaver River were too poor to permit determinations of attitude, hence the interpretation is of two separate dacite flows rather than a fold.

The Arisaig Group is folded in Kenzieville trough and at Arisaig. The undivided sequences west of Eden and Lochaber Lake may also be folded, although to a lesser degree. The French River syncline and the anticline–syncline on Middle Brook plunge to the west. No appreciable increase in cleavage was noticed in these folds, indicating that the cleavage is not related to them. The Arisaig section is dominated by a syncline that plunges to the southwest overturned toward Hollow fault. The axial planes of the major folds are parallel to Hollow fault. Because the Carboniferous rocks overlying the Silurian are unaffected by these folds, the main folding was probably related to the Acadian Orogeny (mid-Devonian). Minor folds affect some of the outcrops, notably the more argillaceous beds of the Ross Brook and French River. It would appear that the arenaceous massive beds behaved competently during the folding, and deformation occurred on the intervening less competent argillaceous beds. Kink folds, less than 2 inches wide, were observed on Doctors Brook and Arisaig Brook. The outcrop pattern at Arisaig suggests that the entire Silurian–Devonian sequence lies on the southern limb of a large southwest-plunging anticline with an axial plane offshore.

Only broad open folds are observed in the Carboniferous; an example can be seen in the Lismore Formation on East French River.

The Goldenville Formation is tightly folded, as is evident on McQuarrie Brook. The overlying Carboniferous sediments are unaffected, and the Devonian granite shows but minor cataclastic effects. The contact metamorphism is a result of the Devonian intrusion, and the folding and regional metamorphism result from the Acadian Orogeny.

The Horton Group in the St. Mary's River graben shows three scales of folding. On Cross and Ross brooks the Ainslie Formation is folded into a large syncline about $1\frac{1}{2}$ miles across, on East River St. Mary's and Cross Brook folds are interpreted between adjacent outcrops and drag-folds measured in inches or feet are observed on the limbs of these folds and near the Chedabucto fault. The deformation of the Horton Group is associated with readjustment of the Meguma block and movement along the Chedabucto fault in post-Lower Carboniferous time, perhaps during the Maritime disturbance.

Chapter IV

TECTONIC HISTORY

An early model of the tectonic history of the Northern Appalachians proposed by Schuchert (1930) involved geosynclines and geanticlines and their deformation during what he referred to as the Taconian orogeny, Acadian disturbance, and Appalachian revolution. More recently, Neale *et al.* (1961), Poole *et al.* (1970), and Rodgers (1970) proposed similar tectonic models for the Appalachian region of Canada.

The tectonic history of the Antigonish Highlands region concerns that of the four main tectonic elements in this part of Nova Scotia: the Antigonish Highlands block, the Meguma block, the Cobequid Mountains block, and the surrounding Carboniferous strata (Fig. 6).

The Antigonish Highlands block is bounded on two sides by major faults, the Chedabucto and Hollow faults. This block is underlain by the Browns Mountain volcanic and sedimentary rocks (unit 1) and the associated syenodioritic (unit 2) and granitic (unit 3) intrusive rocks. These basement rocks are more deformed than the unconformably overlying Silurian to Devonian sediments. The youngest rocks are three small Devonian granite bodies.

The Meguma block consists essentially of weakly metamorphosed quartzite, wacke, and slate (unit 4) intruded by Devonian granite plutons (unit 8). The northern boundary of the Meguma block is concealed by Carboniferous sediments (units 9 and 10), but is assumed to be the Chedabucto fault.

The Cobequid Mountains block is partly composed of Devonian(?) acid to basic volcanics and Silurian sediments and volcanics (unit 6) (Kelley, 1967a, p. 175). The volcanics may be more extensive than indicated on the map, as the Devonian granite (unit 8) may include undifferentiated volcanics.[1]

These three tectonic elements are surrounded by relatively undisturbed Upper Devonian to Upper Carboniferous continental and marine sediments.

The writer proposed that the Antigonish Highlands rocks were formed in an island arc and that the Meguma Group was deposited in a developing geosyncline to the southeast (Benson, 1967b). During the Devonian Acadian Orogeny the older rocks of the Antigonish Highlands were deformed and the Meguma rocks were folded and thrust northward to their present position. The use of the word "thrust" was not meant to imply that the Meguma block was a thrust block. Continental drift was the favoured method of transport, but at that time models of Paleozoic continental drift had not yet been developed.

[1]Recent radiometric K-Ar ages on a granite body in the Cobequids gave ages of 532 ± 22 m.y. on biotite and 606 ± 28 m.y. on hornblende (Wanless *et al.*, Geol. Surv. Can., Paper 73-2, 1974).

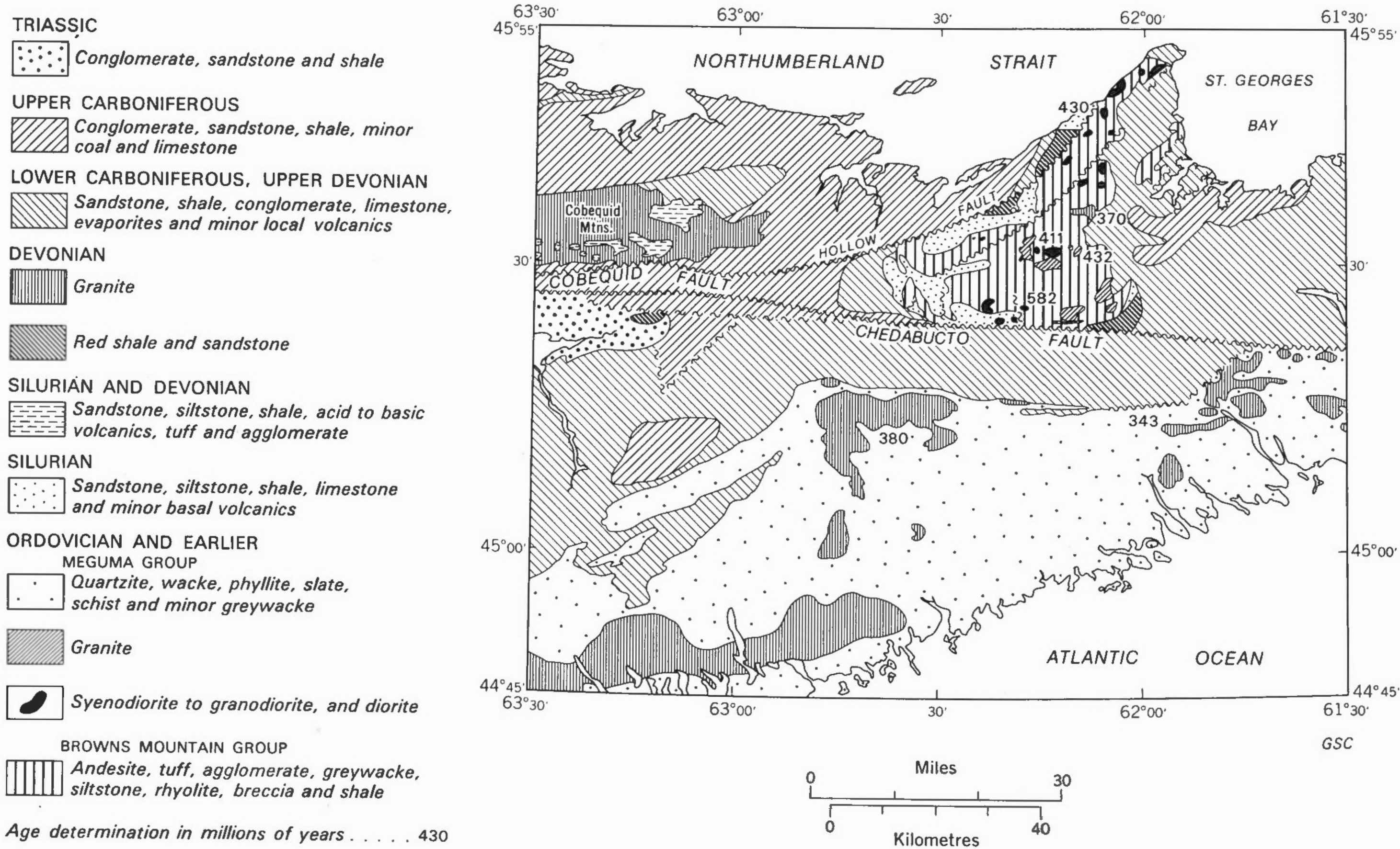

FIGURE 6. General geology of northeastern mainland Nova Scotia.

Several recent papers have undertaken to explain the tectonic history of the continents, with reference to the Appalachians, in terms of plate tectonics (Bird and Dewey, 1970; Dewey, 1969, 1972; Dewey and Bird, 1970; Dewey and Horsfield, 1970; Dickinson, 1971; and Dietz, 1972). Specific reference to the Antigonish map-area was made by Schenk (1971).

The following outline of the tectonic history of northeastern Nova Scotia is based mainly on work in the Antigonish Highlands and adjacent areas, and current models of plate tectonics.

The Antigonish Highlands block was the site of part of a magmatic arc system during the Cambrian and Ordovician. Many thousands of feet of interbedded volcanic and sedimentary rocks of the Browns Mountain Group was deposited with associated plutonic rocks. These rocks were subjected to deformation, low-grade metamorphism, and granodioritic intrusion during the Taconic Orogeny. Bird and Dewey (1970, p. 1051) equate this orogeny with shortening of the continental margin before actual continental collision.

The Ordovician(?) Meguma rocks may, in part, be the same age as the Browns Mountain Group, but the differences in lithology indicate a different and separate depositional environment. The Meguma, accordingly, is considered to have been deposited on a continental terrace or miogeosyncline at the boundary of the African(?) continent. Schenk (1971, p. 1226) concluded that the Meguma may be an abyssal-plain-continental-size complex with an African origin. There is no evidence of Taconic deformation of the Meguma block.

Short-lived, minor early Silurian volcanism in the proto-Antigonish Highlands block was followed by Silurian and early Devonian marine sedimentation. The Siluro-Devonian volcanics and sediments of the Cobequids may have resulted from later activity of the same magnetic arc system that gave rise to the Browns Mountain Group.

The Meguma rocks were deformed and intruded by widespread granite plutons during the Devonian. The rocks of the Antigonish Highlands and Cobequid blocks were also deformed, but in these regions were accompanied by only minor granitic intrusion. During the middle to late Devonian Acadian Orogeny, most of the Appalachian rocks were metamorphosed and deformed by folds and faults (Poole *et al.*, 1970, p. 278-279), possibly, in part, in response to the collision of the "African" and North American continents (Bird and Dewey, 1970, p. 1051; Brown, 1972, p. 49; Schenk, 1971, p. 1222). The Chedabucto fault marks the line of this collision.

Intermittent vertical movement along boundary faults raised the highlands as a horst, and elevated the Meguma block. By late Devonian the three blocks were positive land areas contributing sediments to the developing Carboniferous basins (Benson, 1970a). Differences in Carboniferous lithology on either side of the Chedabucto fault indicate that these basins were not all interconnected, as suggested by their present form. Continued intermittent vertical movement along the boundary faults of the source areas provided a continuous source of sediments, and effected the extrusion of Carboniferous volcanics. Minor changes in the relative position of sea level resulted in deposition of marine beds, with evaporites laid down in restricted parts of the basins. Left-lateral transverse movement along the Chedabucto fault was initiated in the late Carboniferous to early Permian, whereas the movement along Cobequid–Hollow fault to the north has been interpreted as late Pennsylvanian (Upper Carboniferous) oblique right-lateral by Eisbacher (1969, p. 1095). The minor deformation of these Carboniferous sediments into broad open folds is referred to as the Maritime disturbance (Allegheny of Rodgers, 1970, p. 147).

Probable movement along the line of the Chedabucto fault resulted in the Triassic deposition of coarse-grained sediments followed by volcanic extrusion. These events possibly reflect the incipient breakup of Pangaea, the single landmass that split to form the present continents, in either early Permian (Schenk, 1971, p. 1219) or Triassic (Bird and Dewey, 1970,

p. 1051; Dietz and Holden, 1970, p. 35). This plate separation and opening of the North Atlantic Ocean occurred along the margin of the present continent, but movements also occurred along Chedabucto fault. The latest recorded movement along this fault was during the Cretaceous, as recorded by moderately folded offshore sediments (King and MacLean, 1970).

Chapter V

ECONOMIC GEOLOGY

The variety of rock types, ages, and tectonic history of the map-area presents many possible environments for the formation of economic mineral deposits. These range from igneous segregations to contact metamorphic, from volcanic pile deposits to iron deposits, and from heavy metal sedimentary concentrations to coal. Unfortunately, although there are numerous small showings, no economic metallic deposits have been found.

Metallic Minerals

General Reference: Metallic mineral occurrences, Dept. Mines, Nova Scotia, 1966.

Copper

References: Ellis, R. W., Bulletin on ores of Cu in the provinces of Nova Scotia, New Brunswick and Quebec; Geol. Surv. Can., Publ. no. 882, 1904.
Fletcher, H. and Faribault, E. R., Geol. Surv. Can., Ann. Rept., v. 2, pt. P, p. 120, 1887.
Messervey, J. P., Copper in Nova Scotia; Pamphlet no. 7, Dept. Public Works and Mines, Nova Scotia, 1930.
Nova Scotia Dept. Mines, Ann. Rept., 1952, p. 42, 53; 1954, p. 52.
Piers, H., Economic minerals of Nova Scotia; Dept. Public Works and Mines, Nova Scotia, 1906, p. 26.
Williams, M. Y., Arisaig–Antigonish district, Nova Scotia; Geol. Surv. Can., Mem. 60, 1914.

The College Grant copper deposit consists of chalcopyrite, associated with siderite, hematite, calcite, and quartz in veins in a small diorite stock that has intruded dark grey shale and quartzite of the Knoydart Formation. In 1876 a 6-inch mineralized vein and five narrower veins were found during the sinking of a 75-foot shaft. About 240 tons was mined and 40 tons was hand picked and carted to Antigonish. Another shaft, 180 feet deep, was sunk at a later date. Further work was undertaken by Lake Copper Mining Company, Limited in 1910; Northern Minerals Limited, who diamond drilled five holes in 1962; and H. L. Issacs, who diamond drilled five holes in 1954.

In 1961, sulphide minerals were found in a diamond-drill hole about a mile east-northeast of College Grant (lat. 45°32′40″ and long. 62°06′00″). Chalcopyrite and bornite, associated with calcite, sphalerite, and galena, were found in a volcanic breccia underlying Windsor limestone.

Fractures near the Windsor–Horton contact on Brierly Brook contain chalcopyrite and bornite. Two shafts, about 30 feet deep, and a tunnel, 60 feet long, were driven on the property by B. G. Gray and J. A. Grant in 1891. Malachite staining is found in poorly laminated Windsor conglomerate on South Rights River.

The pegmatite dykes that cut the granite and Browns Mountain Group near Georgeville contain coarse-grained segregations of green microcline and pyrite, and minor associated chalcopyrite, a dark brown radioactive mineral thought to be cyrtolite and uranothorite. The pegmatite is cut by fine-grained diabase dykes.

Pyrite, chalcopyrite, and minor bornite occur in carbonaceous siltstone at the Windsor–Lismore contact on the coast a half mile northeast of Knoydart Point. Microscopic amounts of chalcopyrite are associated with pyrite crystals in Browns Mountain volcanics on South Rights River.

Iron

References: Fletcher, H., Geol. Surv. Can., Ann. Rept., v. 5, 1890–91, pt. D, p. 181.
Ingall, E. D., Iron ores of Nova Scotia; Geol. Surv. Can., Ann. Rept., v. 10, 1897, pt. 5, p. 112.
Lindeman, E. and Bolton, L. L., Can. Dept. Mines, Mines Br. Rept. 217, v. 2, p. 177, 1917.
Woodman, J. E., Iron ores of Nova Scotia; Can. Dept. Mines, Mines Br. Rept. 20, 1909.

A thin ferruginous (hematite) wacke bed, the "iron ore bed," occurs near the base of the McAdam Formation. Attempts were made to mine this bed at several locations. Short inclined tunnels were driven on either side of Arisaig Brook before 1900. Near Meiklefield (lat. 45°32′ and long. 62°28′) an 80-foot-deep shaft was dug to mine a 2- to 5-foot-wide "oolitic hematite" bed. The Wentworth property (lat. 45°29′30″ and long. 62°29′30″) reportedly developed an 18-foot-wide bed of hematite over a length of 40 feet. In 1949 Ironlake Exploration Limited diamond drilled two holes near Telford (lat. 45°35′10″ and long. 62°29′) but intersected only 1.7 feet of siderite.

The most extensive exploration for iron has been on Iron and McInnis brooks in the Little Hollow Formation. In 1894, 1,376 tons of "iron ore" was shipped to the blast furnaces at Ferrona in Pictou County, but operations ceased the following year.

Gold

References: Brunton, S., A survey of certain gold districts in the province of Nova Scotia; Ann. Rept. Mines, pt. 2, Dept. Public Works and Mines, Nova Scotia, 1927.
Malcolm, W., Gold fields of Nova Scotia; Geol. Surv. Can., Mem. 156, 1929.
Nova Scotia Dept. Mines, Ann. Rept., 1929 to 1936.

The gold deposits of the Goldenville Formation are in quartz veins near the crests of plunging anticlines. The Cochrane Hill gold mine is east of Route 7, and the Crows Nest gold mine is on the east side of St. Mary's River valley, both about a half mile south of Lochaber map-area. The Goldenville quartzite and slate have been folded into a tight anticline and intruded by granite dykes, and contain metamorphic staurolite, andalusite, garnet, and mica. The gold-bearing quartz veins follow the bedding in both mines. Gold was discovered in 1868 at Cochrane Hill, and surface pits and a shaft were dug. The operation was discontinued in 1908. Work began at Crows Nest mine in 1878 and three adits were driven into the hillside and intermittent mining was carried out until the early 1890's. An attempt to revive the district was made in 1926–27 by the Novamac Mines and Power Corporation, Limited. Diamond drilling and sampling were undertaken in 1934–35 with poor results.

At Little Liscomb Lake several pits were dug in auriferous quartzite and a stamp mill was erected, but no production was reported.

Lead

References: Alcock, F. J., Zinc and lead deposits of Canada; Geol. Surv. Can., Econ. Geol. Ser., no. 8, p. 55, 1930.
Messevey, J. P., Lead and zinc in Nova Scotia; Pamphlet no. 15, Nova Scotia Dept. Mines, 1929.
Nova Scotia Dept. Mines, Ann. Rept., 1929, p. 99; 1930, p. 122.
Wilson, M. E., Mineral deposits in Nova Scotia and New Brunswick; Geol. Surv. Can., Sum. Rept., 1926, pt. C.

Two veins (6 inches and 8 inches) of argentiferous galena in Goldenville quartzite and slate adjacent to the West River St. Mary's fault west of Glenelg were found in 1873. Minor development work was carried out in 1873 and more work was done in 1904, 1925, and 1930. A lower adit, 700 feet long with a 100-foot crosscut, and an upper adit, 470 feet long, were driven.

Manganese

References: Geol. Surv. Can., Ann. Rept., v. 2, pt. P, p. 118, 1886.
Mines Branch, Invest. no. M.D. 3033, 1954.

Bog manganese is found in small quantities as nodules and earthy beds in soil and lakes underlain by Meguma Group. One such location near Caledonia was examined from 1954 to 1958 by Huclif Porcupine Mines. A 5-pound sample yielded 7.70 per cent acid soluble manganese, and a total of 11.65 per cent manganese.

Nonmetallic

Barite

Minor barite veinlets (less than $\frac{1}{2}$ inch wide) occur in the Windsor limestone on Brierly Brook and near Big Marsh.

Diatomite

Reference: Eardley-Wilmot, V. L., Diatomite; Can. Mines Br. Bull. no. 691, p. 65–66, 1928.

An analysis of samples from 40 acres of the bottom of Brora Lake gave results of 82 per cent silica and 12 per cent volatiles. The Nova Scotia Department of Mines has examined Black, McKay, Eden, Black Brook, and Lochaber lakes for diatomite (Nova Scotia Dept. Mines, Mineral Files).

Gypsum and Anhydrite

The Windsor Group contains extensive exposures of gypsum and anhydrite along Brierly Brook and near St. Josephs.

Limestone

A local farmers group operated a quarry for agricultural limestone near Hillcrest (lat. 45°28′ and long. 62°04′) from 1937 to 1948.

Peat Moss

A peat bog on the west side of James River was drained and filled during construction of Highway 4. The small swampy bogs nearby probably also overlie peat deposits.

Phosphate

Dark phosphatic nodules and a few phosphatic shells can be seen in the McAdam, Moydart, and Stonehouse shore sections.

Quartz and Feldspar

The quartz and quartz-feldspar arenites of the Craignish Formation may provide a source of relatively pure quartz or a quartz–feldspar mixture. The best exposures are south of Eden Lake in the barrens, and along East River St. Mary's near Rocky Mountain.

Sand and Gravel

Glacial sand and gravel deposits are located over all the map-area and provide ample sources of this material. New deposits are developed and abandoned as the demand arises.

Stone

A sandstone quarry is in operation at North Grant, where building stone is obtained from a flaggy Horton sandstone.

The gabbro to diorite intrusive near Georgeville was developed during 1960–61 as a source of crushed stone. A large quarry was dug, and crushing and docking facilities were erected, which have since been abandoned.

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APPENDIX

Fossil Collections

ORDOVICIAN

Browns Mountain Group

Brierly Brook Formation

Field No.	Cat. No.	Latitude (N)	Longitude (W)	Remarks
Bo107-B28/64	64421	45°32′30″	62°14′45″	On Middle Brook

Little Hollow Formation

Field No.	Cat. No.	Latitude (N)	Longitude (W)	Remarks
Bo39-B12/66	75371	45°45′30″	62°07′00″	On Iron Brook

SILURIAN

Arisaig Group – undivided

Field No.	Cat. No.	Latitude (N)	Longitude (W)	Remarks
Bo31-B20/62	50908	45°24′20″	62°24′45″	On road; rhynchonellid, dalmanellid and *Leptaena*
Bo32-B20/62	50909	45°24′10″	62°23′15″	On road; *Leptaena* and pelecypod
Bo77-B26/62	50911	45°24′30″	62°25′20″	On small brook
Bo128-B57/62	50915	45°25′55″	62°01′50″	On road; spiriferid, *Isorthis* sp.
Bo543-R24/62	50910	45°25′00″	62°27′35″	Thompson Brook; lingula
Bo604-R26/62	50913	45°24′15″	62°23′30″	Normans Brook; *Isorthis* n. sp., *Resserella* sp.
Bo46-B21/63	57579	45°24′35″	62°09′00″	McKay Brook; dalmanellid
Bo71-B29/63	57577	45°26′10″	62°02′00″	On small brook; *Meristina billingsi* (lower McAdam or French River)
Bo534-W14/63	56032	45°26′25″	62°01′35″	Lakeshore; *Neobeyrichia* (*Nodibeyrichia*) sp. (Stonehouse)
Bo579-W37/63	57578	45°27′50″	62°01′30″	On small brook; *Salopina* cf. *submedia* (younger than Beechhill Cove)

Beechhill Cove Formation

Field No.	Cat. No.	Latitude (N)	Longitude (W)	Remarks
Bo94-B25/64	60984	42°34′30″	62°16′20″	Middle Brook; lingulid
Bo150-B44/64	64376	45°35′45″	62°19′15″	Base of hill

Field No.	Cat. No.	Latitude (N)	Longitude (W)	Remarks
Bo151-B44/64	64378	45°35′45″	62°19′05″	Hillside; *Fascifera* sp., *Isorthis?* sp., *Fardenia* sp., *Leptaena* sp., *Eostropheodonta beechhillensis* (Beechhill Cove)
Bo165-B46/64	64407	45°37′55″	62°16′05″	Hillside; crinoid stems, coral
Bo174-B49/64	64420	45°38′00″	62°15′20″	Baileys Brook; crinoid stems, gastropod, coral fragments
Bo175-B49/64	64419	45°35′20″	62°18′20″	West Barneys River
Bo580-P15/64	60968	45°33′55″	62°24′00″	On small brook
Bo668-P22/64	60985	45°34′40″	62°17′00″	On road
Bo707-P27/64	64392	45°34′50″	62°21′55″	On small brook
Bo742-P38/64	64382	45°34′55″	62°24′05″	On East French River
Bo755-P41/64	64380	45°34′55″	62°21′50″	On small brook
Bo760a-P44/64	64413	45°37′40″	62°17′35″	On Barneys River
Bo760b-P44/64	64418	45°37′40″	62°17′35″	On Barneys River
Bo766-P47/64	64411	45°38′05″	62°15′25″	On Baileys Brook
Bo768-P47/64	64416	45°38′10″	62°15′25″	On Baileys Brook
Bo771-P47/64	64409	45°38′12″	62°15′25″	On Baileys Brook; lingulid, *Eocoelia?*
Bo42-B12/66	75372	45°45′30″	62°07′05″	On Iron Brook; indet. brachiopods
Bo43-B12/66	75373	45°45′30″	62°07′25″	On Iron Brook; indet. brachiopods
Bo44-B12/66	75374	45°45′30″	62°07′25″	On Iron Brook; crinoid stems
Bo51-B14/66	75368	45°35′00″	62°10′40″	On highway; *Eoleptostrophia beechhillensis* (McLearn 1924) (Beechhill Cove)
Bo52-B14/66	75369	45°35′00″	62°10′35″	On highway; *Orthoceras*
Bo53-B14/66	75370	45°35′00″	62°10′30″	On highway; *Orthoceras* sp. indet., *Cornulites serpularius* Schlotheim, *Eoleptostrophia beechhillensis* (Beechhill Cove)
Bo501-L1/67	79673	45°45′30″	62°07′25″	On Iron Brook
Bo918-G51/65	69335	45°35′00″	62°10′35″	On small brook

Ross Brook Formation

Field No.	Cat. No.	Latitude (N)	Longitude (W)	Remarks
Bo25-B5/64	60964	45°33′10″	62°26′25″	On French River
Bo26-B5/64	60966	45°33′20″	62°26′15″	On French River
Bo30-B6/64	60962	45°34′00″	62°24′55″	On road
Bo45-B12/64	60963	45°34′15″	62°25′50″	On French River
Bo50-B14/64	60975	45°33′40″	62°25′40″	On small brook
Bo51-B14/64	60976	45°33′55″	62°25′45″	On small brook
Bo52-B15/64	60977	45°34′08″	62°25′25″	On small brook
Bo53-B15/64	60978	45°34′10″	62°25′25″	On small brook
Bo188-B54/64	64402	45°34′40″	62°22′35″	On small brook
Bo189-B54/64	64405	45°34′35″	62°22′35″	On small brook
Bo190-B54/64	64403	45°34′35″	62°22′30″	On small brook; *Calymene replicata* Shirley, *Dalmanites weaveri* (Salter), *Phacops marklandensis* McLearn, *Eocoelia* cf. *hemisphaerica* (middle Ross Brook)
Bo191-B54/64	64400	45°34′20″	62°22′30″	On small brook
Bo192-B54/64	65802	45°34′35″	62°22′30″	On small brook; same fauna as 64403
Bo517-P2/64	60958	45°32′15″	62°27′00″	On French River
Bo518-P3/64	60967	45°32′25″	62°27′50″	On French River
Bo581-P15/64	60969	45°34′05″	62°24′00″	On small brook
Bo674-P24/64	60986	45°35′20″	62°16′25″	On Middle Brook
Bo675-P24/64	60987	45°35′30″	62°16′15″	On Middle Brook

Field No.	Cat. No.	Latitude (N)	Longitude (W)	Remarks
Bo677a-P25/64	60988	45°35′55″	62°16′25″	On Middle Brook; *Calymene* sp., *Homalonotus* sp., *Eocoelia* cf. *hemisphaerica*, *Protochonetes tenuistriatus?*, *Dalmanites* sp. (middle Ross Brook)
Bo677b-P25/64	60988	45°35′55″	62°16′25″	On Middle Brook; *Eocoelia* cf. *hemisphaerica* (middle Ross Brook)
Bo678-P25/64	60990	45°35′45″	62°16′20″	On Middle Brook; *Eocoelia* cf. *hemisphaerica* (middle Ross Brook)
Bo705-P27/64	64394	45°34′00″	62°21′35″	On small brook
Bo706-P27/64	64417	45°34′40″	62°21′45″	On small brook
Bo714-P32/64	64395	45°34′25″	62°25′50″	On French River
Bo722-P34/64	64390	45°34′45″	62°22′15″	On East French River
Bo725-P34/64	64393	45°34′45″	62°22′25″	On East French River
Bo726-P34/64	64396	45°34′40″	62°22′45″	On East French River
Bo729-P34/64	64383	45°34′55″	62°23′40″	On East French River
Bo741-P38/64	64381	45°34′55″	62°23′50″	On East French River
Bo757-P43/64	64398	45°37′20″	62°17′00″	On Barneys River
Bo218-B49/64	69341	45°45′05″	62°10′55″	On Smith Brook
Bo226-B46/65	69338	45°46′20″	62°07′35″	On Doctors Brook
Bo907-G51/65	69331	45°34′15″	62°24′10″	On small brook
Bo63-B17/64	60979	45°33′55″	62°20′55″	On East French River
Bo64-B17/64	60980	45°34′10″	62°20′55″	On East French River
Bo65-B17/64	60981	45°34′25″	62°21′00″	On East French River
Bo92-B25/64	60982	45°35′10″	62°16′45″	On Middle Brook
Bo93-B25/64	60983	45°35′00″	62°16′55″	On Middle Brook
Bo148-B43/64	64389	45°35′30″	62°19′30″	On small brook; *Eocoelia* cf. *hemisphaerica* (Ross Brook)
Bo149-B43/64	64391	45°35′25″	62°19′20″	On small brook; *Portlockia?* sp. *Phacops marklandensis* McLearn (middle Ross Brook)
Bo152-B45/64	64408	45°36′55″	62°16′55″	On West Barneys River; *Eocoelia?* crinoid stems
Bo153-B45/64	64414	45°36′50″	62°17′00″	On West Barneys River; *Eocoelia* cf. *hemisphaerica*, *Protochonetes tenuistriatus?*, orthotetacid, *Calymene* cf. *replicata* Shirley (middle Ross Brook) (middle and upper Llandovery)
Bo154-B45/64	64404	45°36′50″	62°17′02″	On West Barneys River; *Eocoelia* cf. *hemisphaerica* (middle Ross Brook)
Bo155-B45/64	64397	45°36′50″	62°17′10″	On West Barneys River; *Eocoelia* cf. *hemisphaerica* (middle Ross Brook)
Bo156-B45/64	64410	45°36′45″	62°17′15″	On West Barneys River; *Eocoelia* cf. *hemisphaerica*, *Camarotoechia rossonia* (middle Ross Brook)
Bo157-B45/64	64415	45°36′35″	62°17′15″	On West Barneys River
Bo158-B45/64	64412	45°36′20″	62°17′20″	On West Barneys River; *Visbyella nana*, *Plagiorhyncha* aff. *glassi*, *Protochonetes tenuistriatus* (middle or upper Ross Brook)
Bo159-B45/64	64422	45°36′25″	62°17′25″	On West Barneys River
Bo160-B45/64	64406	45°36′25″	62°17′35″	On West Barneys River; *Salopina?* sp., *Plagiorhyncha* cf. *glassi*, *Atrypa* cf. *reticularis* (middle or upper Ross Brook)
Bo908-G51/65	69334	45°34′20″	62°23′15″	On small brook; pelecypod
Bo910-G51/65	69337	45°35′00″	62°20′40″	On highway; lingulid

Field No.	Cat. No.	Latitude (N)	Longitude (W)	Remarks
Bo48-B13/66	75365	45°44′55″	62°11′45″	600″ offshore in 30′ water
Bo50-B14/66	75367	45°35′35″	62°15′55″	In road-cut; *Eocoelia hemisphaerica*
		French River Formation		
Bo27-B5/64	60957	45°34′00″	62°25′55″	On French River
Bo40-B12/64	69333	45°34′05″	62°25′50″	On French River–type section
Bo40-B12/64	60973	45°34′05″	62°25′50″	On French River–type section–0′ to 10′
Bo41-B12/64	60974	45°34′05″	62°25′50″	On French River–type section–10′ to 20′
Bo42-B12/64	60972	45°34′05″	62°25′50″	On French River–type section–20′ to 30′
Bo43-B12/64	60960	45°34′10″	62°25′55″	On French River–type section
Bo44-B12/64	60961	45°34′12″	62°25′55″	On French River–type section
Bo22-B4/64	69336	45°45′45″	62°07′50″	On South Doctors Brook
		McAdam Formation		
Bo120-B31/64	64387	45°33′55″	62°28′05″	On small brook east of Telford Brook
Bo121-B31/64	64388	45°34′00″	62°28′05″	On small brook east of Telford Brook
Bo122-B31/64	64379	45°34′00″	62°28′05″	On small brook east of Telford Brook
Bo123-B31/64	64374	45°34′00″	62°28′05″	On small brook east of Telford Brook
Bo124-B34/64	64377	45°34′05″	62°27′30″	On small brook east of Telford Brook
Bo125-B34/64	64375	45°34′00″	62°27′25″	On small brook east of Telford Brook
Bo400-J1/64	64399	45°32′00″	62°28′55″	On hillside *Dalmanites* sp. *Homalonotus* sp. *Meristina billingsi* *Dalejina* sp., rhynchonellid (lower member, McAdam)
Bo401-J1/64	64401	45°32′00″	62°29′00″	On hillside *Meristina billingsi* *Dalejina* sp., rhynchonellid (lower member, McAdam)
		Moydart Formation		
Bo118-B31/64	64386	45°33′40″	62°28′10″	On small brook; *Homalonotus* sp., *Protochonetes novascoticus*, *Salopina submedia*, rhynchonellid (McAdam and younger)
Bo219-B50/65	69340	45°44′55″	62°11′40″	300′ offshore–15′ water depth; *Howellella moydartensis* or *Delthyris* (*Quadrifarius rugaecosta*) (French River to Stonehouse)
Bo220-B50/65	69332	45°44′55″	62°11′45″	500′ offshore–22′ water depth; *Leptaena* sp.
		Stonehouse Formation		
Bo9-B2/64	60959	45°31′35″	62°30′10″	Sutherland River *McLearnites mertoni* *Delthyris* (*Quadrifarius*) *rugaecosta* (Stonehouse Formation)

Field No.	Cat. No.	Latitude (N)	Longitude (W)	Remarks
Bo10-B2/64	60965	45°31′40″	62°30′10″	Sutherland River *Homalonotus* sp. *Calymene antigonishensis* McLearn *Shaleria gilpeni* rhynchonellid nautiloid
Bo115-B31/64	64385	45°33′25″	62°28′05″	On small brook
Bo117-B31/64	64384	45°33′30″	62°28′05″	On small brook
Bo35-B11/66	75375	45°40′10″	62°15′20″	East Branch Baileys Brook brachiopods mollusca worm casts

DEVONIAN

Knoydart Formation

Field No.	Cat. No.	Latitude (N)	Longitude (W)	Remarks
Bo186-B42/65	69342	45°43′45″	62°12′25″	On McArras Brook

LOWER CARBONIFEROUS

Horton Group

Rights River Formation

Field No.	Cat. No.	Latitude (N)	Longitude (W)	Remarks
Bo159-B22/65	7395	45°42′05″	62°03′55″	On Rights River *Calamospora* sp. *Leiotriletes* sp. *Retusotriletes* sp. *Granulatisporites* sp. *Stenozonotriletes* sp. *Gristatisporites* sp. *Cyclogranisporites* spp. *Vallatisporites* sp. ? *Secarisporites* sp. *Verrucosisporites* spp. *Dictyotriletes* spp. *Apiculatisporis* sp. cf. *Gulisporites* sp. *Rugospora* sp. *Lophotriletes* sp. *Punctatisporites* spp. ? *Spinozonotriletes* sp. *Cyclogranisporites* cf. *commodus* Playford *Punctatisporites planus* Hacquebard *Converrucosisporites parvinodosus* Playford *Verrucosisporites nitidus* Playford *Verrucosisporites* cf. *papulosus* Hacquebard *Verrucosisporites congestus* Playford *Retusotriletes* cf. *incohatus* Sullivan *Endosporites* cf. *minutus* Hoffmeister, Staplin, and Malloy

Field No.	Cat. No.	Latitude (N)	Longitude (W)	Remarks
				Granulatisporites crenulatus? Playford *Gulisporites torpidus* Playford cf. *Pustulatisporites gibberosus* (Hacquebard) Playford *Pustulatisporites pretiosus?* Playford (The above assemblage is a fairly typical one for the upper Horton Group in the Maritime Provinces.)
Bo734-G42/65	7491	45°41′05″	62°01′45″	On Rights River
Bo730-G42/65	7492	45°41′20″	62°01′50″	On Rights River *Leiotriletes tortilis* Playford *Punctatisporites solidus* Hacquebard *Punctatisporites debilis* Hacquebard *Punctatisporites planus* Hacquebard *Cyclogranisporites commodus* Playford *Punctatisporites* sp. *Verrucosisporites* spp. *Cyclogranisporites* sp. *Grandispora* sp. *Retusosporites* sp. *Apiculatisporis* sp. *Endosporites* sp. *Perotrilites perinatus* Hughes and Playford *Vallatisporites vallatus* Hacquebard *Vallatisporites verrucosus* Hacquebard *Verrucosisporites nitidus* (Naumova) Playford (Horton Group, possibly older than Horton Bluff)
Bo737-G42/65	8462	45°40′50″	62°01′25″	On Rights River *Perotriletes perinatus* Hughes and Playford *Grandispora echinata* Hacquebard *Verrucosisporites congestus* Playford *Emphanisporites rotatus* McGregor *Verrucosisporites* spp. *Knoxisporites* sp. *Punctatisporites* spp. *Acanthotriletes* sp. *Convolutispora* spp. (The presence of *Emphanisporites rotatus* indicates an upper Devonian age for this assemblage.)

Field No.	Cat. No.	Latitude (N)	Longitude (W)	Remarks
		Craignish Formation		
Bo19-B11/62	6282	45°17′20″	62°21′40″	On Ross Brook *Lepidodendropsis corrugata* (Dawson) Bell (Horton Group) *Vallatisporites* (Horton Bluff)
Bo20-B11/62	6283	45°17′55″	62°21′55″	On Ross Brook *Asterocalamites scrobiculatus* (Schlotheim) *Lepidodendropsis corrugata* (Dawson) Bell (Horton Group)
Bo-22-B13/62	6284	45°17′15″	62°17′25″	On Barren Brook *Lepidodendropsis corrugata* (Dawson) Bell (Horton Group)
Bo-24-B13/62	6285	45°17′20″	62°17′25″	On Barren Brook *Lepidodendropsis corrugata* (Dawson) Bell (Horton Group) *Vallatisporites* Hacquebard (Horton Bluff)
Bo25-B17/62	6286	45°16′50″	62°14′50″	On McDonald Brook *Asterocalamites scrobiculatus* (Schlotheim) Zeiller (Horton Group) *Spinozonotriletes* Hacquebard *Verrucosisporites* (Ibrahim) Potonié and Kremp (older than Horton Bluff)
Bo90-B42/62	6387	45°17′00″	62°14′55″	Stratigraphic interval of 340 feet on McDonald Brook
Bo91-B42/62	6388	45°16′55″	62°14′55″	
Bo92-B42/62	6389	45°16′55″	62°14′55″	*Spinozonotriletes* Hacquebard
Bo94-B42/62	6391	45°16′55″	62°14′50″	*Verrucosisporites* (Ibrahim) Potonié and Kremp
Bo534-R16/62	6288	45°17′45″	62°16′40″	On Sutherland Brook *Lepidodendropsis corrugata* (Dawson) Bell (Horton Group)
Bo535-R18/62	6289	45°18′50″	62°15′10″	On McDonald Brook *Vallatisporites* Hacquebard (Horton Bluff)
Bo536-R18/62	6290	45°18′40″	62°15′20″	On McDonald Brook *Vallatisporites* Hacquebard (Horton Bluff)
Bo537-R18/62	6291	45°18′30″	62°15′20″	On McDonald Brook *Lepidodendropsis corrugata* (Dawson) Bell (Horton Group)
Bo7-B6/63	6651	45°19′35″	62°03′20″	Road-cut *Leiotriletes* sp. *Convolutispora* sp. *Endosporites* sp. *Converrucosisporites* cf. *parvinodosus* Playford *Apiculatasporites* cf. *compactus* Playford cf. *Vallatisporites* spp. (Horton Group)

Field No.	Cat. No.	Latitude (N)	Longitude (W)	Remarks
Bo12-B9/63	6650	45°16′55″	62°03′20″	Road-cut *Verrucosisporites nitidus* Playford *Verrucosisporites* spp. *Leiotriletes* sp. *Vallatisporites* spp. *Lycospora torulosa* Hacquebard *Perotrilites magnus* Hughes and Playford *Anapiculatisporites* sp. *Acanthotrilites* sp. *Granulatisporites crenulatus* Playford (Horton Bluff)
Bo533-W13/63	6657	45°16′35″	62°00′40″	Railway-cut east of McKeen Brook *Punctatisporites* sp. *Verrucosisporites nitidus* Playford *Vallatisporites verrusosus* Hacquebard *Apiculatasporites* cf. *compactus* Playford *Dictyotriletes submarginatus* Playford *Vallatisporites* sp. *Pustulatisporites pretiosus* Playford (lower part of the Cheverie)

Ainslie Formation

Field No.	Cat. No.	Latitude (N)	Longitude (W)	Remarks
Bo123-B53/62	6399	45°16′30″	62°10′35″	On Glencross Brook *Vallatisporites* spp. *Pustulatisporites pretiosus* Playford (Horton Bluff–Cheverie transition zone)
Bo530-R15/62	6280	45°18′35″	62°21′40″	On Ross Brook *Lepidodendropsis corrugata* (Dawson) Bell (Horton Group) *Pustulatisporites pretiosus* Playford (Cheverie)
Bo531-R15/62	6281	45°18′30″	62°21′35″	On Ross Brook *Lepidodendropsis corrugata* (Dawson) Bell (Horton Group) *Pustulatisporites pretiosus* Playford (Cheverie)
Bo533-R16/62	6287	45°17′15″	62°16′25″	On Sutherland Brook *Lepidodendropsis corrugata* (Dawson) Bell (Horton Group) *Pustulatisporites pretiosus* Playford (Cheverie)
Bo501-W1/63	6654	45°16′15″	62°13′20″	On West River St. Mary's *Spinozonotriletes* spp. *Cristatisporites* sp. *Verrucosisporites* spp. *Convolutispora* spp. *Raistrickia* sp. *Acanthotriletes* sp. *Reticulatisporites* sp. *Punctatisporites* spp.

Field No.	Cat. No.	Latitude (N)	Longitude (W)	Remarks
				Cyclogranisporites spp. cf. *Knoxisporites* sp. (may be older than Horton Bluff)
Bo503-W2/63	6649	45°16′10″	62°10′35″	On West River St. Mary's *Vallatisporites verrucosus* Hacquebard *Perotrilites perinatus* Hughes and Playford *Vallatisporites vallatus* Hacquebard *Convolutispora* cf. *finis* Love *Calamospora* spp. *Cyclogranisporites* spp. *Perotrilites* sp. *Punctatisporites* spp. *Endosporites* spp. *Pustulatisporites* sp. (Horton Bluff)
Bo513-W4/63	6653	45°15′50″	62°06′30″	On West River St. Mary's *Leiotriletes* spp. *Punctatisporites* spp. *Granulatisporites* sp. *Verrucosisporites* spp. *Cyclogranisporites commodus* Playford *Endosporites micromanifestus* Hacquebard *Pustulatisporites pretiosus* Playford (Cheverie)
Bo514-W4/63	6648	45°14′50″	62°06′20″	On West River St. Mary's *Pustulatisporites pretiosus* Playford *Cyclogranisporites commodus* Playford *Converrucosisporites parvinodosus* Playford *Microreticulatisporites* cf. *hortenensis* Playford *Cyclogranisporites* spp. *Verrucosisporites* spp. *Punctatisporites* spp. *Gulisporites* sp. *Convolutispora* sp. *Spinozonotriletes* sp. *Leiotriletes* spp. *Granulatisporites* sp. (Cheverie)

Windsor Group

Bo154-B32/65	68644	45″30′15″	62°03′45″	On tributary to Ohio River *Schuchertella pictoense* Bell *Productus avonensis* Bell *Diaphragmus tenuicostiformia* (Beede) *Spirifer nox* Bell

Field No.	Cat. No.	Latitude (N)	Longitude (W)	Remarks
				Martinia galataea Bell (subzone E)
Bo155-B32/65	68645	45°30′15″	62°03′45″	On tributary to Ohio River *Productus avonensis* Bell *Productus (Linoproductus) lyelli* Verneuil *Productus* cf. *latissimus* Sowerby *Diaphragmus tenuicostiformis* (Beede) *Composita windsorensis* *Pugnoides* sp. *Spirifer nox* Bell *Martinia galataea* Bell (subzone E)
Bo157-B33/65	68646	45°32′55″	62°01′40″	Old quarry near Glen Road *Schellwienella pictoense* Bell *Productus avonensis* Bell *Diaphragmus tenuicostiformis* (Beede) *Pugnoides ?* sp. *Camarotoechia atlantica* Bell *Martinia galataea* Bell (subzone E)
Bo184-B42/65	69339	45°43′15″	62°13′20″	On shore west of McArras Brook Same sample as Mamet #32

UPPER CARBONIFEROUS
Canso Group

Lismore Formation

Field No.	Cat. No.	Latitude (N)	Longitude (W)	Remarks
Bo28-B6/64	7074	45°38′05″	62°18′20″	On small stream at road *Cyclogranisporites* spp. *Punctatisporites* spp. cf. *Lycospora* sp. *Apiculatisporis* sp. *Endosporites* sp. *Leiotriletes* spp. *Calamospora* spp. *Perotrilites* sp. *Convolutispora* spp. cf. *Cirratriradites* sp. (zone B/C of Canso–Riversdale)
Bo126-B35/64	7176	45°34′45″	62°29′20″	On small brook cf. *Clorinites* sp. *Punctatisporites* sp. (zone D of Canso–Riversdale or younger)
Bo128-B35/64	7177	45°35′26″	62°29′55″	Road-cut on Route 45 *Lophotriletes* sp. *Verrucosisporites* *Punctatisporites* sp. *Calamospora* sp. (Canso–Riversdale)
Bo130-B37/64	7171	45°36′40″	62°29′45″	Mouth of Sutherland River *Converrucosisporites* sp. *Calamospora* spp. cf. *Acanthotriletes* sp.

Field No.	Cat. No.	Latitude (N)	Longitude (W)	Remarks
				Punctatisporites spp. *Perotrilites* cf. *perinatus* Hughes and Playford *Cyclogranisporites* spp. *Verrucosisporites* sp. *Stenozonotriletes* sp. *Convolutispora ?* Species W (zones B/C and D of Canso–Riversdale)
Bo132-B38/64	7179	45°36′50″	62°29′15″	Shore of Merigomish Harbour *Punctatisporites* sp. *Calamospora* sp. *Florinites* sp. (zone D of Canso–Riversdale or younger)
Bo133-B38/64	7175	45°37′10″	62°28′50″	Shore of Merigomish Harbour *Florinites* sp. *Punctatisporites* sp. *Perotrilites* sp. cf. *Velosporites* sp. *Convolutispora* sp. *Granulatisporites* sp. *Lycospora* sp. *Verrucosisporites* sp. *Leiotriletes* sp. (zone D of Canso–Riversdale)
Bo135-B40/64	7183	45°37′50″	62°26′15″	Mouth of French River } Almost identical spore assemblages
Bo136-B40/64	7184	45°37′45″	62°26′10″	Mouth of French River
Bo137-B41/64	7182	45°35′40″	62°24′45″	On East French River *Calamospora* sp. *Verrucosisporites* spp. *Granulatisporites* sp. *Leiotriletes* sp. *Convolutispora* Species W *Punctatisporites* spp. *Convolutispora* sp. *Schopfipollenites* sp. *Perotrilites* sp. cf. *Retusotriletes* sp. (zone B/C of Canso–Riversdale)
Bo138-B41/64	7181	45°35′55″	62°24′55″	On East French River *Lycospora* sp. *Punctatisporites* sp. cf. *Florinites* sp. *Knoxisporites seniradiatus* Neves *Perotrilites* spp. *Cyclogranisporites* sp. cf. *Stenozonotriletes* sp. (zone D of Canso–Riversdale)
Bo139-B41/64	7180	45°36′30″	62°25′15″	On East French River *Calamospora* sp. *Perotrilites* sp. cf. *Spinozonotriletes* sp. *Granulatisporites* sp. *Convolutispora* Species W *Punctatisporites* sp.

Field No.	Cat. No.	Latitude (N)	Longitude (W)	Remarks
				Cyclogranisporites sp. *Leiotriletes* sp. cf. *Stenozonotriletes* sp. (zone B/C of Canso–Riversdale)
Bo167-B47/64	7189	45°38′40″	62°24′30″	On shore of Merigomish Harbour *Punctatisporites* spp. *Calamospora* spp. *Endosporites* sp. *Leiotriletes* spp. *Cyclogranisporites* sp. *Convolutispora* spp. *Foveosporites* sp. *Rugospora ?* sp. *Raistrickia* sp. *Stenozonotriletes* sp. *Schopfipollenites* sp. *Schopfipollenites ellipsoides* cf. *Perotrilites perinatus* (zone B/C of Canso–Riversdale)
Bo180-B51/64	7193	45°40′50″	62°16′40″	On Baileys Brook *Punctatisporites* spp. *Calamospora* spp. *Lycospora* sp. *Cyclogranisporites* sp. *Foveosporites* sp. *Rugospora ?* sp. *Apiculatisporis* sp. *Cirratriradites* sp. *Schopfipollenites* sp. *Schopfipollenites ellipsoides* cf. *Perotrilites perinatus* *Convolutispora ampla* (zone B/C of Canso–Riversdale)
Bo181-B51/64	7185	45°41′10″	62°16′15″	On Baileys Brook *Lycospora* sp. *Leiotriletes* sp. *Punctatisporites* sp. (no age assignment)
Bo185-B52/64	7192	45°41′15″	62°15′05″	On Vamey Brook *Punctatisporites* spp. *Calamospora* spp. *Granulatisporites* sp. *Cyclogranisporites* sp. *Foveosporites* sp. *Reticulatisporites* sp. *Apiculatisporis* sp. *Schopfipollenites* sp. *Schopfipollenites ellipsoides* *Perotrilites perinatus* *Knoxisporites stephanophorus* *Grandispora ?* sp. *Auroraspora solisoctus* (zone B/C of Canso–Riversdale)
Bo713-P28/64	7178	45°33′55″	62°29′50″	On small brook *Lophotriletes* sp. *Perotrilites* sp. cf. *Auroraspora* sp. *Schopfipollenites* sp.

Field No.	Cat. No.	Latitude (N)	Longitude (W)	Remarks
				Punctatisporites sp. *Florinites* sp. *Lycospora* sp. *Leiotriletes* sp. *Spinozonotriletes* sp. *Knoxisporites* sp. (zone D of Canso–Riversdale)
Bo740-P37/64	7172	45°37′45″	62°27′15″	On shore near Grave Head *Florinites* sp. cf. *Perotrilites* sp. cf. *Grandispora* sp. *Cyclogranisporites* sp. *Convolutispora* Species W (spore zone D of Canso–Riversdale)
Bo752-P40/64	7174	45°37′15″	62°23′15″	On Hogan Brook *Punctatisporites* spp. *Leiotriletes* spp. *Verrucosisporites* spp. cf. *Grandispora* sp. *Convolutispora* sp. *Knoxisporites stephanophorus* Love *K.* cf. *triradiatus* Hoffmeister, Staplin and Malloy *Perotrilites* cf. *perinatus* Hughes and Playford *Retusotriletes incohatus* Sullivan *Perotrilites* spp. *Lycospora* spp. *Convolutispora* Species W *Calamospora* sp. (spore zone B/C of Canso–Riversdale)
Bo758-P44/64	7188	45°39′25″	62°19′25″	On Barneys River *Punctatisporites* spp. *Calamospora* spp. *Endosporites* sp. *Cyclogranisporites* sp. *Rugospora ?* sp. *Verrucosisporites* sp. *Schopfipollenites ellipsoides* *Perotrilites perinatus* *Endosporites micromanifestus* *Knoxisporites seniradiatus* (zone B/C of Canso–Riversdale)
Bo759-P44/64	7196	45°39′25″	62°19′15″	On Barneys River *Punctatisporites* spp. *Calamospora* spp. *Foveosporites* sp. *Rugospora ?* sp. *Perotrilites* spp. *Reticulatisporites* sp. *Verrucosisporites* sp. *Stenozonotriletes* sp. *Schopfipollenites ellipsoides* *Perotrilites perinatus* *Endosporites minutus* *Leiotriletes* spp.

Field No.	Cat. No.	Latitude (N)	Longitude (W)	Remarks
				Convolutispora ampla
				(zone B/C of Canso–Riversdale)
Bo779-P48/64	7199	45°40′05″	62°16′35″	On Baileys Brook
				Punctatisporites sp.
				Schopfipollenites sp.
				Perotrilites perinatus
				(zone B/C of Canso–Riversdale)
Bo782-P50/64	7186	45°41′40″	62°17′25″	On shore near Lismore
				Punctatisporites spp.
				Calamospora spp.
				Endosporites sp.
				Granulatisporites sp.
				Lycospora sp.
				Leiotriletes spp.
				Cyclogranisporites sp.
				Convolutispora spp.
				Rugospora ? sp.
				Perotrilites spp.
				Reticulatisporites sp.
				Schopfipollenites ellipsoides
				Perotrilites perinatus
				(zone B/C of Canso–Riversdale)
Bo783-P50/64	7194	45°42′00″	62°17′00″	On shore near Lismore
				Punctatisporites spp.
				Calamospora spp.
				Schopfipollenites sp.
				Granulatisporites sp.
				Grandispora ? sp.
				Leiotriletes spp.
				Rugospora sp.
				cf. *Perotrilites* spp.
				Reticulatisporites sp.
				Verrucosisporites sp.
				Convolutispora florida
				Stenozonotriletes sp.
				Perotrilites perinatus
				Endosporites minutus
				Microreticulatisporites cf. *fundatus*
				(zone B/C of Canso–Riversdale)
Bo784-P50/64	7198	45°42′55″	62°15°30″	On shore NW of Lismore
				Punctatisporites spp.
				Calamospora spp.
				Foveosporites sp.
				Rugospora ? sp.
				cf. *Camptotriletes* sp.
				Schopfipollenites sp.
				Convolutispora mellita
				Perotrilites perinatus
				Endosporites minutus
				Leiotriletes spp.
				Knoxisporites stephanophorus
				(zone B/C of Canso–Riversdale)
Bo785-P50/64	7190	45°43′00″	62°15′10″	On shore near Lismore
				Punctatisporites sp.
				Endosporites sp.
				Lycospora sp.
				Cyclogranisporites sp.
				Rugospora ? sp.

Field No.	Cat. No.	Latitude (N)	Longitude (W)	Remarks
				Schopfipollenites sp. *Perotriletes perinatus* *Endosporites minutus* *Knoxisporites polygonalis* *Grandispora ?* sp. (zone B/C of Canso–Riversdale)
Bo811-P54/64	7191	45°41′55″	62°16′00″	On Vamey Brook *Punctatisporites* spp. *Calamospora* spp. *Cristatisporites* sp. *Granulatisporites* sp. *Lycospora* sp. *Leiotriletes* spp. *Knoxisporites seniradiatus* *Convolutispora* spp. *Auroraspora solisortus* *Rugospora ?* sp. *Perotrilites* spp. *Schopfipollenites* sp. *Schopfipollenites ellipsoides* *Perotrilites perinatus* *Endosporites minutus* (zone B/C of Canso–Riversdale)
Bo167-B22/65	7396	45°43′05″	62°14′50″	On Knoydart (Mill) Brook *Punctatisporites* spp. *Perotrilites* spp. *Lycospora uber* Hoffmeister, Staplin and Malloy *Perotrilites perinatus* Hughes and Playford *Schopfipollenites ellipsoides* (Ibrahim) Potonié and Kremp ? *Secarisporites* sp. ? *Grandispora* sp. (zone B/C of Canso–Riversdale)
Bo168-B22/65	7397	45°43′05″	62°14′45″	On Knoydart (Mill) Brook *Calamospora* sp. *Perotrilites* sp. ? *Grandispora* sp. *Punctatisporites planus* Hacquebard *Lycospora uber* Hoffmeister, Staplin and Malloy *Retusotriletes incohatus* Sullivan ? *Secarisporites* sp. *Leiotriletes* sp. (zone B/C of Canso–Riversdale)
Bo181-B22/65	7398	45°43′10″	62°14′50″	On shore, east of Knoydart Brook *Perotrilites* sp. *Schopfipollenites* sp. *Punctatisporites* spp. *Convolutispora* sp. ? *Secarisporites* sp. *Leiotriletes* sp. cf. *Spelaeotriletes* sp. *Endosporites* cf. *micromanifestus* Hacquebard

Field No.	Cat. No.	Latitude (N)	Longitude (W)	Remarks
				Laevigatosporites desmoinensis (Wilson and Coe) Schopf, Wilson and Bentall cf. *Knoxisporites stephanophorus* Love (zone B/C of Canso–Riversdale)
Bo182-B22/65	7399	45°43′20″	62°14′20″	On shore, east of Knoydart Brook *Perotriletes* sp. *Schopfipollenites* sp. cf. *Cristatisporites* sp. *Convolutispora* sp. *Foveosporites* sp. *?Laevigatosporites* sp. *?Secarisporites* sp. *Leiotriletes* sp. *Retusotriletes* sp. *Punctatisporites* spp. *Dictyotriletes* sp. *Perotrilites perinatus* Hughes and Playford *Knoxisporites stephanophorus* Love *Schopfipollenites ellipsoides* (Ibrahim) Potonié and Kremp *Endosporites minutus* Hoffmeister, Staplin and Malloy *Lycospora* cf. *uber* Hoffmeister, Staplin and Malloy cf. *Auroraspora solisortus* Hoffmeister, Staplin and Malloy (zone B/C of Canso–Riversdale)
Bo183-B22/65	7400	45°43′25″	62°13′50″	On shore, east of Knoydart Brook *?Grandispora* sp. *Calamospora* sp. *Verrucosisporites* spp. *?Auroraspora* sp. *Punctatisporites* spp. *Foveosporites* sp. *Endosporites* sp. *?Lycospora* sp. *Cirratriradites* sp. *?Secarisporites* sp. *Convolutispora* spp. *Cyclogranisporites* sp. *Stenozonotriletes* sp. *Apiculatisporis* sp. *Rugospora* sp. *Schopfipollenites* sp. *Perotrilites* sp. *Punctatisporites* cf. *viriosus* Hacquebard P. *planus* Hacquebard *Retusotriletes* cf. *incohatus* Sullivan *Auroraspora* cf. *solisortus* Hoffmeister, Staplin and Malloy *Microreticulatisporites* cf. *hortenensis* Playford

Field No.	Cat. No.	Latitude (N)	Longitude (W)	Remarks
				Knoxisporites stephanophorus Love *Perotrilites perinatus* Hughes and Playford (zone B/C of Canso–Riversdale)
		Pictou Group		
Bo735-P35/64 Same sample as CRS No. ML17		45°40′05″	62°26′30″	Coal Point, Merigomish Island *Laevigatosporites* spp. *Triquitrites* spp. *Raistrickia* spp. *Cyclogranisporites* spp. *Reticulatisporites* sp. *Lophotriletes* spp. *Verrucosisporites* sp. *Punctatisporites* sp. cf. *Torispora* sp. *Florinites* spp. *Protohaploxypinus* sp. *Wilsonites* sp. *Converrucosisporites* sp. *Knoxisporites* sp. *Lycospora* sp. *Speciososporites* sp. *Calamospora* spp. *Foveolatisporites* sp. (*Linopteris obliquaa–Ptychocarpus unitus* zone of Morien (Pictou) Group of the Sydney Coalfield)
Bo737-P37/64	7173	45°39′10″	62°29′00″	On shore at Kings Head *Laevigatosporites* sp. *Granulatisporites* spp. *Verrucosisporites* sp. *Florinites* sp. *Calamospora* sp. *Lycospora* spp. cf. *Vestigisporites* sp. *Limitisporites* sp. *Leiotriletes* sp. (*Linopteris obliquaa–Ptychocarpus unitus* zone of Morien (Pictou) Group of the Sydney Coalfield)
Bo121-B22/65	7391	45°48′15″	62°33′15″	On Pictou Island east of Roger Point *Punctatisporites* *Convolutispora* *Granulatisporites* *Calamospora microrugosa* (Ibrahim) Schopf, Wilson and Bentall *Laevigatosporites minimus* (Wilson and Coe) Schopf, Wilson and Bentall *Thymospora perverrucosa* (Alpern) Wilson and Venkatachala (upper Morien (Pictou) Group or post-Morien beds. Westphalian D or Stephanian)

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