GEOLOGICAL SURVEY OF CANADA

DEPARTMENT OF ENERGY, MINES AND RESOURCES

MEMOIR 351

BADDECK AND WHYCOCOMAGH MAP-AREAS
with emphasis on Mississippian stratigraphy of central Cape Breton Island, Nova Scotia (11 K/2 and 11 F/14)

Danford G. Kelley

Price, $2.50

1967

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2,000—1966—5555

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Printed on NO. 2 OFFSET ENAMEL

Set in Times Roman with
20th Century captions by
THE RYERSON PRESS

Artwork by CARTOGRAPHIC UNIT, GSC

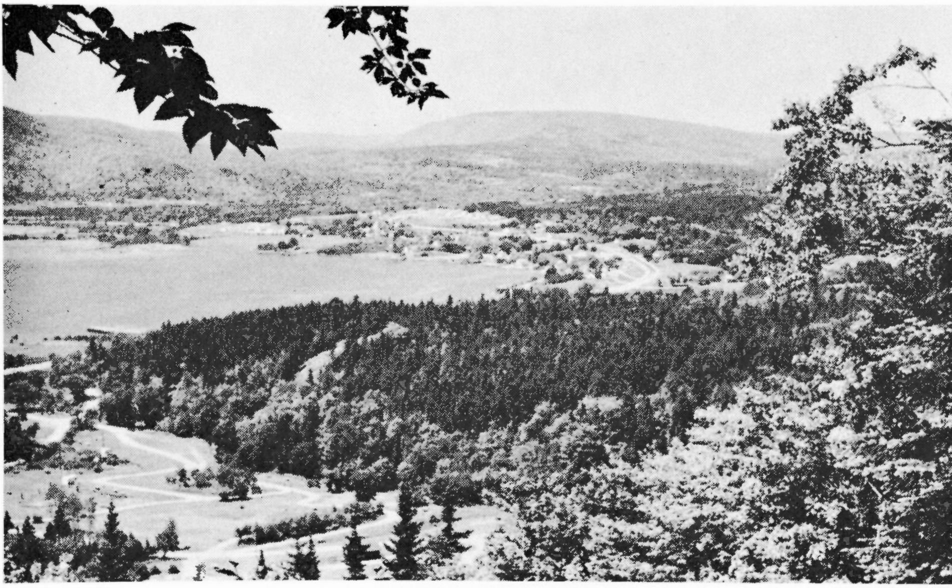

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PLATE I. View of Whycocomagh.

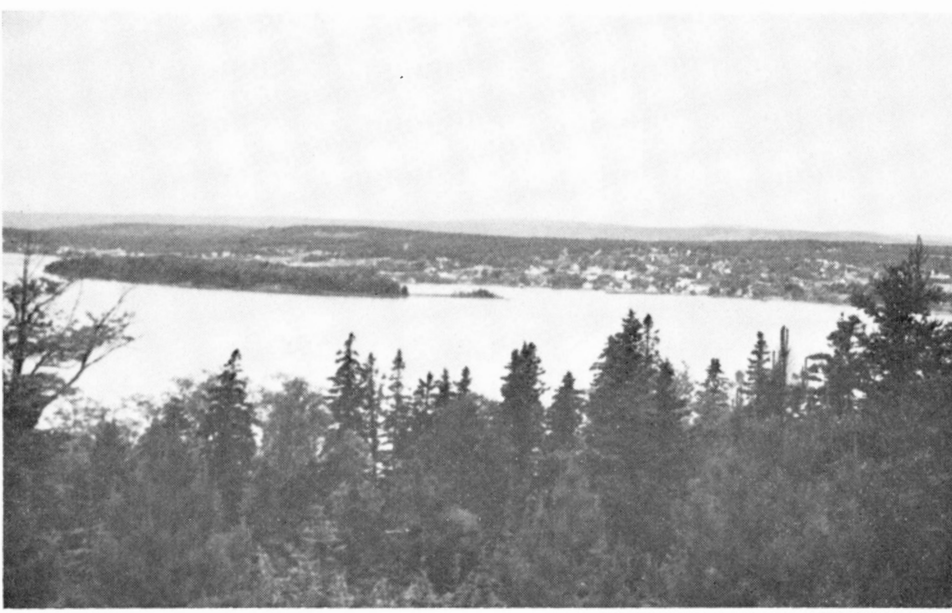

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PLATE II. View of Baddeck.

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ENERGY, MINES AND RESOURCES
CANADA

Available by mail from the Queen's Printer, Ottawa,
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Price subject to change without notice

ROGER DUHAMEL, F.R.S.C.
Queen's Printer and Controller of Stationery
Ottawa, Ontario
1967

PREFACE

Many of the fundamental relationships established by the reconnaissance geological mapping of Cape Breton Island in the later part of the 19th century remain unchallenged. However, the increase in basic knowledge of stratigraphy, changes in geological concepts, and improvements of mapping methods since the early work have made revision necessary. The present work was undertaken as part of that revision.

In addition to providing data on pre-Carboniferous rocks of the two map-areas, this report presents new information on Mississippian stratigraphy of Cape Breton Island. The Mississippian Horton Group has been subdivided into formations and a relationship has been established between previously mapped Mississippian strata in eastern Cape Breton Island and those in the western part of the Island. Information on the nature of the basin of deposition of Mississippian sediments is also presented.

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

OTTAWA, December 15, 1964

MEMOIR 351 — Kartenblätter Baddeck und Whycocomagh, mit besonderer Berücksichtigung der Stratigraphie des Mississippians im Zentralgebiet der Kap-Breton-Insel (Neuschottland).
Von Danford G. Kelley

Beschreibt die allgemeine Geologie der beiden Kartenblätter im Südwesten der Kap-Breton-Insel, mit besonderer Berücksichtigung der Faziesveränderungen und Ablagerungsverhältnisse der Gesteine des Mississippians.

МЕМУАР 351 — Беддекский и Вайкокомагский листы геологической карты, с упором на миссиссиппскую стратиграфию центральной части острова Кап Бретон, Новая Шотландия.
Д. Г. Келлей

Отчет описывает общую геологию двух листов геологической карты в югозападной части острова Кап Бретон, с упором на изменения фаций и условия осадкообразования миссиссиппских отложений.

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BADDECK AND WHYCOCOMAGH MAP-AREAS, CAPE BRETON ISLAND, NOVA SCOTIA

Abstract

The two map-areas contain rocks that range in age from Precambrian to Pennsylvanian. The oldest rocks are George River Group: quartz-feldspathic and micaceous-quartz rocks, quartzites, marbles, and minor volcanic rocks. Areally associated with the George River Group, but of unknown contact relationships, are highly altered intermediate to acidic volcanic rocks. They are tentatively placed in the Precambrian.

Middle Cambrian volcanic and sedimentary rocks occur in the southeast part of Baddeck map-area. These rocks are relatively unaltered and secondary foliation is only locally developed.

Granitic rocks range in composition from granite to gabbro although the most common are quartz monzonite and granodiorite. Field relations outside the map-areas suggest that these granitic rocks were emplaced after earliest Ordovician and before Middle Devonian times.

An essentially complete succession of Mississippian strata is present in central Cape Breton Island. The youngest Mississippian rocks, the Mabou Formation, are conformable into the Pennsylvanian. The Pennsylvanian Morien Group is unconformable on the Mississippian Windsor Group.

Mississippian rocks are divided into the Horton and Windsor Groups and the Mabou Formation. The Horton Group, a sequence of continental beds, is divided into the Craignish and Strathlorne–Ainslie Formations. This group is more than 10,000 feet thick in the western part of the Island and wedges out eastward. Facies changes are common. The mainly marine Windsor Group conformably overlies the Horton Group except at one locality, where there is an angular unconformity. The Windsor Group is conformably to disconformably overlain by fresh-to-brackish-water, fine-grained sedimentary rocks of the Mabou Formation.

The eastern edge of the Horton basin is established in the wedge-out of Horton strata and the overlap of Windsor strata in a conformable transgressive sequence of beds. The lower strata of the Windsor Group transgressed (generally from west to east) areas of high relief that existed during deposition of all Horton Group and most Windsor Group strata. There is no evidence of basin margins during Mabou sedimentation.

Résumé

Les deux régions à l'étude contiennent des roches datant du Précambrien au Pennsylvanien. Les plus vieilles sont du groupe de la rivière George: roches felds-pathiques et micacées à quartz, quartzites, marbres, et un peu de roches volcaniques. Des roches volcaniques très altérées allant de l'intermédiaire à l'acide sont associées par zones au groupe de la rivière George, mais leurs contacts sont inconnus. L'auteur les place provisoirement dans le Précambrien.

Il y a des roches sédimentaires et volcaniques du Cambrien moyen dans le sud-est de la région de Baddeck. Ces roches sont à peine altérées et la schistosité secondaire n'existe que par endroits.

Les roches granitiques varient du granite au gabbro, mais les plus communes sont la monzonite quartzitique et la granodiorite. Les liens qui existent entre les terrains à l'extérieur des régions à l'étude portent à croire que ces roches granitiques ont été mises en place après l'Ordovicien inférieur et avant le Dévonien moyen.

Au centre de l'île du Cap-Breton, on a découvert la présence d'une succession essentiellement complète de strates du Mississippien. Les roches les plus jeunes du Mississippien, la formation de Mabou, gisent en concordance dans le Pennsylvanien. Le groupe de Morien du Pennsylvanien repose en discordance sur le groupe de Windsor du Mississippien.

Les roches du Mississippien se partagent entre les groupes de Horton et de Windsor et la formation de Mabou. Le groupe d'Horton, une succession de couches continentales, se divise en deux formations, Craignish et Strathlorne-Ainslie. Ce groupe a une épaisseur de plus de 10,000 pieds dans l'ouest de l'île et se rétrécit vers l'est. Les changements de faciès sont nombreux. Le groupe de Windsor, qui est principalement marin, repose en concordance sur le groupe d'Horton, excepté à un endroit où il y a une discordance angulaire. Le groupe de Windsor est recouvert parfois en concordance, parfois en discordance, par des roches sédimentaires à grain fin de la formation de Mabou, et qui se sont déposés dans de l'eau douce à saumâtre.

La limite orientale du bassin d'Horton se trouve dans le coin extérieur des strates d'Horton et du chevauchement des strates de Windsor dans une succession de couches concordantes en transgression. Les strates inférieures du groupe de Windsor ont transgressé, généralement de l'ouest à l'est, les régions de haut relief qui existaient durant la mise en place des strates de tout le groupe d'Horton et d'une partie du groupe de Windsor. Il n'y a pas d'indices des bordures des bassins durant la sédimentation de la formation de Mabou.

Chapter I

INTRODUCTION

Baddeck and Whycocomagh are diagonally adjoining map-areas in Cape Breton Island, Nova Scotia. Baddeck map-area lies between latitudes 46°00′ and 46°15′, longitudes 60°30′ and 61°00′, and Whycocomagh map-area between latitudes 45°45′ and 46°00′, longitudes 61°00′ and 61°30′. Together they comprise an area of about 830 square miles.

Field work in the map-areas was commenced in 1952 and completed in 1956. The investigation was carried out primarily to establish the age relationships and boundaries of the various rock formations and to assess the mineral potential of the region.

Preliminary geological maps of Baddeck and Whycocomagh map-areas on the scale of 1 inch to the mile (Kelley, 1957, a and b) have been published.

Acknowledgments

During the field seasons of 1952–56 the writer was capably assisted by Dr. W. H. Pinson and Messrs. W. F. MacIsaac, R. A. Landy, Sheldon Dick, E. W. Carlson, D. J. McMahon, Cyril Hadley, G. C. Taylor, C. Sperling, W. H. Hopper, C. Milan, I. M. Harris, Victor Sutherland, D. J. MacEachern, and William Gromick.

The writer is indebted to Dr. Walter L. Whitehead, formerly of the Massachusetts Institute of Technology, for his interest, suggestions, assistance, and encouragement during the course of the investigation.

Appreciation is extended to Dr. L. J. Weeks, Dr. B. C. Murray, Dr. W. A. Bell, and Professors N. McL. Sage and D. J. MacNeil for their visits and discussions during pursuit of the field work.

The writer also wishes to thank Dr. E. R. W. Neale for his many contributions during the final analysis of the investigation.

Early Geological Mapping

Coal mining was a major industry in Cape Breton Island during the latter part of the 19th century, so it was natural that the areas underlain by coal seams should be the first parts of Nova Scotia to receive attention from the Geological Survey of Canada.

Ms. received 23 March, 1964.

The first systematic geological mapping was started in the Sydney coal basin in 1870 by Edward Hartley (Robb, 1873, p. 238). This work was continued in 1872 by Charles Robb (1873) after Hartley's death. Robb was assisted in the field by Hugh Fletcher and in 1876 they published a geological map (one inch to the mile) of the Sydney coal field (Robb and Fletcher, 1876). With the resignation of Robb from the Survey in 1875, Fletcher carried on the regional mapping of Cape Breton Island.

Because of the interest in coal most attention was devoted to Carboniferous rocks. Robb and Fletcher (1876) divided Carboniferous rocks into: Coal Measures, Millstone Grit, Carboniferous Limestone, and Carboniferous Conglomerate. The first two are now classified as Pennsylvanian and the last two as Windsor Group of the Mississippian.

Fletcher (1877) continued to use the same Carboniferous classification that he and Robb used in the Sydney coal basin, but stated that no clearly defined contact existed between the Carboniferous Conglomerate and the overlying Carboniferous Limestone. As he worked southwest of the Sydney area, however, he (Fletcher, 1878, p. 438) interpreted a specific limestone bed as the upper limit of the "Carboniferous Conglomerate formation". This is the same limestone bed that is now interpreted as the basal member of the Mississippian Windsor Group. Therefore, in some parts of Fletcher's map-areas, the Carboniferous Conglomerate formation belongs to the Mississippian Horton Group, which underlies the Windsor group. Fletcher (1878, p. 437) recognized this general relationship when he stated: "A portion at least of this division (Carboniferous Conglomerate) is probably contemporaneous with strata, which must be referred to the Carboniferous Limestone formation".

In southeastern Cape Breton Island, Fletcher (1879, p. 16F) interpreted highly contorted rocks as Devonian(?) metamorphic rocks. These were later mapped by Weeks (1954) as Mississippian and Pennsylvanian. Fletcher's classification was apparently based on the fact that these rocks are more highly indurated than the Mississippian and Pennsylvanian rocks of the Sydney area, and furthermore they are intruded by diorite and trap (Fletcher, 1879, p. 19F). Weeks (1954, p. 78) interpreted these basic intrusive rocks as Mississippian(?) because they cut Windsor and Horton strata, but are not known to cut Pennsylvanian rocks.

In western Cape Breton Island, Fletcher (1885, p. 6H) changed his Carboniferous nomenclature and divided the strata into Middle Carboniferous and Lower Carboniferous. The former included Millstone Grit and Coal Measures and the latter included a Conglomerate formation and a Limestone formation. The Limestone formation consists mainly of strata now designated as Windsor Group. One major exception is the strata included in the Limestone formation of Baddeck map-area. There, this formation includes both Horton and Windsor Group strata.

The Conglomerate formation, designated "Lower Carboniferous Metamorphics" on Fletcher's maps of western Cape Breton Island, consists mainly of strata at present classified as Horton Group. This Conglomerate formation is part of the same group of strata that Fletcher earlier designated as Devonian(?) metamorphic rocks. Fletcher acknowledged (1885, p. 37H) that the Carboniferous conglomerate, ". . . frequently resembles the supposed Devonian rocks of Madame Island and Guysborough County". Fletcher's maps were of a reconnaissance nature, but they constituted a useful guide for subsequent, more detailed mapping, and were also helpful in locating old mineral prospects.

Detailed investigations of particular problems and mineral occurrences in central Cape Breton Island date back to the early part of the 19th century. The first report on the geology was by Brown (1846). The first comprehensive discussion of the Carboniferous rocks was written by Sir William Dawson in "Acadian Geology", the first edition of which was published in 1855 and the fourth and final edition in 1891. Dawson's (1868, p. 129) subdivision of the Carboniferous was the same as that later followed by Robb and Fletcher (1878) except that the strata they mapped as "Carboniferous Conglomerate", were termed the "Lower Coal Measures" by Dawson.

Remapping of the Sydney coal basin was commenced by A. O. Hayes in 1917 and, following his resignation from the Geological Survey, the work was completed by W. A. Bell in 1921 (Hayes and Bell, 1923). This work was the beginning of a remapping program of Cape Breton Island that has continued to the present. The remapping program was necessary because of the better understanding of Carboniferous stratigraphy that resulted from Bell's work in Nova Scotia and because very little was known about pre-Carboniferous rocks of the Island, with the exception of the Cambrian rocks studied by Matthew (1903).

Accessibility

The southern part of Baddeck map-area and the eastern part of Whycocomagh map-area include part of the Bras d'Or Lakes, with docking facilities for ocean-going ships available at the villages of Baddeck and Iona. The Sydney-Truro line of the Canadian National Railways passes through the southeast corner of Whycocomagh map-area. The Trans-Canada highway extends diagonally across both map-areas, and Highway 19, a hard-surfaced road, follows the western edge of Whycocomagh map-area. These highways connect with good secondary roads, which extend into most parts of the two map-areas.

Industries

The principal industry is farming but many farmers depend on additional income from cutting pulpwood, fishing, or working as casual labour.

The 1958 Trade Directory of the Atlantic Provinces Economic Council listed 59 sawmills in the map-areas. These are mainly small operations, 48 of them producing less than 200,000 F.B.M.[1] per year.

Gypsum is quarried by United States Gypsum Company at Little Narrows, in the southeast corner of Baddeck map-area, which shipped 414,911 tons in 1961.

The tourist industry is becoming increasingly important in the vicinities of the villages of Baddeck and Whycocomagh.

The only Gaelic College in North America is located in the northeast part of Baddeck map-area, on St. Anns Bay. Although it is not a major industry in itself, it is an asset to the local economy.

[1]Feet Board Measure.

Physical Features

The most prominent physical features in the area investigated are the Cape Breton Highlands, the southern end of which is in the northern part of Baddeck map-area, and a series of northeasterly trending uplands. These highland areas, with a maximum elevation of 1,400 feet, are underlain by igneous and metasedimentary rocks. Between the uplands are rolling lowlands or water basins which are underlain, for the most part, by Carboniferous sedimentary rocks. The uplands when viewed from a distance, present a flat, even skyline (Pl. II). They are, however, incised by a network of steep-sided V-shaped valleys and the boundaries between upland and lowland usually are sharply defined by steep slopes.

Chapter II

GENERAL GEOLOGY

Cape Breton Island, Nova Scotia, is part of the Appalachian Mountain System that extends from southeastern United States to Newfoundland. All periods of the Palaeozoic, with the possible exception of the Permian, are represented in the sedimentary and volcanic rocks of the Island. Rocks present in Baddeck and Whycocomagh map-areas include Precambrian and Cambrian sedimentary and volcanic rocks, granitic rocks, lowermost Mississippian volcanic and sedimentary rocks, and Mississippian and Pennsylvanian sedimentary rocks. Carboniferous rocks are areally most important, for they underlie approximately two-thirds of the land area.

Precambrian—George River Group

Geologists who have worked in Cape Breton Island during the last 30 years have included in the George River Group all unfossiliferous metasedimentary rocks that contain crystalline limestone (Guernsey, 1928; Norman, 1935; Bell and Goranson, 1938; Ferguson and Weeks, 1950; Weeks, 1954; Kelley, 1957, a and b).

Honeyman (1872, p. 196) introduced the term George River 'series' to apply to a group of rocks exposed along George River, near St. Andrews Channel. However, Fletcher (1877) was the first geologist to give a detailed description of George River rocks. He mapped the crystalline limestone and dolomite ". . . interstratified with felsite, syenite[1], diorite, mica schist, quartzite, and quartzose conglomerate" as George River Limestone (Fletcher, 1877). From his description of the areas traversed there is no doubt that he was referring to the same rocks as Honeyman.

Guernsey (1928) used the term George River 'series' to describe a group of rocks that include a volcanic member, a limestone member, and a quartzite–greywacke member. He was not able to map the three members separately, but interpreted the volcanic member as oldest and the quartzite greywacke member as youngest. Bell and Goranson (1938a), in the type area, recognized two subdivisions of George River strata consisting of a carbonate member and a quartzite–schist–gneiss member. They interpreted the carbonate member as being the younger of the two. Neither of these investigations supplied conclusive evidence for dividing the George River Group, which is not surprising when the structural complexities of the group are considered.

[1]The word syenite, as used in early reports of the Geological Survey, indicates a rock composed principally of feldspar, hornblende, and quartz.

TABLE I

Table of Formations

ERA	PERIOD OR EPOCH	GROUP OR FORMATION	FORMATION OR MEMBER	LITHOLOGY
CENOZOIC	RECENT			Stream alluvium, beach sands and gravels, sand bars (0-?)
	PLEISTOCENE			Till; stratified sand and gravel (0-125)
Unconformity				
PALAEOZOIC	PENNSYLVANIAN	Pictou Group		Sandstone, grit, conglomerate, minor limestone (?)
	Unconformity			
	PENNSYLVANIAN-MISSISSIPPIAN	Mabou Formation		Red and grey sandstone, siltstone, shale, minor limestone (7,000+)
	MISSISSIPPIAN	Windsor Group		Red siltstone, mudstone, sandstone, conglomerate, limestone, gypsum, anhydrite, and salt? (2,500 ±)
		Horton Group	Strathlorne-Ainslie Formation	Red and grey sandstone, siltstone, conglomerate, grey siltstone, sandstone, shale (400-2,900±)
			Craignish Formation	Grey arkosic sandstone and conglomerate, red siltstone, sandstone, and conglomerate, some grey siltstone and sandstone (0-8,000±)
				Andesite and minor rhyolitic rocks, conglomerate, and sandstone (800-1,500)
	Unconformity			
	PRE-MIDDLE DEVONIAN TO POST-LOWERMOST ORDOVICIAN			Quartz monzonite, granodiorite, and minor granite and monzonite. Granodiorite, quartz diorite and diorite, biotite and biotite-hornblende gneiss, mixed rocks, composite gneiss
	Intrusive contact ?			
	CAMBRIAN			Tuff, breccia, amygdaloidal basalt, andesite, sandstone, siltstone, and shale (?)
Not in contact				
PRECAMBRIAN ?				Intermediate to acidic volcanic rocks (?)
Unconformity ?				
PRECAMBRIAN		George River Group		Quartzo-feldspathic and micaceous-quartzo gneisses and schists, limestone and quartzite, minor volcanic rocks and greywacke (?)

Note: numbers in parentheses refer to thickness in feet — *GSC*

Except for areas around George River, and in Whycocomagh map-area around Marble Mountain, Dunakin, and East McPhail Brook, crystalline limestone is a minor component of those schistose and gneissic rocks that have been included in the George River Group by all recent workers in the southern part of Cape Breton Island. More commonly, large areas underlain by metasedimentary rocks are included in the George River Group on the basis of one or two widely spaced beds of marble or skarn.

Distribution

Rocks included in the George River Group occur in the upland areas where they are always associated with granitic rocks. The granitic rocks commonly contain multi-sized inclusions of George River strata near the contacts of the granite and George River Group. Scattered outcrops of granitic rocks, miles from areas underlain by George River Group strata, contain inclusions of George River type rocks.

Lithology

Rocks in the George River Group consist chiefly of quartzo-feldspathic and micaceous-quartz rocks, commonly referred to as schistose quartzites, sericite schists, quartzites, quartzose metasedimentary rocks, and limestone and dolomite. Limestone, dolostone, and quartzite locally constitute a high percentage of the rocks present in the group. Hornfelsic or baked shales are common in the area mapped as George River Group in the Boisdale Hills and immediately to the west, near St. Andrews Channel. The only reason for including the rocks of these two areas in the George River Group was the presence of limestone in that part of the Boisdale Hills mapped by Weeks (1954, p. 9). Hornblende schists are present at intervals in the metasedimentary rocks and may represent metamorphosed volcanic flows or sill-like masses (Neale, 1964b). No primary features in these rocks are known.

Volcanic rocks may be more common in George River Group strata than the author recognized. Some highly sheared volcanic rocks in Baddeck map-area closely resemble some sheared types of metasedimentary rocks of the George River Group. It is unlikely, however, that volcanic rocks form a distinct unit within the metasedimentary rocks of the George River Group, or older than them. The mineral assemblage of the metamorphic rocks examined in thin section suggests that most, if not all, of the rocks mapped as George River Group in the two map-areas belong to the greenschist facies of Fyfe, *et al.* (1958).

Although insufficient work has been done to indicate the metamorphic zones on the accompanying geological maps (*in pocket*), it appears that within the greenschist facies all three subfacies described by Fyfe, *et al.* (1958, p. 218) are present. These are the quartz–albite–muscovite–chlorite (chlorite zone), the quartz–albite–epidote–biotite (biotite zone), and the quartz–albite–epidote–almandine subfacies (low-grade portion of the almandine zone).

The most common rock types present in the two map-areas are quartzo-feldspathic assemblages and these grade into relatively pure quartzites and sericite–quartz schists.

The quartzo-feldspathic rocks most commonly contain sericite, muscovite, chlorite, biotite, quartz, albite, and epidote. The feldspar is kaolinized or sericitized in varying degrees. Quartz-free schists and gneisses, consisting predominantly of hornblende, albite, and epidote with minor leucoxene, suggest that some of these rocks were probably calcareous shales within basic flows or sills, whereas others, now consisting mainly of 50–60 per cent hornblende and 30 per cent turbid feldspar, probably represent flows or sills.

The limestone varies from relatively unaltered rock with no reaction between the few fresh grains of silicate minerals and the carbonate to rocks consisting mainly of calcium and magnesium silicate minerals. Rocks of the latter type are best developed along East McPhail Brook and the former around Marble Mountain and Dunakin. Quartzite is of local importance in the small 'finger-like' area mapped as George River Group immediately west of Christopher McLeod Brook, near the northeastern boundary of Baddeck map-area.

Origin and Age

Because of structural complexities and insufficient stratigraphic control, the true succession of the George River Group is unknown. The group is predominantly, if not wholly, a sedimentary unit, although rocks of possible volcanic origin have been described (Fletcher, 1877; Guernsey, 1928; Ferguson and Weeks, 1950). Fletcher (1877, p. 12F) stated that the limestones were always deposited on "laminated felsites". This statement possibly led Guernsey (1928, p. 53C) to conclude that the volcanic rocks on North Mountain were part of the George River Group and hence, the oldest rocks of that area. However, later work by Bell and Goranson (1938a), Hutchinson (1952), and Weeks (1954) showed that all the "felsites" described by Fletcher, around the type area of the George River Group, are actually younger than the George River Group. Bell and Goranson (1938a) did not mention volcanic rocks within the George River Group.

Honeyman (1872) considered the 'syenite' to be part of the George River Group, and to have resulted from metamorphism of the sedimentary rocks. He classified the George River Group as Silurian and ". . . a counterpart of the metamorphic, syenite, serpentine, and calcite, of Arisaig, Nova Scotia" (p. 193).

Fletcher (1877) classified the George River Limestone as Precambrian and the 'syenite' as part of the succession of gneisses and other feldspathic rocks, older than the George River Limestone. This older sequence included felsites that have since been included by Weeks (1954) in the Proterozoic Fourchu Group and the Cambrian Bourinot Group.

Despite the age problems presented by some of the volcanic rocks originally mapped as George River Group, the group as a whole, at least in the type area, is most probably Precambrian. As first pointed out by Matthew (1903) and later by Hutchinson (1952, p. 6), the George River Group is unconformably overlain by Middle Cambrian volcanic and sedimentary rocks. Lower Cambrian strata that outcrop a few miles east of this contact differ greatly from George River rocks.

Precambrian(?) Volcanic Rocks

Rocks that have been mapped as Precambrian(?) volcanic rocks may be correlative with the Fourchu Group of southeast Cape Breton Island (Weeks, 1954) or they may be a unit of the George River Group. Volcanic rocks were reported from the George River Group of North Mountain (Guernsey, 1928), but they are present only in minor amounts and are not a mappable unit. Also, Neale (1963b) included in questionable George River Group minor basic metavolcanic rocks.

Distribution

Rocks that have been mapped as Precambrian(?) volcanic rocks are located at the southern end of the Cape Breton Highlands, in the northwest part of Baddeck map-area.

Lithology

The volcanic rocks near the southern end of the Cape Breton Highlands in Baddeck map-area were found to be highly altered, intermediate to acidic varieties, on the basis of poor determinations of feldspar composition and general appearance; precise determinations could not be made. In general these rocks contain considerable sericite, chlorite, and epidote as alteration products. Porphyritic varieties commonly have a poorly defined to well-defined trachytic texture whereas others show no indication of flowage; some may even be intrusive rocks. The phenocrysts are all plagioclase. Amygdules were noted in several thin sections: in one they were presumably microcrystalline quartz and sericite; in another, they consisted of epidote and chlorite and were deformed. The groundmass was generally too well masked by chlorite or sericite or too fine grained to determine its composition, although microlites of feldspar were common. Tuffaceous rocks are fairly common; they appear to be mixed lithic-crystal tuffs. Quartz, although common in some thin sections, was in general rare.

Age

The age of the volcanic rocks in the northern part of Baddeck map-area is uncertain. Their correlation with the Fourchu Group is based on a vague lithological similarity to that group. If they are equivalent to part of the Fourchu Group, they would be of Late Precambrian or Early Cambrian age.

Cambrian

Rocks now known to be of Cambrian age were first delimited in Cape Breton Island by Hugh Fletcher in 1874 and were later described by him in the following Reports of Progress of the Geological Survey: 1875–76, pages 389 to 393: 1876–77, pages 428 to 437; and 1877–78, pages 11F to 16F. The rocks were described by Fletcher as Lower Silurian because, at that time, the Cambrian had not been fully recognized in America as a system separate from the Lower Silurian and with a distinctive fauna. Fletcher later recognized these strata as Cambrian and the fauna and stratigraphy were subsequently studied by Matthew (1903) and Hutchinson (1952). Weeks (1954), on the basis of Hutchinson's work, correlated rocks in eastern Cape Breton Island with the Cambrian that had formerly been mapped as Precambrian.

Distribution

Middle Cambrian rocks outcrop in the southeastern corner of Baddeck map-area in a synclinal structure that is faulted along part of its eastern edge. Lower and Upper Cambrian rocks do not outcrop in Baddeck map-area, and no Cambrian rocks are present in Whycocomagh map-area.

Lithology

Middle Cambrian rocks include tuff, flow breccia, amygdaloidal basalt, andesite, spilite, greywacke, quartzite, sandstone, shale, and rarely conglomerate (Weeks, 1954). The sedimentary rocks are fossiliferous. The contacts of Cambrian strata with granitic rocks are not exposed in the map-area, but Hutchinson (1952, p. 9) maintained that the granitic rocks are intrusive into the Cambrian strata along the same structure.

An interesting aspect of these rocks is their lack of well-developed secondary foliation on a regional scale. These rocks have supposedly been involved in the Taconic and Acadian orogenies, both of which may have been accompanied by granitic intrusions. They are, however, commonly less altered than some Mississippian rocks in southeastern Cape Breton Island and in Guysborough county on the mainland, which were involved in the deformation only near the end of the Palaeozoic (*see* tectonic map, Neale, *et al.*, 1961). Cambrian rocks of the Indian River basin can be followed along strike northeast of Baddeck map-area. At St. Andrews Channel cleavage is well developed in the shale and siltstone. Detailed descriptions of Cambrian stratigraphy and geological history in Cape Breton Island have been given by Hutchinson (1952) and Weeks (1954).

Age

Hutchinson's (1952) work on Cambrian trilobites of Cape Breton Island has demonstrated that eight palaeontological zones are represented in the rocks of the Island. These eight zones range from late Early Cambrian to latest Cambrian. In the Indian River valley, the age of Cambrian rocks ranges from Middle Cambrian to latest Cambrian, but rocks in the part of the valley that lies in Baddeck map-area are limited to Middle Cambrian.

Granitic Rocks

Granitic rocks are widespread in the upland areas and range in composition from granite to gabbro. In Lake Ainslie map-area, which is west of Baddeck and north of Whycocomagh map-areas, Norman (1935, p. 11) interpreted the granitic rocks (granite to diorite) as differentiates of one magma. East and southeast of Baddeck map-area, Weeks (1954) and Bell and Goranson (1938) also assigned the granitic rocks to a single period of intrusion. Crosscutting relationships suggest that the order of intrusion followed the order of increasing silicity. Except for some dioritic or 'diabasic' dyke rocks, granite is the youngest 'intrusive' rock in the map-area.

Distribution

Granitic rocks occur in all the upland parts of the two map-areas. Unlike other outcrops, which are mainly limited to stream valleys, the granitic rocks also commonly outcrop in the interstream areas.

Lithology

The granitic rocks are highly variable in composition and may grade in a single outcrop from granite to diorite. Rocks mapped as quartz monzonite, granodiorite, and minor granite and monzonite (map-unit 5 on the geological maps *in pocket*) are mainly pinkish grey to light brownish grey, medium-grained rocks. Their composition is commonly 20–40 per cent quartz, 20–45 per cent potash feldspar (generally microcline), and 25–50 per cent plagioclase (most commonly a sodic variety, but in some specimens as calcic as An_{30}). These rocks as seen in thin section commonly show shearing and granulation around grain boundaries. Two thin sections of rocks from near the northern boundary of the small granodiorite body southwest of Blue Mills show the rocks to be wholly cataclastic. This is the basis for the fault contact.

The small area of granite about a mile north of Crowdis Mountain in Baddeck map-area is a fine-grained micrographic granite. The granite consists of a micrographic intergrowth of potash feldspar, albite, and quartz, surrounding phenocrysts of altered albite and a few grains of highly strained quartz as much as 1.5 mm long. The granite includes minor amounts of biotite, chlorite after biotite, ilmenite, magnetite (partly derived from the alteration of biotite), and leucoxene. Plagioclase twins are commonly bent and the granite is in part foliated and sheared. Near its northern contact, the granite along Leonard McLeod Brook alternates with metasedimentary rocks that show varying degrees of feldspathization. The foliation is parallel with that in the metasedimentary rocks, and the foliated granite may have resulted from metasomatism of selective layers of the metasedimentary rocks. It is also possible that the granite is older than the main quartz monzonite prevalent throughout the two map-areas.

The dioritic phases are probably the oldest intrusive rocks, as indicated by crosscutting relationships. They range in composition from granodiorite to diorite and display various hues of grey. The granodiorites are commonly 10–25 per cent quartz, 50–75 per cent plagioclase (An_{10-20}), 5–15 per cent potash feldspar, as much as 10 per cent biotite and 20 per cent hornblende, and minor chlorite and epidote. Syenodiorite is of similar composition but has less quartz than the granodiorite. The quartz diorite and diorite phases commonly contain as much as 25 per cent quartz, 50–90 per cent plagioclase (An_{30-50}), and as much as 25 per cent hornblende and 20 per cent biotite. They contain minor amounts of epidote, chlorite, sericite, and calcite. Common accessory minerals are sphene, apatite, hematite, and magnetite. The granodiorite–diorite rocks are weakly to strongly sericitized and a few samples appear to be strongly saussuritized. Alteration in these rocks is somewhat irregular in distribution, however, for some specimens show relatively unaltered plagioclase grains associated with strongly altered grains.

Gneissic rocks intimately associated with both the granodiorite–diorite and George River Group rocks are probably in part recrystallized George River sedimentary rocks and in part intrusive phases of the granodiorite–diorite rocks. Both biotite and biotite–hornblende types of gneisses are common. Injection of pinkish quartz monzonite into the biotite and hornblende gneisses and George River Group rocks has produced hybrid types of gneiss. In some areas, because of scarcity of outcrop or because of the hybrid nature of some of the rocks, the granitic and meta-sedimentary rocks have been grouped as one map-unit.

Age

Hayes and Bell (1923, p. 54) in Sydney map-area assigned a Palaeozoic age to the granitic rocks. Later Bell and Goranson (1938a) mapped them as being older than the Cambrian rocks. Weeks (1947) first interpreted the granitic rocks in southeastern Cape Breton Island as post-Cambrian, pre-Carboniferous; later (1954) he assigned them to the late Lower or early Middle Devonian.

The only fossiliferous rocks cut by granitic rocks in Cape Breton Island are Middle Cambrian strata of Sydney and Gabarus map-areas (Weeks, 1954, p. 68; Hutchinson, 1952, p. 6). The suggestion that the granitic rocks are Devonian is based in part on their crosscutting relationships to strata designated Middle River Group (Weeks, 1954, p. 68). However, as the Silurian age of the Middle River Group is based on the crosscutting relationship of the granitic rocks (Weeks, 1954, p. 62), it is apparent that the premise for a Devonian age for the granitic rocks rests on a tenuous basis.

Because no structural break exists between Cambrian and Lower Ordovician rocks (Hutchinson, 1952, p. 29), the granitic rocks that cut Middle Cambrian beds are probably post-earliest Ordovician. Also, granitic pebbles are included in the Middle Devonian McAdam Lake Formation (Weeks, 1954, p. 68). Therefore, the age of at least some of the granitic rocks is probably post-earliest Ordovician and pre-Middle Devonian.

In Baddeck and Whycocomagh map-areas there is no stratigraphic evidence to further limit the age of the granitic rocks suggested above. It is also possible that more than one age of granite is present, because conflicting ages have been found for granitic rocks of Cape Breton Island, as discussed below. Five granite samples from Cape Breton Island have been dated isotopically at the Massachusetts Institute of Technology (Fairbairn, *et al.*, 1960). Samples from Framboise, in the southeastern part of Cape Breton Island, and from Black Brook, in the northern part, were dated at 365 million years. A sample from MacKenzie River, also in northern Cape Breton Island, was dated at 400 million years. A sample from the Boisdale Hills, half a mile east of the eastern boundary of Baddeck map-area, was dated at 500 million years, as was an inferior sample from Kelly Cove, at the northeast end of Kelly Mountain.

If the granite dates listed above approximate their ages of intrusion, at least two ages of granite are present on Cape Breton Island, one perhaps associated with the Taconic orogeny, the other with the Acadian orogeny. The 500 million year age for the Boisdale Hills granite is important because it establishes the minimum age of 500 million years for earliest Ordovician rocks, as pointed out by Holmes (1959, p. 194) and Kulp (1961, p. 1112).

Mississippian Sedimentary and Volcanic Rocks[1]

Sedimentary and volcanic rocks occur stratigraphically below the Mississippian Horton Group in parts of western and northwestern Cape Breton Island. They represent the first deposits to follow the Acadian orogeny in this part of the Island and their tectonic environment is similar to that of the Horton Group. They differ from the lower part of the Horton Group only by the presence of volcanic rocks; the sedimentary rocks of the sedimentary–volcanic sequence are indistinguishable from Horton Group rocks. They probably will be included in the Horton Group.

Distribution

The sedimentary and volcanic rocks occur in two small areas, one near the western boundary of Baddeck map-area, the other in the southwest corner of Whycocomagh map-area. Recent work has shown that they also occur intermittently from the Strait of Canso area to Cape St. Lawrence in northern Cape Breton Island (Kelley, *in* Lord and Jenness, 1961; Kelley, *in* Caley, *et al.*, 1962; Neale, 1963b, 1964b).

Lithology

Within Baddeck map-area, the sedimentary and volcanic rocks consist of reddish grey conglomerate, sandstone, and amygdaloidal and vesicular andesite. In other parts of the belt the sequence has been worked out by Mackasey (1963). The base of the sequence commonly consists of conglomerate with minor sandstone to siltstone, followed by a thick sequence of andesite flows, and commonly topped by conglomerate, sandstone, and rhyolite. The unit is 800 to 1,500 feet thick.

Origin and Age

The strata were apparently deposited in a continental environment as indicated by the lens-like conglomerate beds and the presence of fossil spores in the sandstone commonly found at the base of these strata.

The following spores were obtained from sandstone at the base of the volcanic-sedimentary section along Fisset Brook in the Chéticamp area.

Leiotriletes sp.
Calamospora sp.
Punctatisporites spp.
Granulatisporites sp.
Cyclogranisporites spp.
Apiculatasporites sp.
Endosporites sp.
Grandispora spp.
Perotrilites spp.
Reticulatisporites spp.
Convolutispora sp.
Phyllothecotriletes sp.
cf. *Acanthotriletes* spp.
cf. *Chaetosphaerites* sp.
Hystricosporites sp.

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[1]Subsequent to completion of this report these rocks have been included in the Horton Group and designated the Fisset Brook Formation. (*See* Kelley, G. and Mackasey, O.: Basal Mississippian volcanic rocks in Cape Breton Island, *Geol. Surv. Can.*, Paper 64-34, 1965.)

Barss in a report to the author commented as follows:

> The spores in the assemblages are fragmentary with some well preserved specimens. Only generic identifications were attempted, but comparison of the better preserved specimens with specimens from other samples from Nova Scotia and New Brunswick indicate a lowermost Mississippian age for the sample. The presence of the genus Hystricosporites gives some suggestion of comparison with samples from the Memramcook Formation of New Brunswick, which has been dated as late Devonian (Report F1-13-1962-DCM).

A Mississippian age therefore appears likely, with a slight possibility that the age might be late Devonian.

Mississippian Sedimentary Rocks

Mississippian sedimentary rocks in the Maritime Provinces have most commonly been divided into three groups: the Lower Mississippian Horton Group and the Upper Mississippian Windsor and Canso Groups. The term 'Canso Group' will not be used in this report except for reference purposes, because its past usage has age connotations that should be avoided in a rock-stratigraphic term. Use of the term 'Mabou Formation' (Norman, 1935, p. 43) avoids this difficulty. The Mabou Formation contains all strata in the map-areas previously assigned to or correlated with the Canso Group, plus additional strata that would be restricted from the Canso Group because of their age.

Mississippian sediments of Cape Breton Island were deposited on the eastern edge of a large basin that intermittently may have occupied many thousands of square miles of eastern Canada. Parts of the Mississippian basin were interrupted by landmasses at various times. These landmasses were probably ridges that trend parallel with the northeast regional structure. Localized folding and faulting accompanied deposition of the Mississippian so that both conformable and unconformable contacts exist between the three groups. Local folding and faulting also resulted in the occurrence of erosion simultaneously with nearby deposition.

Distribution

The upland areas of Cape Breton Island are all flanked by Mississippian rocks except near the Mabou Highlands or in places where faulting has resulted in placing Pennsylvanian strata in juxtaposition to pre-Carboniferous rocks. Mississippian sedimentary rocks underlie about 400 square miles in the two map-areas and probably an additional 200 square miles beneath Bras d'Or Lake.

Lithology

The Lower Mississippian Horton Group consists of conglomerate, arkosic sandstone, sandstone, siltstone, shale, and minor limestone. The Upper Mississippian Windsor Group consists of siltstone, shale, sandstone, limestone, gypsum, anhydrite, and salt in the central part of the basin, and conglomerate, sandstone, siltstone, limestone, and possibly some gypsum in marginal areas of the basin. The chiefly Upper Mississippian Mabou Formation consists of fine-grained siltstone, sandstone, and minor limestone, which probably reflect a cessation of the tectonic activity that accompanied deposition of earlier Mississippian sediments.

Origin and Age

Lower Mississippian rocks of the Horton Group are probably continental in origin, as suggested by the presence of a terrestrial flora and the lack of marine fossils. Upper Mississippian rocks of the Windsor Group are chiefly marine as indicated by the numerous marine fossils found in Windsor limestones. The Mabou Formation may be marine in part, but is mainly non-marine as is indicated by the contained flora and fauna.

More detailed information on the origin and age of Mississippian strata will be given in the following two chapters. Their age has, in general, been well established by fossils.

Pennsylvanian

Pennsylvanian rocks in eastern Canada have been divided into three groups and, as in earlier periods, the contained fauna and flora are more easily correlated with European fossils than with North American. The oldest group is the Riversdale, the medial is the Cumberland, and the youngest is the Pictou. In the map-areas, Pennsylvanian rocks are represented by the upper part of the Mabou Formation at Maple Brook and by the Pictou Group rocks on Boularderie Island. The Mabou Formation which is chiefly Mississippian, will be discussed in the chapter entitled "Upper Mississippian Stratigraphy."

Distribution

Pennsylvanian strata occur on Boularderie Island in the northeastern part of Baddeck map-area. However, the regional distribution, thickness, and attitudes of Pennsylvanian strata suggest that most of Cape Breton Island, except possibly part of the Cape Breton Highlands, was covered by Pennsylvanian rocks at the end of this period.

Lithology

Pennsylvanian rocks on Boularderie Island are sandstone, grit, conglomerate, and minor fresh-water limestone. A few, thin, uneconomical coal seams have been reported on the southern part of the island, but these are stratigraphically minor. Coal seams are economically important on the northeastern end of Boularderie Island, beyond the limits of the map-area.

Origin and Age

Pennsylvanian sedimentary rocks of Cape Breton Island have been described by Hayes and Bell (1923, p. 56) as flood-plain deposits in a progressively subsiding, ancient river valley. Their main lines of evidence are as follows: (1) marine fossils are lacking; (2) each seam is underlain by, and genetically connected with, an ancient soil in the form of an underclay; (3) crossbedded sandstones are channelled into underlying shales and coal beds; (4) mud-cracked and rain-pitted shales are common; (5) rapid lateral and vertical lithological changes commonly take place. These points, plus the fact that the stratigraphic interval between the coal seams is fairly uniform, suggest a depositional history involving plains, but a fluvial plain fits the facts as well as a flood plain. Haites (1951, pp. 329, 331–332) followed Hayes and Bell and stated that a flood-plain environment best explains some of the sedimentary features in the coal seams and associated sediments.

The stratigraphy and fossil flora of Pennsylvanian rocks in Nova Scotia have been carefully studied by W. A. Bell. Before Bell's work, which commenced in 1911, Pennsylvanian strata in Nova Scotia had a threefold division based on the assumption that the coal beds were all the same age. The rocks below the coal-bearing strata were called "Millstone Grit", and those above were referred to as "Upper Coal Measures." The coal-bearing strata were the "Productive Coal Measures." Bell's fossil flora studies have shown that Pennsylvanian rocks are correlative with several zones of the European Upper Carboniferous: Westphalian A, B, C, and D. The Westphalian B zone is apparently missing on Cape Breton Island. All zones contain "Productive Coal Measures" at some locality in Nova Scotia, and in Cape Breton Island coal is mined from seams in rocks of Westphalian A, C, and D. Bell assigned the rocks of Boularderie Island mainly to Westphalian C.

For a complete discussion of the fossil flora of Pennsylvanian rocks of Cape Breton Island, the reader is referred to Bell's reports (1938, 1944).

Chapter III

LOWER MISSISSIPPIAN STRATIGRAPHY

For a proper understanding of Mississippian rocks in the Baddeck and Whycocomagh map-areas it is necessary to discuss Mississippian rocks in other parts of Cape Breton Island. Central Cape Breton Island, which will commonly be mentioned, refers to that part of the Island between north latitudes 45°45′ and 46°15′ (Fig. 4). Lower Mississippian rocks of Cape Breton Island are mainly a conformable sequence of continental sedimentary rocks that rest unconformably on older rocks. There are several areas in central Cape Breton Island where the basal part of the Mississippian section includes volcanic rocks. These were described in the previous chapter[1]. All Lower Mississippian rocks on the Nova Scotian mainland have been included in the Horton Group.

Horton Group

The name for the Horton Group is derived from the type locality near Horton Bluffs, north of Windsor, Nova Scotia. Bell (1929) in the type area divided the Horton Group into a lower Horton Bluff Formation and an upper Cheverie Formation. These two formations have not been mapped separately in Wolfville map-area (Crosby, 1952), which includes the type section, or in the adjoining map-areas to the east and northeast (Stevenson, 1957; Weeks, 1948). However, the Horton Group as a whole is traceable across the mainland of Nova Scotia to Cape Breton Island. At the Strait of Canso, which separates mainland Nova Scotia from Cape Breton Island, a fresh-water limestone in the Horton Group is on strike with a similar limestone on Cape Breton Island, a mile distant (Weeks, personal communication), indicating the continuity of the group across the strait.

Distribution and Thickness

The distribution of the Horton Group in the two map-areas is shown on the geological maps (*in pocket*). The pre-Carboniferous highlands were probably originally covered by Horton sediments. The isopach map (Fig. 1) shows the original thickness of the Horton Group over a large part of Cape Breton Island at the time of the beginning of Windsor sedimentation. This map is an interpretation of thickness based on fourteen surface sections: five of the fourteen were measured; the other

[1]Subsequent to the completion of this Memoir these rocks were included in the Horton Group and their stratigraphy described. *See* Kelley, D. G. and Mackasey, W. O., Basal Mississippian volcanic rocks in Cape Breton Island, N.S.; *Geol. Surv. Can.*, Paper 64-34 (1965).

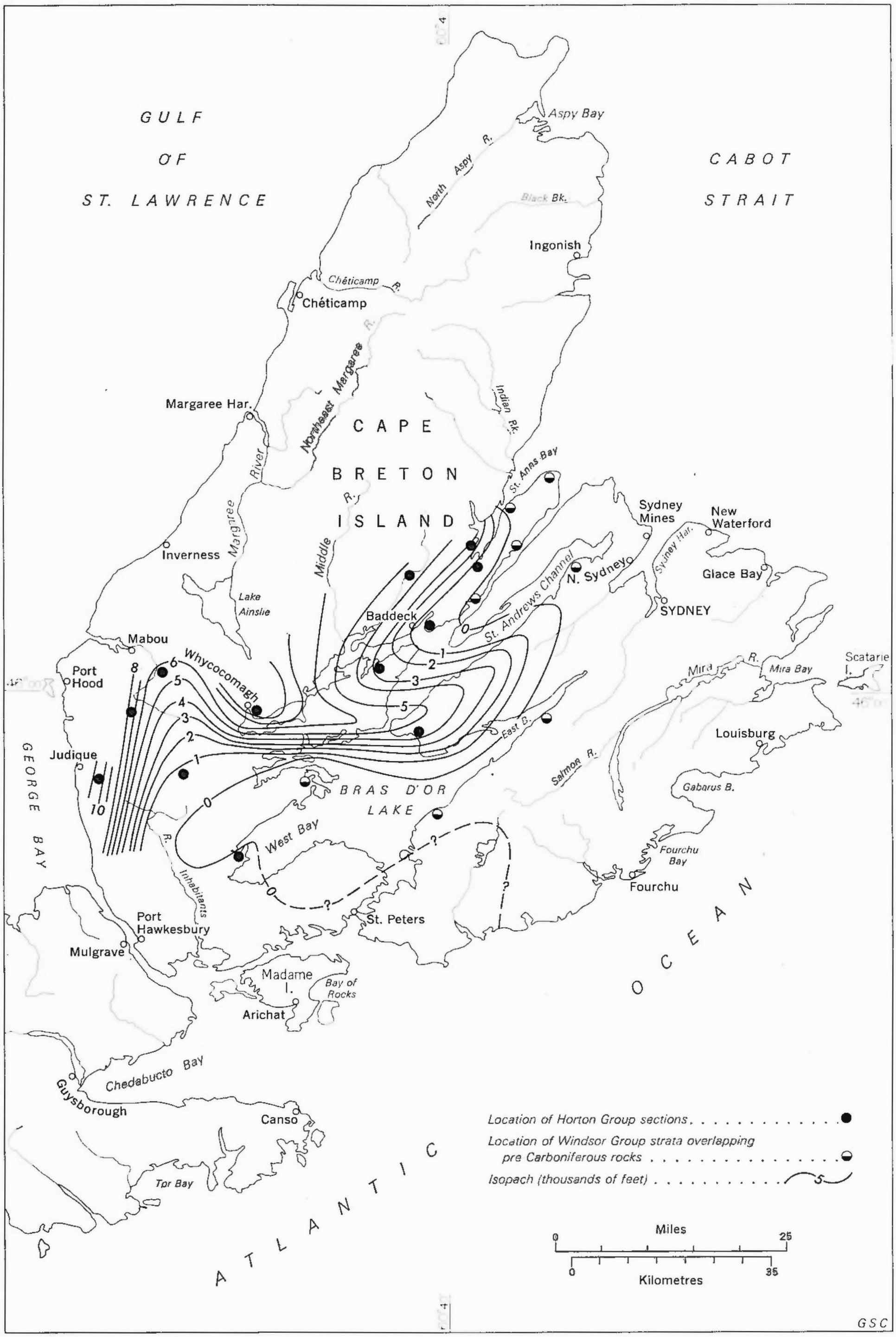

FIGURE 1. Isopach map showing original thicknesses of the Horton Group.

nine were calculated from the numerous attitudes in the general area of the recorded points. The isopach lines were spaced at equal intervals between the recorded sections. The trends of the isopach lines were chiefly interpreted from the geological maps of the area that indicate the directions in which Horton units show consistencies and variations in thickness.

Horton Group rocks of Lake Ainslie map-area have not been contoured on the isopach map (Fig. 1) because total thicknesses are not available. An examination of the geological map of the Lake Ainslie area (Norman, 1935) suggests that an approximate thickness of the Horton Group could be obtained along the east side of Lake Ainslie, but Norman (1935, p. 30) has pointed out the probability that the pre-Carboniferous–Horton contact in this area was faulted. The contact a mile north of the village of Trout River is in fact a high angle thrust or reverse fault, which the writer has seen at the face of an old adit that was reopened in 1954 to explore the barite and fluorite deposits associated with the fault. As this area does not contain a complete Horton section it does not provide the information necessary for Figure 1. The only other place where a thickness determination could be obtained in the Lake Ainslie map-area is along the east side of the Mabou Highlands, where outcrop is too scarce to make any significant approximation of thickness. However, the Lake Ainslie area was probably covered with Horton sediments except for the Mabou Highlands, parts of which were positive during much of Carboniferous time.

Age

Fossil collections from the Horton Group are meagre and uncommon. The only typical Early Mississippian plants found in the Horton Group of central Cape Breton Island are *Aneimites acadia* Dawson and *Lepidodendropsis corrugata* Dawson[1]. *Aneimites acadia* has been identified only in Lake Ainslie map-area, but *Lepidodendropsis corrugata* occurs in Lake Ainslie and Whycocomagh map-areas and just north of Baddeck map-area. Carbonized plant fragments are common. Fish scales, teeth and bones, and plant spores also occur in the Horton Group of central Cape Breton Island. The presence of these few diagnostic fossils, plus the continental origin of the rocks and the absence in most places of an unconformity between them and the overlying marine Upper Mississippian beds, reasonably establishes the presence and age of the Horton Group in central Cape Breton Island.

Lithological Subdivisions

The most comprehensive study of the Horton Group in Nova Scotia is that by Murray (1960). He divided the Horton Group into three formations: the Craignish below, the Strathlorne, and the Ainslie above[2]. The type section of the three formations is along Southwest Mabou River, in the western part of Whycocomagh map-area. It is extremely difficult to map the three Horton formations separately throughout

[1]Unless otherwise stated all Mississippian fossils were identified by palaeontologists of the Geological Survey of Canada.

[2]The Ainslie Formation of Murray (1960) should not be confused with the Ainslie sandstones of Mather and Trask's report (1928). The Ainslie sandstones are included in Murray's Ainslie Formation.

Baddeck and Whycocomagh map-areas, even though the various lithological units can be distinguished in most measured Horton sections. This difficulty is due partly to poor exposures but mainly to lateral facies changes of these sedimentary units. The writer therefore includes Murray's Strathlorne and Ainslie Formations in one formation, the Strathlorne–Ainslie. Reasons for the change will be dealt with later in this chapter.

Norman did not map subdivisions of the Horton Group in Lake Ainslie map-area, because ". . . any division of the Horton strata on a lithological basis would only have local significance" (1935, p. 25). He did, however, describe two Horton 'groups' in this area. His lower group is essentially the Craignish Formation and his upper group includes the Strathlorne and Ainslie Formations. Recently, Norman (personal communication, 1957) implied that subdivision of the Horton Group in Lake Ainslie map-area should be possible with detailed study.

Craignish Formation

The Craignish Formation is 5,130 feet thick in the type section (Murray, 1960, p. 12) and consists 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. The red colour is due to iron oxide in the cement, which commonly forms a coating on the subangular to rounded pebbles of granite, quartzite, limestone, felsite, quartz, and feldspar in the conglomerates. The formation rests unconformably on pre-Carboniferous granite and metasedimentary rocks except in places where it rests on Mississippian volcanic and sedimentary strata. It is conformably overlain by the Strathlorne–Ainslie Formation. The upper contact is placed at the top of the uppermost red bed in a typical section. The Craignish Formation exhibits a definite sequence of facies, which can be recognized in various sections. Variations in thickness and interfingering of these several facies make it nearly impossible to map them as separate units, but in a general way they can be recognized, especially in Whycocomagh map-area.

The seven columnar sections of the Horton Group on Figure 2 (*in pocket*) show some of the variations of Horton lithology and thickness in various parts of Cape Breton Island. The datum plane for the seven sections is the A_1 limestone of the Windsor Group. This limestone, which is stratigraphically below fossiliferous subzone B limestone of the Windsor, is widely distributed over Nova Scotia and Newfoundland. This thin (no more than 60 feet thick) limestone member of the Windsor Group is conceded to be a time-stratigraphic unit (Murray, 1960, p. 43; Smith, 1956, p. 117; Bell, personal communication, 1957).

Murray (1960, p. 12) divided the Craignish Formation into two members; an upper McLeod Member and a lower Skye River Member. The McLeod Member is characterized in the type section by red and alternating red and grey sandstone and siltstone and was assigned a thickness of 2,230 feet. The contact between the McLeod and Skye River Members was arbitrarily drawn. The Skye River Member consists mainly of coarse-grained, grey, feldspathic sandstone, arkose, arkosic grit, conglomerate, and red siltstone, sandstone, and conglomerate, and was assigned a thickness of 2,900 feet. The grey beds are most abundant in the middle part of this upper member whereas red and grey strata alternate in the lower and upper parts. The lowermost 450 feet of alternating red and grey beds are not included in the Skye River Member by the writer because they are similar to strata on Graham River that has been distinguished as a separate member of the Craignish Formation. In the Graham River section (Fig. 2), 8,025 feet of strata are tentatively assigned to the Craignish Formation. Although some strata may be repeated by faulting, the general sequence is considered normal because it is correlative with the Craignish Formation in the Southwest Mabou River section and, in part, with the Southeast Mabou River section of Lake Ainslie map-area (Norman, 1935).

The Craignish Formation on Graham River can be divided into three units. The uppermost unit consists of red sandstone and siltstone, conglomerate, and interbedded red and grey siltstone and sandstone. Although outcrops of the uppermost unit are few in the Graham River section, there is enough lithological similarity to correlate this uppermost unit with the McLeod Member. The only distinguishing features that separate the McLeod Member on Graham River from the underlying Skye River Member are its colour and the fact that there is less, thinly laminated, grey siltstone in the McLeod than in the Skye River.

Beneath the McLeod Member on Graham River is a thick section of grey strata which includes 120 feet of alternating grey and red strata. These rocks belong to the Skye River Member, and as shown on Figure 2 are 3,225 feet thick in this section. The true thickness is probably less than this, however, because of repetition of beds due to a probable fault (*see* Map 1212A, *in pocket*) suggested on airphotos by a pronounced lineament just southwest of Graham River. The Skye River Member, as exposed on Graham River, consists chiefly of thinly laminated grey siltstone, blocky siltstone, and sandstone, but also includes conglomerate, coarse-grained sandstone, arkosic sandstone, and quartzose sandstone. The grey beds contain abundant plant debris.

The Skye River Member on Graham River looks much like the Strathlorne Member of the Strathlorne–Ainslie Formation but differs by its content of conglomerate, coarse-grained sandstone, and arkosic and quartzitic sandstones.

The basal lithological unit of the Craignish Formation on Graham River is herein informally called the Graham River Member. It has an apparent thickness of 1,750 feet and is seemingly conformable with the overlying Skye River Member. It consists of grey conglomerate, grit, and greyish red to moderate reddish brown siltstone interbedded with red and grey sandstone. These sedimentary rocks are cut by five diorite dykes as much as 50 feet thick. The most distinguishing feature of the Graham River Member is the bright, moderate reddish brown siltstone. It is considered correlative with the lower 450 feet of Murray's Skye River Member on Southwest Mabou River because of similar lithology and stratigraphic position. The writer has shown these 450 feet as Graham River strata on Figure 2, column 2.

The Graham River Member is missing in the Southeast Mabou River section. The lowest strata on Southeast Mabou River suggest correlation with the Skye River Member. Strata that the writer correlates with the Skye River Member include 1,250 feet of grey arkosic sandstone and grit with thin interbeds of grey siltstone and a few thin seams of carbonaceous clay with abundant plant rootlets, and pebble-conglomerate. This sequence is overlain by 300 feet of red siltstone, which in turn is overlain by 850 feet of arkosic grit and pebble-conglomerate with some interbedded, grey, thinly laminated siltstone. This latter 1,150 feet (300+850) of strata contain beds typical of both the McLeod and Skye River Members. The uppermost part of the Craignish Formation consists of 540 feet of red siltstone and sandstone which, as stated by Murray (1960, p. 23) is typical of the McLeod Member.

In all sections examined east of the Southeast Mabou River section, the thick, massive, grey beds of the Craignish Formation are missing. The lowest Horton strata in Baddeck map-area contain beds typical of the McLeod Member but with varying amounts of conglomerate. The conglomerate is rather weakly consolidated so that pebbles are easily broken from their matrix. Also, the Craignish Formation in Baddeck map-area is commonly calcareous as is the McLeod Member of the Craignish Formation in Whycocomagh map-area, whereas the Skye River and Graham River Members are rarely calcareous.

Strathlorne–Ainslie Formation

In the type section, Murray (1960, pp. 15 and 16) assigned 1,050 feet of strata to the Strathlorne Formation and 1,820 feet to the Ainslie. These two formations, proposed by Murray, are mappable on the scale of 1 inch to 1 mile over a large part of Whycocomagh and Baddeck map-areas. There are, however, localities within these areas and in other map-areas, subsequently worked on by the writer, where the Strathlorne and Ainslie are not separate mappable units.

The writer generally had no difficulty in recognizing the Craignish–Strathlorne contact. There is commonly a significant lithological change (conglomerate to siltstone) as well as a colour change (red to grey) between the Craignish Formation and the Strathlorne Formation of Murray. In some sections, however, recognition of an upper contact of the Strathlorne was more difficult, for one or more of the following reasons: (1) scarcity of outcrops, (2) lack of any apparent lithogical change, and (3) no colour change. Also, there are some sections, such as east of the Creignish Hills, where the Strathlorne and Ainslie are too thin to show as separate units on a map to the scale of 1 inch to 1 mile. Because of these reasons, the writer has combined the Strathlorne and Ainslie Formations of Murray into a single map-unit, the Strathlorne–Ainslie Formation. This reduction of two formations into one is more realistic for regional usage on Cape Breton Island; where two subdivisions can be recognized they are called the Strathlorne Member and the Ainslie Member. The Strathlorne–Ainslie Formation is best exposed along Southwest Mabou River, where the two members can be mapped separately.

The lower Strathlorne Member in the type section is composed of fine, "non-red" clastic rocks (Murray, 1960, p. 15) that include thinly laminated grey siltstone, shale, medium-bedded sandstone, and thin impure limestones. Murray's "non-red" criterion is not practical for mapping purposes. Thin beds of red siltstone, sandstone, and, rarely, conglomerate occur in sections that are otherwise of typical Strathlorne lithology. These red beds are included in the Strathlorne by the present author.

In the type section, the Strathlorne Member is conformable with the underlying Craignish Formation and the overlying Ainslie Member. Murray (1960, Fig. 7) drew the lower contact of the Strathlorne Member at the top of the uppermost Craignish red bed. He fixed the upper contact of the Strathlorne at the base of the first Ainslie red bed or at the base of the first limestone intraformational conglomerate, whichever was lower in the section.

The Ainslie Member in the type section and surrounding areas west of the Creignish Hills, and in the western part of Baddeck map-area, consists mainly of red and grey sandstone and siltstone, whereas, east of the Creignish Hills and in most of Baddeck map-area, conglomerate is an important component of the uppermost Horton unit. Thin beds of intraformational limestone and conglomerate are also common in the Ainslie Member. The lower contact of the Ainslie Member was described previously. Its upper contact is at the base of a grey, laminated limestone that is the basal member of the Windsor Group. It conformably to disconformably overlies the Ainslie Member.

An angular unconformity between the Horton and Windsor Groups is present west of the Mabou Highlands on the northwest side of Lake Ainslie map-area (Norman, 1935, p. 34). Similar local unconformities occur along this contact at several other localities in Nova Scotia and are probably related to uplift of isolated positive areas along pre-existing faults. Norman (1935, p. 31) stated that, with the exception noted above, the Horton–Windsor contact is disconformable in Lake Ainslie map-area. The evidence for a disconformity is more suggestive than factual. Norman's main evidence (1935, p. 31) is that the basal member of the Windsor Group (A_1 limestone) was deposited on sediment of varied lithology. However, this relationship can be as easily ascribed to facies change in the uppermost Horton sediments. Bell (1927, p. 104C) noted that the A_1 Windsor limestone truncates plant rootlets in outcrops along the shores of Lake Ainslie. This does suggest non-deposition but not necessarily mechanical erosion; the non-deposition could be of short duration, more in the nature of a diastem. Other than the angular unconformity near the Mabou Highlands, there is no evidence to indicate a significant sedimentational break between the Ainslie Formation and Windsor strata in central Cape Breton Island. Horton and Windsor strata in Baddeck and Whycocomagh map-areas are essentially conformable (Kelley, 1957a, 1957b), and Weeks (1954, p. 71) stated that the contact is conformable in southeastern Cape Breton Island.

Murray (1960, p. 16) divided his Ainslie Formation into two members, the McIsaac Point below and the Glencoe above. As the writer found these units unmappable, owing to the subtleness of the lithological differences between the two and the scarcity of outcrop, they are retained in the following section only for the convenience of description. The Glencoe Member on Southwest Mabou River consists of thinly bedded fine sandstone interbedded with poorly bedded siltstone or shale. These Glencoe strata are commonly crossbedded and show graded sequences of fine sandstone to fine siltstone. The McIsaac Point Member on Southwest Mabou River is characterized by graded sequences of strata. Where fully developed, the sequence commences with intraformational conglomerate and progresses through sandstone to siltstone or shale (Murray, 1960, p. 17). There are only a few complete sequences, but the sandstone to siltstone or shale graded-bed sequences are characteristic cycles, as was first pointed out by Shrock (1948, pp. 31–33).

Although the Glencoe Member is a rather striking assemblage of homogeneous strata on Southwest Mabou River and in other parts of western Cape Breton Island (Murray, 1960, p. 49), it is not recognizable as a distinct lithological unit in northern Cape Breton Island, in Baddeck map-area, or east of the Creignish Hills in Whycocomagh map-area. On Southwest Mabou River, the Glencoe Member differs from the underlying McIsaac Point Member in that it is finer grained and lacks intraformational conglomerate, fossils, ripple-marks, and massive sandstone beds. Five miles to the northeast, on Southeast Mabou River, Murray (1960, p. 44) assigned 700 feet of strata to the Glencoe Member. Eight miles to the northeast of Southeast Mabou River at McIsaac Point, the Glencoe Member seems to be missing. Murray, however, following Bell (1927) and Norman (1935), interpreted the Horton–Windsor contact as representing an erosional interval, which would explain the missing Glencoe Member at McIsaac Point.

In the Baddeck area, Murray agreed that the Horton–Windsor contact is conformable (Murray, 1960, p. 92). There, the Ainslie Formation (sic) consists of strata Murray correlated with the McIsaac Point Member plus a coarser facies of grit and conglomerate. Therefore, if Murray's (1960, p. 96) postulation that the Ainslie Formation (sic) is a time-stratigraphic unit is correct, he should have concluded that the Glencoe Member is a facies of his Ainslie Formation, and hence that its absence is not evidence of erosion.

The Ainslie and Strathlorne Members on Morgan Brook (Fig. 2) in the Baddeck River valley are together 2,800 feet thick. This thickness is about the same as those in the three Ainslie and Strathlorne sections mentioned above. Strathlorne lithology resembles that of the type area but there is a greater amount of silty limestone. The Ainslie lithology is a mixture of blocky red siltstone and graded sequences of red conglomerate to siltstone. Grey beds, identical to Strathlorne grey beds, are present and, also, the characteristic intraformational conglomerate. Lenses and beds (which are probably lensoid) of red conglomerate and grit are present and these are typical of the Horton section at Grand Narrows and of the Ainslie Member on the peninsula north of Iona. The apparent interfingering of Strathlorne and Ainslie lithologies is shown in the Mount Young area of Lake Ainslie map-area.

In the succession of strata exposed in a small stream flowing south from Mount Young, the upper part of the Craignish Formation is exposed. Overlying the Craignish are about 1,800 feet of grey beds similar to Strathlorne lithology. They are succeeded by a few red beds and the A_1 Windsor limestone. Southwest of this stream, many of the strata between the Craignish Formation and the basal Windsor limestone are typical of the Ainslie Member and their thickness is within the limits expected of that member. Therefore, the uppermost Horton rocks in the general area of Mount Young do not appear to be divisible into the Strathlorne and Ainslie Members and are best referred to as the Strathlorne–Ainslie Formation because of the interfingering of the two lithologies.

Some Problems of Stratigraphy

Horton stratigraphy is most easily deciphered through the presence and recognition of the Strathlorne Member. The location of the contact between the Strathlorne Member and the overlying Ainslie Member is difficult to determine in some exposed sections, and latitude of Murray's criteria (1960, p. 47) is necessary to establish a useful contact.

Anomalous sections of the Horton Group are present at Grand Narrows and near Baddeck. The more than 4,300 feet of section at Grand Narrows are mainly conglomerate and conglomeratic sandstone whereas, near Baddeck, the 480 feet of Horton Group can be lithologically subdivided into the constituent formations of the group.

Strathlorne Member

The Strathlorne Member is the only rock unit in the Horton Group on Cape Breton Island with lithological features that easily distinguish it from other Horton units. These features are most apparent in the lower part of this member. The upper part of the Strathlorne, as mentioned previously and in the section to follow, is difficult to distinguish from the overlying Ainslie Member in areas of few outcrops. Also, in areas of complex structure it is difficult to determine the stratigraphy of the Horton Group, owing to the similar lithology in parts of the upper and lower units. The key to deciphering the Horton stratigraphy is recognition of the Strathlorne Member and the A_1 Windsor limestone.

Murray (1960, p. 41) interpreted the Strathlorne Formation as a time-stratigraphic unit and considered all Strathlorne-type Horton strata that occur in comparable parts of the section in the Maritimes to be correlative in time. This type of correlation is often unreliable, however, as has been found for the continental strata of the Pennsylvanian system in Nova Scotia (Bell, 1944, p. 3).

The Horton Group contains few fossils and cannot be palaeontologically subdivided. It may be possible, however, by palynology, to demonstrate whether or not the Strathlorne is a time-stratigraphic unit. In this regard, it is interesting to note that D. C. McGregor (GSC unpublished Report F1-13-1962-DCM) found spores from the lowest formation of the Horton Group in New Brunswick (the Memramcook Formation) that he tentatively concluded were uppermost Devonian.

Strathlorne–Ainslie Contact

Comparison of the Southwest Mabou River section (Fig. 2) with the Graham and Southeast Mabou Rivers sections demonstrates some of the problems involved in drawing the Strathlorne–Ainslie contact. The Graham River section is 7½ miles southwest and the Southeast Mabou River section 6 miles northeast of the Southwest Mabou River section. The Strathlorne and Ainslie Members in the three sections are assumed to have been deposited simultaneously because each formation has a similar, fine-grained lithology and the total stratigraphic interval occupied by the two is approximately the same. Also, the uppermost part of the Craignish Formation, which in each of the three sections is overlain by the Strathlorne, has the same fine-grained lithology. This fact strengthens the probability that the Strathlorne is not time transgressive in this small area.

It is obvious from examination of these three sections (Fig. 2) that the Ainslie Member consists of laterally changing facies. Some grey beds of the Ainslie Member are indistinguishable from Strathlorne grey beds so that in parts of the basin during Ainslie deposition, tectonic, climatic, and environmental conditions were, at times, probably similar to those present during deposition of the Strathlorne. These grey beds in the Ainslie Member are commonly interbedded with red beds, into which they probably grade laterally, as suggested by a comparison of the several Horton sections.

The base of the Ainslie Member, according to Murray (1960, p. 47) "... is defined as the lowest stratum of limestone intraformational conglomerate, red coloured sedimentary rocks, or massive cross-lamination. Secondary criteria are: small-scale choppy cross-lamination, graded sequences of any kind, general coarsening of grade with respect to the underlying Strathlorne, massive sandstone, profuse ripple-marking, and evidence of rapidly varying depositional conditions". The only criticism of Murray's criteria is that the presence of red beds was used as a diagnostic criterion for the Ainslie Member. Thus, a thin sequence of red strata in an otherwise normal Strathlorne lithology compels Murray, by definition, to assign this sequence to the Ainslie. In the Graham River section (Fig. 2), for example, 60 feet of well-laminated, brownish red siltstone occur in an exposed section of 360 feet. The 240 feet of well-laminated, greenish grey siltstone above the red beds have typical Strathlorne lithology and were assigned to the Strathlorne by the author. Higher strata in the section are mainly massive, red sandstones, typical of the Ainslie Member in this general locality. However, Murray would have had to assign the red beds and the 240 feet of grey strata above them to the Ainslie Member.

Grand Narrows Section

The Horton section at Grand Narrows, which is 3 miles south of Baddeck map-area (Fig. 2, col. 7) includes more than 4,300 feet of red sandstone and conglomerate and was mapped by Weeks (1954, p. 73) as part of the Windsor Group. The author interprets this succession of strata as part of the Horton Group because it is conformably overlain by the A_1 Windsor limestone. This conformable contact was seen near Grand Narrows and on the peninsula north of Iona, about $2\frac{1}{2}$ miles west-southwest of Grand Narrows. Weeks (personal communication) noted the limestone near Grand Narrows, but did not interpret it as A_1 Windsor limestone because it is underlain by conglomerate similar in lithology to Windsor conglomerate that outcrops to the east.

The limestone at Grand Narrows is identical in lithology to other outcrops of A_1 Windsor limestone observed in Baddeck and Whycocomagh map-areas. Throughout the eastern parts of Baddeck and Whycocomagh map-areas, the A_1 Windsor limestone is underlain by conglomerate similar in lithology to the conglomerate at Grand Narrows. The limestone at Grand Narrows is cut by carbonate veins, a common feature of the A_1 Windsor limestone. The conglomerate underlying the limestone at Grand Narrows displays malachite stains on some of the pebbles, a feature common to several outcrops of conglomerate underlying the A_1 Windsor limestone. These facts are the basis for the writer's interpretation of the Grand Narrows section.

Additional support for considering the clastic rocks in the vicinity of Grand Narrows as part of the Horton Group is gained from a study of the geology of the peninsula north of Iona. Rocks of the peninsula north of Iona occupy an anticlinal structure. On the northwest flank of the anticline, intermittent outcrops of A_1 Windsor limestone can be traced for 6 miles. Strata above the limestone are chiefly overlain by drift or covered by water. Fossiliferous B limestone, in its normal stratigraphic position above the basal Windsor limestone, outcrops on the lakeshore at one locality. The 2,900 feet of Horton strata below the basal Windsor limestone on the northwest side of the peninsula include: 1,000 feet of Ainslie Member, 900 feet of Strathlorne Member, and 1,000 feet of Craignish Formation (Fig. 2, col. 6). The Craignish Formation is faulted against the pre-Carboniferous, so that the base of the Horton Group in this section is missing. However, Horton strata on the northwest side of the peninsula are, in general, structurally conformable with strata on the southeast side. These strata on the southeast side of the peninsula were mapped as Windsor by Weeks (1954) and are conformably underlain by limestone. The limestone has the same diagnostic lithological features as the A_1 Windsor limestone on the northwest flank of the anticline, 4 miles distant. It is therefore concluded that the laminated limestone at Grand Narrows and on the eastern side of the peninsula north of Iona is the A_1 Windsor limestone. Consequently, by definition, the Mississippian sandstone and conglomerate stratigraphically below this limestone are part of the Horton Group.

The coarseness of Horton clastic rocks in the Grand Narrows area suggests that they are a marginal phase of the Horton Group. It is questionable, however, which formations of the group are represented by this marginal phase, because the rocks are chiefly of one general lithology.

It is possible that the lower part of the conglomerate and sandstone around Grand Narrows is equivalent to at least part of the Craignish Formation; the lithology of the conglomerate in the Ainslie Member and Craignish Formation on the peninsula north of Iona is identical to the conglomerate in the Grand Narrows area. This possibility is strengthened by the loss of identity of the Strathlorne Member in the southern part of the peninsula north of Iona. This facies change is from a typical grey Strathlorne lithology in the northern part of the peninsula to mainly red sandstone and conglomerate in the southern part. The first evidence of change in Strathlorne lithology was noted immediately south of the boundary of Baddeck map-area. There, the grey beds are intercalated with red beds. Further change of the Strathlorne in a southerly direction can be inferred from examination of two drill-hole logs[1]. These holes (1,614 and 2,005 feet deep) are located about $3\frac{1}{2}$ miles N80°W of Grand Narrows. A few thin beds of grey to black limestone and shale were cored at the expected position of the Strathlorne Member, although the holes were drilled mainly through conglomerate and sandstone. This apparent facies change of the Strathlorne Member in the southern part of the peninsula would have the result that equivalent strata, if present, would be unrecognizable in the Grand Narrows area.

[1]Generalized drill-hole logs furnished by D. J. MacNeil.

Section Near Baddeck

The thinnest known section of the Horton Group is located a mile east of Baddeck (Fig. 2, col. 5). The section totals 480 feet and consists of 65 feet of Craignish Formation, 75 feet of Strathlorne Member, and 340 feet of Ainslie Member. The basal few feet of the Craignish Formation are composed of weathered detritus of the underlying igneous rocks plus a few foreign pebbles. The upper part of the formation is typical of other coarse-grained Craignish rocks, the pebbles having been transported from a more distant source. Fish scales, fragments of decorticated plant stems, and plant debris were found in the Strathlorne Member, but all were unidentifiable with the exception of one pelidendriod stem, which according to W. A. Bell, is probably *Lepidodendropsis corrugata* (Dawson).

Chapter IV

UPPER MISSISSIPPIAN STRATIGRAPHY

Upper Mississippian rocks of Baddeck and Whycocomagh map-areas include the chiefly marine sedimentary rocks of the Windsor Group and the younger, fresh-to-brackish-water sedimentary rocks of the Mabou Formation. The Windsor Group and Mabou Formation are each a conformable sequence of strata, but their contacts with older and younger strata are both conformable and unconformable.

An angular unconformity between the Horton and Windsor Groups is located west of the Mabou Highlands on the northwest side of Lake Ainslie map-area (Norman, 1935, p. 34). Similar local unconformities occur along this contact at several other localities in Nova Scotia and are probably related to uplift of isolated positive areas along pre-existing faults. In Baddeck and Whycocomagh map-areas this contact is conformable. The Windsor–Mabou contact is conformable to disconformable in central Cape Breton Island. The significance of this relationship is discussed in Chapter V.

The contact of the Mabou Formation with the Pennsylvanian Port Hood Formation is not present in Baddeck or Whycocomagh map-areas, but in other parts of Cape Breton Island the contact is placed "... where the interbedded shales and fine to medium-grained sandstones, with occasional interbeds of massive, grey sandstone carrying drift plant fragments, typical of the Mabou formation, give place to massive, arkosic sandstone and interbedded red and grey shale typical of the Port Hood formation" (Norman, 1935, p. 45). This contact is excellently exposed at Broad Cove in Margaree map-area.

Windsor Group

The name Windsor Group was derived from the type locality near Windsor, Nova Scotia. Bell (1929, p. 46) divided the Windsor Series[1] at the type area into five subzones on the basis of fossil evidence.

Upper Windsor Zone of *Martinia galataea*:

- subzone E, characterized by *Caninia dawsoni* and *Chonetes politus*
- subzone D, characterized by *Productus semicubiculus*
- subzone C, characterized by *Dibunophyllum lambii* and *Nodosinella priscilla*

[1]The word 'series' was used to designate the six Carboniferous subdivisions in Nova Scotia until 1944, when all 'series' were changed to 'groups' (*see* Bell, 1944, p. 5). This change from 'series' to 'groups' causes confusion today because all Carboniferous 'groups' are not rock-stratigraphic units; some are recognized on the basis of their contained fossils and hence tend towards time-stratigraphic or biostratigraphic units.

Lower Windsor Zone of *Composita dawsoni*:
subzone B, characterized by *Diodoceras avonensis*
subzone A, basal "limestone".

The applicability of these subzones over all of Nova Scotia has been substantiated by Stacy (1953) and Sage (1954). Stacy, working on the Windsor Group of Cape Breton Island, found enough specimens ". . . to suggest that the five faunal zones of the type section, and of the Cape Breton area (1) occupy the same stratigraphic positions, (2) have similar facies relationships, and (3) contain generically and specifically comparable suites of fossils. Therefore, they are considered essentially contemporaneous" (1953, p. 49).

Distribution and Thickness

The distribution of the Windsor Group in the map-area is shown on the geological maps (*in pocket*). Windsor strata occur in the lowlands but, because of their susceptibility to erosion, rarely outcrop. Only one fairly complete section of Windsor strata is known to outcrop in the central part of Cape Breton Island. This section is on Port Hood Island, about a mile off the west coast, latitude 46°. The basal Windsor limestone is missing there, but Norman (1935, pp. 34 and 40) measured 1,739 feet of Windsor strata and Stacy (1953, pp. 31–36) 1,780 feet. Stacy (1953, p. 29) estimated the total thickness of the Windsor Group in western Cape Breton Island to be between 2,200 and 2,700 feet. Bell (1929, p. 45) estimated the thickness of the Windsor Series in the type area to be not less than 1,550 feet. In a relatively undisturbed section, 2,200–2,700 feet of Windsor strata is probably a reasonable estimate of thickness. However, this thickness may be much greater than normal because the more plastic salt and gypsum members of the group were concentrated by flowage during folding and faulting. Evidence for such flowage is established by the abnormal thicknesses of gypsum and salt encountered during drilling of anticlinal structures (N.S. Annual Report on Mines, 1956, 1957, pp. 129–141).

Stacy (1953, pp. 37 and 38) measured 1,005 feet of Windsor strata on the northeastern tip of Kelly Mountain, at Cape Dauphin. He interpreted the lowest limestone in the section as the middle of the B subzone and concluded that the lower part of the Windsor section was faulted out. However, Sage (1954, p. 58) considered the base of the Cape Dauphin section to be unbroken B subzone. He further reported (personal communication) that by digging through the drift he uncovered A_1 Windsor limestone. It therefore appears possible that the total Windsor section is present at Cape Dauphin and is not more than 1,100 feet thick.

About 1,300 feet of Windsor strata in western Cape Breton Island were considered to be Lower Windsor by Norman (1935, p. 34). In the same area, Stacy (1953, p. 13) estimated 1,200 feet of strata as Lower Windsor. Lower Windsor strata at Cape Dauphin total about 300 feet (Stacy, 1953, pp. 37 and 38). In Sydney map-area, Bell and Goranson (1938a) assigned 3,500 feet of red conglomerate and interbedded red sandstone and shale to the Lower Windsor. Upper Windsor strata in Sydney map-area total 790 feet (Bell and Goranson, 1938a), at Cape Dauphin 685 feet, and on Port Hood Island 884 feet to the top of E_1 limestone (Stacy, 1953, pp. 31–34, 37 and 38).

Age

Fossils are common in limestone members of the Windsor Group and have been extensively studied in Nova Scotia by Bell (1929), Stacy (1953), and Sage (1954). These investigators identified a combined total of 154 species belonging to 106 genera.

Correlations of the Windsor Group with strata outside the Atlantic provinces were worked out by Bell (1929). He (pp. 71–74) concluded that the Windsor Series correlated with the Visean of western Europe and showed close affinities with the Meramecian and Chesterian of Mississippian sections in the United States. Sage's work, and to a lesser extent Stacy's, supports Bell's correlation. A list of the fossils collected by the writer from Windsor strata in Whycocomagh and Baddeck map-areas is given in Table II.

Lithological Subdivisions

Lithologically, the Windsor Group in the two map-areas consists of thick members of massive red siltstone and shale, some red sandstone, thin beds of limestone and dolomite, and, locally, thick deposits of gypsum, anhydrite, and salt. As in the Ainslie Member of the Horton Group, conglomerate is an important rock type of the Windsor Group along the eastern part of the basin. This conglomerate is a marginal facies and represents a continuation of Horton Group sedimentation.

The shale, siltstone, and minor sandstone are mainly red, even-grained, soft, calcareous rocks that are massive to poorly bedded. They commonly do not display any bedding features in 15 to 20 feet of section. Thin beds of flaggy, fine-grained, red to greenish sandstone are intercalated with the massive siltstones, and commonly show the only indication of bedding in these rocks. A greenish grey mottling effect and thin gypsum veins are locally common in the siltstone.

Intercalated with the red siltstones are thin tabular beds of limestone. These limestones are most commonly less than 50 feet thick and are chiefly massive, grey limestones except for the ones of subzone A. However, massive, oolitic and algal limestones are fairly common, the algal structures being most commonly observed in subzone C limestones. The matrix of the oolitic and fossiliferous limestones contains abundant shell fragments and many of the fossils are replaced with calcite. Other phases have a vuggy appearance because the fossils are partly or wholly dissolved. Porosity is also due to the voids in many shell interiors; this is especially true in the highly fossiliferous B subzone, which in some localities is practically a coquinoid. The fossils are well preserved and easily removed from the limestone. Bituminous staining in Lower Windsor limestones has been noted at several localities.

Gypsum deposits in Windsor strata of Cape Breton Island are well known (Goodman, 1952). The thickest deposits are in the Lower Windsor. Salt is not known to outcrop but it has been encountered in drill-holes in Lake Ainslie map-area (N.S. Report on Mines, 1956; 1957, pp. 129–141). Salt springs have been found in Baddeck and Whycocomagh map-areas (*see* maps). In the type area, Bell (1929, p. 45) estimated that "... gypsum may make up almost 20 per cent of the total volume [of the Windsor Group], with red shale 55 per cent and calcareous beds 25 per cent". Stacy (1953, p. 29) estimated that the Windsor Group in Cape Breton Island contains about 70 per cent

TABLE II

Fauna collected from the Windsor Group

LOCALITY*	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
INFERRED SUBZONE	B	B	B	LW?	C	?	D	B	LW	?	E	B	B	B	C?	B	B	UW	B	B	UW	C?	B	C	D
FORAMINIFERA																									
Nodosinella priscilla (Dawson)																						×			
COELENTERATA																									
Zaphrentis minas Dawson											×														
Lophophyllum						?									×										
Dibunophyllum sp.																									×
Dibunophyllum lambii Bell					×																				
Conularia sp.																	×		×						
Conularia planicostata Dawson								×					×												
Conularia sorrocula Beede	×													×											
BRYOZOA																									
Batostomella sp.		×						×																	
Batostomella exilis (Dawson)	×												×	×											
BRACHIOPODA																									
Protoniella baddeckensis (Bell)	×	×						×				×													
Productus																		×							
Productus avonensis Bell											×										×				
Linoproductus semicubiculus (Bell)															×										
Linoproductus lyelli (Verneuil)	×	×	×			×		×			×	×	×	×		×	×		×		×		×	×	
Linoproductus dawsoni (Beede)				×																					
Pustula exigua Bell											×														
Diaphragmus tenuicostiformis (Beede)			×					×								?	×		?				×		
Camarotoechia atlantica Bell											×														
Pugnoides sp.											?														
Pugnax dawsonianus (Davidson)	×							×	×				×	×			×						×	?	
Pugnax magdalena Beede		×										×													
Composita sp.																×	×		×						
Composita dawsoni (Hall and Clarke)												×	×							×					
Composita windsorensis Bell	×	×	×					×						×							?				?
Composita obligata Bell											×														
Composita offirmata Bell											×														
Ambocoelia acadica Bell																		?							
Martinia galataea Bell							×				×										×				
Martinia sp.																								?	
Beecheria davidsoni (Hall and Clarke)										×						×	×			×			×		×
Beecheria latum (Bell)										×	×								×						
Beecheria milviformis (Bell)																			×						
Beecheria mesaplanum (Bell)																×									
Cranaena sp.									×								×								
Cranaena tumida Bell	×	×	×									×	×	×		×			×				×		
Hartella dielasmoidea Bell																				×					
Orthotetes											?														
PELECYPODA																									
Sanguinolites sp.																								?	
Leptodesma dawsoni (Beede)	×																								
Leptodesma acadia (Beede)	×																								
Leptodesma shubenacadiensis (Dawson)																							×		
Schizodus sp.																								?	
Aviculopecten lyelli Dawson	×	×						×	×				×	×			×		×				×		
Aviculopecten subquadratus Bell																×									
Modiola dawsoni Bell									×																
Lithophagus poolii (Dawson)	×	×						×				×		×			×						×		
GASTROPODA																									
Bellerophon sp.																									×
Euphemus urei Fleming											×														
Straparollus minutus de Koninck																									×
Naticopsis howi Dawson														×											

*Localities are denoted on following page

UW . . . . Upper Windsor Group LW . . . . Lower Windsor Group

GSC

red beds with no trace of organic life, 17 per cent gypsum and anhydrite, 6 per cent salt, and about 7 per cent limestone and dolomite.

In Eastern Cape Breton Island, coarse clastic sediments are intercalated with and underlie Windsor limestone and gypsum. These sediments consist of red, calcareous conglomerate, conglomeratic sandstone, and sandstone. Pebbles in the conglomerate less than half an inch in maximum dimension are subangular to subrounded, whereas the larger pebbles are subrounded to rounded. The pebbles are composed of rhyolite, granite, diorite, and metamorphosed sedimentary and volcanic rocks. These strata have well-demarcated bedding planes and are several inches to several feet thick. Where these strata "... lie below marine limestone or sandstone of Lower Windsor age and form the base of the series they are mapped as the Grantmire member" (Bell and Goranson, 1938a). Weeks (1954, p. 73) found this definition too restrictive and redefined the Grantmire as "... a formation comprising all Windsor conglomerate members that form the base of the group, regardless of whether they are Lower or Upper Windsor in age." The Grantmire Formation, as designated by Weeks, is apparently a useful time-stratigraphic unit for mapping in eastern Cape Breton Island. However, to be of formational status it should not have time designation and that is where drawbacks to its general usefulness are encountered.

In the western part of Sydney map-area, the upper part of the Grantmire is *dated* as Lower Windsor (Bell and Goranson, 1938a). Along part of the western boundary of the map-area, strata mapped as Grantmire by Bell can be traced along strike to the southwest where they are overlain by A_1 Windsor limestone and are, therefore, part of

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Windsor Group Fossil Localities

1. East shore of North Gut, St. Anns Harbour.
2. McLeod Pt., between North and South Gut, St. Anns Harbour.
3. Head of North Gut, St. Anns Harbour.
4. Leonard McLeod Brook at Route 19 highway bridge.
5. Middle River, at foot bridge near west side Middle River settlement.
6. Indian Brook.
7. Seventy-five feet north of bridge over Middle River at Middle River settlement.
8. North of bridge over Foyle Brook on road to South Side of Baddeck River settlement.
9. Peters Brook, a few feet north of junction with Foyle Brook.
10. Peters Brook, about 100 feet north of locality 9.
11. Man of War Pt., Boularderie Island.
12. Downstream on small brook from New Glen road, 1,500 feet north of McRae Brook.
13. Two hundred feet downstream from locality 12.
14. In Baddeck River, about 300 feet below bridge at Forks Baddeck.
15. North Baddeck River, near United Church Manse at Forks Baddeck.
16. East side of Route 19, about 1,700 feet north of 'Yankee Line' at Lower Middle River settlement.
17. Three hundred feet east and 100 feet north of Route 5 and Route 19 intersection.
18. Cow Point, Indian Bay.
19. Half a mile east of Cabot Trail on Mill Creek that flows into St. Anns Harbour.
20. East side of Washabuck River, 8,500 feet northeast of Washabuck Bridge.
21. Five hundred feet below bridge over Southwest Mabou River at River Centre settlement.
22. Upper Diogenes Brook, about 1,300 feet downstream from old silica sand quarry.
23. Two thousand four hundred feet southwest of West Alba Post Office, on a point of land where road is closest to the water.
24. Two thousand seven hundred feet north of first bridge over River Denys south of Blue Mills.
25. One thousand three hundred to 1,400 feet south of locality 24.

the Horton Group (*in sensu stricto*). The Grand Narrows section (Fig. 2, column 7) is probably equivalent, in part, to at least the Strathlorne Member and could be equivalent to at least part of the Craignish Formation. Strata of Grantmire-type lithology are therefore time-transgressive from some unknown time during deposition of the Horton Group upwards into the time of deposition of the Windsor Group. The Grantmire conglomerate is overlain by either Lower or Upper Windsor limestones at a number of localities in eastern Cape Breton Island. The conglomerate underlies and overlies fossiliferous Windsor limestone and in several outcrops the limestone can be seen to grade laterally into conglomerate (Weeks, 1954, p. 75). The Grantmire Formation was therefore time-transgressive during Lower and Upper Windsor deposition.

Stacy (1953) recognized twelve limestone units associated with the five Windsor subzones of Cape Breton Island. Each limestone was identified by the letter of the subzone to which it belonged and these were given numbers in ascending order. A_1 limestone is the basal member of the Windsor Group; the other units are A_2; B_1, B_2, B_3; C_1, C_2, C_3; D_1, D_2, D_3; E_1. Two limestone beds were recognized above the E_1 limestone at Cape Dauphin (Stacy, 1953, p. 37), but these were not numbered. Stacy's subdivisions of Windsor limestones were useful for detailed descriptions of sections but could not be applied on a regional basis (Stacy, 1953, Abstract).

The basal member of the Windsor Group in Baddeck and Whycocomagh map-areas (A_1 limestone) is 30–60 feet thick. It is a thinly laminated, fine-grained limestone, medium to dark grey. The closely spaced laminae may be apparent only on weathered surfaces; the laminae in the upper part are commonly less than 0.5 mm apart. The basal part is commonly more massive than the upper. Quartz and/or gypsum and anhydrite grains, less than 0.05 mm in size, are scattered along the bedding planes. These give the rock a laminated appearance with alternating light and dark grey layers.

Several fossils were found in the A_1 limestone in Baddeck map-area on St. Anns Bay, Forks Baddeck, and Upper Middle River. They include Ostracoda and *Spirorbis*. Overlap by A_1 Windsor limestone of pre-Carboniferous rocks occurs at the southern boundary of Whycocomagh map-area. The limestone is underlain by 8 feet of Horton conglomerate. The lower contact of the conglomerate is gradational with weathered granitic rocks. The conglomerate was probably deposited on a weathered surface of granite, as indicated by the presence in the conglomerate of both highly weathered and relatively fresh granitic rocks. The lower few feet of conglomerate contain pebbles that are mainly of local derivation, whereas the upper part contains numerous foreign pebbles. The A_1 limestone outcrops on a small point in Ross Pond near West Bay Marshes and is probably overlain by gypsum because the water deepens abruptly into a large sink-hole 10–15 feet from shore.

Sage (1954, p. 76) considered A_2 limestone an anomaly in the sequence of beds when correlating Windsor subzones of Antigonish and Cape Breton Island with the type section near Windsor. He stated that the sequence of beds would be more comparable if the A_2 limestone were correlative with the lowermost fossiliferous bed in the type section, which belongs to subzone B. Sage's suggested correlation is correct because the writer found fossiliferous A_2 limestone with a subzone B faunal assemblage in the river at Forks Baddeck. This limestone is yellow, brecciated, and silty and is identical to the "Canary" limestone described by Mather and Trask (1928, p. 281), which was designated A_2 limestone by Stacy (1953, p. 41). This fossiliferous A_2 limestone outcrops about 20 feet stratigraphically above A_1 limestone; the strata between are covered.

The faunal assemblage of A_2 limestone is shown in column 14 of Table II. In an unpublished report the writer received from W. A. Bell concerning this assemblage, it is stated: "*Cranaena tumida* is by far the most abundant species. *Composita windsorensis* is rare. Beds are inferred to belong to Subzone B of Lower Windsor, although they may not necessarily belong to the same stage in this Subzone as beds of lot K53-1". The fossils from collection K53-1 are listed in column 1 of Table II.

Three miles northeast of Baddeck map-area, along St. Anns Bay, subzone B limestone overlapped earlier Windsor strata and was deposited on granite. Also, on the north and east sides of North Mountain in Whycocomagh map-area, fossiliferous B limestone is resting almost directly on granite, and 10 miles northeast of Boisdale, along St. Andrews Channel, subzone B limestone is resting directly on pre-Carboniferous rocks (Bell and Goranson, 1938a).

Outcrops of Upper Windsor strata are scarce in Baddeck and Whycocomagh map-areas and Upper Windsor limestones are not as fossiliferous as those of the Lower Windsor. However, fossils from Upper Windsor strata were obtained in the western part of Whycocomagh map-area, the Denys Basin between North Mountain and Creignish Hills, Middle River and Baddeck River valleys, and along the shore zone of Boularderie Island. Upper Windsor strata are located at the boundary of Glace Bay and Louisburg map-areas (Bell and Goranson, 1938c), where they were deposited on pre-Carboniferous rocks. This is the only known locality where the Late Windsor sea transgressed the border of the Early Windsor seas in the central part of Cape Breton Island.

Windsor seas did not have as pronounced an effect on the gross lithology in eastern Cape Breton Island as in the central and western parts of the Island. In eastern Cape Breton Island coarse clastic sediments were major contributors to the Windsor succession. With one exception, all marine Windsor strata are underlain by red sandstone and conglomerate (Grantmire Formation) in eastern Cape Breton Island. The most easterly exposures of Windsor strata on the Island are those mentioned above, at the boundary of Glace Bay and Louisburg map-areas. There limestone, together with dolomite and sandstone, was deposited above several feet of conglomerate.

Mabou Formation (includes Canso Group)

The Canso Group was defined by Bell (1943, p. 5), who stated that it ". . . comprises non-marine red and grey shales and sandstones that overlie the marine Windsor group or non-marine rocks of equivalent age". The name was derived from a type locality along the eastern shore of the Strait of Canso, on Cape Breton Island.

Recent work has been done on the 'Canso Group' of Nova Scotia by Belt (unpublished Ph.D. thesis, 1962), who elevated the Mabou Formation of Norman (1935) in western Cape Breton Island to the Mabou Group. In Cape Breton Island, he included in the Mabou Group all strata previously considered to belong to the Canso Group and also some strata previously considered to belong to the Riversdale Group. He recommended dropping the two terms 'Canso Group' and 'Riversdale Group' because they have been used as time-stratigraphic units. When Belt's work is published, it should demonstrate that the Mabou can be divided into several rock-stratigraphic units and be called Mabou Group. Until it is shown that the Mabou does contain mappable units it is better to use Norman's terminology—'Mabou Formation' (1935, p. 43).

The author could probably have used the term 'Canso Group' in this description except for strata in the central part of the syncline at Maple Brook in Whycocomagh map-area. Strata in the axial part of the syncline are probably of Westphalian A age. Consequently, these strata would have to be called 'Riversdale Group'. The writer considers these strata to be part of one major unit that should not be divided into two groups because part is of Namurian age and part Westphalian A age.

Distribution and Thickness

The distribution of the Mabou Formation in Baddeck and Whycocomagh map-areas is shown on the geological maps (*in pocket*).

Bell (1943, p. 6) assigned about 2,000 feet of strata to the Canso Group in the type section along the Strait of Canso whereas, in the same section, Ferguson (1946, p. 3) assigned about 3,000 feet to the Canso. The difference in thickness resulted from the selection of different beds as the stratigraphic top of the Canso Group. In the same section Belt (1962, p. 31) assigned 9,660 feet of strata to the Mabou Group; this includes more than 6,000 feet of strata Ferguson considered as Riversdale Group.

Norman (1935, pp. 43 and 44) measured 2,900 feet of Mabou Formation in Lake Ainslie map-area. Cameron (1948, p. 6) calculated the Mabou Formation to be 2,700 feet thick in Margaree map-area, although he suspected there was some repetition of beds due to faulting. Bell and Goranson (1938a) measured 750 feet of Canso strata (Point Edward Formation) in Sydney map-area and calculated that an additional 500 feet were covered by the water of Sydney Harbour. However, some of the section is missing as the top of the Canso section was a surface of erosion. The top segment of the 275 feet of Canso Group at Cape Dauphin was also an erosion surface (Bell and Goranson, 1938b). The thickest measured Canso section in Nova Scotia is in the Antigonish area, which is about 20 miles southwest of Cape Breton Island. There, Sage (1954, p. 60) assigned 5,949 feet of strata to the Canso Group.

The writer calculated a minimum thickness of 7,000 feet for strata that he mapped as Canso Group, in the Maple Brook area in the south-central part of Whycocomagh map-area (1957b). It is these strata that are here being assigned to the Mabou Formation because of the age connotation in the use of the term 'Canso Group'. The strata of this area were previously considered by Bell (written communication, 1958) to belong to the Riversdale Group. Bell later agreed with the author (written communication, 1958) that these strata included Horton Group, Windsor Group, and Canso Group strata. He maintained, however, that the upper part of the section was probably

Riversdale (Bell, 1958, p. 129). The basis for Bell's disagreement was the probable age of the contained fossils.

The parts of the section in the Maple Brook syncline, assigned by the author to the Canso Group (Kelley, 1957b), are lithologically similar to Belt's type section of the Mabou Group in the southwest Mabou basin (Belt, 1962, chart 1b). Both areas include the three formations Belt assigned to the Mabou Group in Cape Breton Island. The status of the formations in the Mabou Group has not been demonstrated, but various facies can be recognized in sections and they may be mappable. There can be little doubt that the Mabou Formation in many areas reflects continuous sedimentation. It only complicates the problem, and does not follow accepted stratigraphic procedure, to divide the Maple Brook rocks into two rock-stratigraphic units solely on the basis of contained fossils. In the past, this has been the accepted procedure by the Geological Survey in the Strait of Canso section, a few miles to the south, and in other parts of Nova Scotia.

Age

The Canso Group does not contain a large assemblage of fossils, but the few fossil flora present correlate with the Namurian A zone of the Upper Carboniferous of Europe (Bell, 1943, Fig. 11). Copeland (1957, p. 8) placed the Canso Group in the basal part of the Upper Carboniferous without suggesting what part of the Namurian the Canso is correlative with.

The Mississippian Subcommittee of the Committee on Stratigraphy of the National Research Council (Weller, *et al.*, 1948) has tentatively accepted Moore's (1937) correlations, which conclude that the Mississippian–Pennsylvanian contact corresponds to the Lower and Upper Namurian contact of Europe.

No fossils useful for dating have been found in the upper part of the Canso Group. Copeland (1957, p. 8) concluded from his study of the Arthropods that "A gradation from strata of Namurian to possible Lower Westphalian A age appears to be indicated with only a slight faunal variation and no apparent lithologic break". It is therefore possible that the actual contact between the Mississippian and Pennsylvanian is within the Canso Group. The contact would also have to be within the Mabou Formation because it spans the time interval in question.

All fossils found in the three areas mapped as Mabou Formation are apparently consistent with a Namurian age, except for spores from the thin coal seam in the axial part of the Maple Brook syncline, near Glendale. There, the spores suggest a Westphalian A age (Barss, personal communication, 1962). In accordance with past procedure of the Geological Survey, rocks of the three areas, except for rocks in the vicinity of the coal seam, could be (and were) mapped as Canso Group. The axial part of the syncline would have to be part of the Riversdale Group.

Anthracomya angulata Dawson and "*Estheria*"? sp. were found in grey shale about 2 miles from Baddeck toward Nyanza on the north side of the Trans-Canada Highway. *Carbonicola* sp. was found on the small stream that flows from Whycocomagh Portage Post Office to St. Patrick's Channel. *Anthracomya* cf. *angulata* Dawson was found at several locations in the Maple Brook syncline, near Glendale. *Lioestheria* *striata* (Goldfuss and Münster), *Leaia tricarinata* Meek and Worthen, and *Leaia* cf. *acutilirata* Copeland were found 600 feet southeast of the southern boundary of Whycocomagh map-area on a branch of River Inhabitants, south of Princeville Post Office.

Lithology

The Mabou Formation in Baddeck and Whycocomagh map-areas includes laminated grey shale and siltstone, thin beds of limestone, interbedded grey and red siltstone, shale, and fine- to medium-grained sandstone. Bell (1943, p. 10) pointed out that the lithological differences between the Canso and succeeding Carboniferous groups: "... most significant [in the Canso Group] are: (1) the absence or rarity of conglomerate in Nova Scotia; (2) the widespread distribution, horizontally and vertically (except in the Cumberland Basin facies), of laminated, rippled, and mud-cracked beds carrying a fluviolacustrine fauna".

The most common rock types of the Mabou Formation within the map-areas are red shale, siltstone, and fine-grained sandstone. Green, grey, and black siltstone and shale are also prevalent. Limestone beds, chiefly less than 2 feet thick, are present; these are mainly thinly laminated, algal-like and silty limestones. The thinly laminated, grey siltstone and shale are commonly varve-like in appearance, with alternating light and dark layers less than one-quarter inch thick. The dark bands are grey to black shale and the light grey bands are fine-grained siltstone. Crossbedding and ripple-marks are commonly seen; mud-cracks, scour-and-fill structures, and pseudomorphs after salt crystals are less frequent features. Carbonized plant debris and iron sulphide crystals are locally abundant.

The most common feature of Mabou strata is thin bedding or lamination. This appears generally in the lower part of the formation. Grey, thinly laminated siltstone with minor red siltstone are the most prevalent rock types of the lower part of the Mabou Formation.

Chapter V

GEOLOGICAL HISTORY OF THE MISSISSIPPIAN PERIOD

In early Mississippian time, central Cape Breton Island, including Baddeck and Whycocomagh map-areas, was an area of deposition and erosion. The eastern part of the Island was a highland area (or nearly so) that controlled the sedimentation to the west; it existed throughout deposition of the Horton Group and during most, if not all, the time of Windsor Group deposition. During latest Mississippian time the highland area was either non-existent or quiescent, as attested by the sedimentary rocks of the Mabou Formation and its correlatives.

Horton Group Deposition

The Horton and Windsor Groups, where deposited, formed an unbroken succession of strata over all central Cape Breton Island except in the vicinity of the Mabou Highlands. There, an unconformity separates the two groups. Inasmuch as these two groups are conformable over the remainder of Cape Breton Island, the zero line of thickness of Horton strata at the time of A_1 Windsor deposition is equivalent to the zero line of deposition (Fig. 1).

Margin of Basin

The conformable contact of the Horton Group with the Windsor Group in Nova Scotia is, with one exception, characterized by the presence of a thinly laminated limestone (A_1 Windsor limestone). The one exception is present in some marginal areas of the basin where clastic sediments and limestone were deposited contemporaneously. This relationship has been discussed by Murray (1960) and Smith (1956) in the Antigonish basin.

For more than 40 miles, from the west side of Kelly Mountain to the southwest end of North Mountain, in Baddeck and Whycocomagh map-areas, the most easterly strata of A_1 Windsor limestone rest conformably on the Ainslie Member, or overlap pre-Carboniferous rocks. The locality where the A_1 Windsor limestone overlaps pre-Carboniferous rocks is on the southeast side of North Mountain and establishes the edge of the Horton basin in the southern extremity of the area (Fig. 1) at the time A_1 limestone of the Windsor Group was being deposited.

The general area of North Mountain was positive during most of Horton deposition. This is shown by the fact that fossiliferous B limestone of the Windsor Group overlaps the earlier Windsor and is practically resting on Precambrian rocks on the north and east sides of North Mountain. On the west side of North Mountain 0–500 feet of Mississippian conglomerate and sandstone underlie fossiliferous B limestone. The clastic rocks may all belong to the Windsor Group; if this is the case, North Mountain must have been positive during Horton deposition. If, on the other hand, part of the clastic rocks belong to the Horton Group, then the edge of the Horton basin was along the western edge of North Mountain.

An indication that the edge of the Horton basin was close to the southeastern part of Whycocomagh map-area is that 5,000 feet or more of Craignish Formation present on the western side of the Creignish Hills is missing on the eastern side. This indicates that during deposition of the Craignish Formation the base level of erosion was probably close to the present eastern edge of the Creignish Hills. On the eastern side of the hills, a thinner but representative section of the Strathlorne–Ainslie Formation unconformably overlies pre-Carboniferous rocks and is conformably overlain by the basal Windsor limestone. Thus, at some locality between the eastern side of the Creignish Hills and the western side of North Mountain, the A_1 Windsor Limestone either overlapped onto the pre-Carboniferous or interfingered with the thin zone of conglomerate and sandstone that flanks the western side of North Mountain. In this vicinity (North Mountain), the zero line of Horton deposition was arbitrarily placed halfway between the 800 feet of Horton strata on the east side of the Creignish Hills and the western edge of North Mountain (Fig. 1). As indicated above it is possible that the zero line of deposition may be along the western edge of North Mountain.

Windsor strata rest directly on pre-Carboniferous rocks at several localities along the southeast side of Kelly Mountain. However, on the northwest side, about 700 feet of red sandstone and conglomerate separate the A_1 Windsor limestone from the pre-Carboniferous. At Englishtown, on the northwest side of Kelly Mountain, and at Fairy Hole, half a mile west of Cape Dauphin, subzone B limestone rests on granite. The zero line of deposition is therefore placed near the southeastern edge of the mountain and swings northwestward before Englishtown (Fig. 1). This 700 feet of Horton sandstone and conglomerate is one lithological unit. Therefore, it may be a marginal phase of the Horton Group or a marginal facies of the Strathlorne–Ainslie Formation of the Horton Group.

Southeast of Grand Narrows, on the southeast shore of East Bay, B Windsor Limestone is separated from the pre-Carboniferous by a thin zone of conglomerate. The limestone in several places grades into conglomerate as the individual beds are followed to the east toward the pre-Windsor erosion surface (Weeks, 1954, pp. 74–75). Therefore, the zero line of deposition is at some position between Grand Narrows and the southeast shore of East Bay (Fig. 1).

Northeast of Grand Narrows, at Shunacadie, the basal Windsor limestone has been noted by Hyde (1914) and Norman (1927, 1928). Seventeen miles northeast of Shunacadie, however, B Windsor limestone was deposited directly on the pre-Carboniferous (Bell and Goranson, 1938a). Therefore, the zero line of Horton deposition can be only approximately located along St. Andrews Channel (Fig. 1).

An extension of the Horton basin has been projected into Sydney map-area because the basal part of the 3,500 feet of conglomerate, sandstone, and shale that Bell and Goranson (1938a) mapped as the Grantmire member of the Windsor Group may belong to the Horton Group. The upper part of the Grantmire succession is well dated as Lower Windsor but the age of the basal part is unknown and could be part of the Horton Group, even if the Horton is restricted to a time-rock unit. Structural and lithological data suggest, as mentioned in Chapter IV, that the Grantmire is the same lithological unit as the Horton conglomerate and sandstone in the area of Grand Narrows and the peninsula north of Iona. The conglomerate and sandstone in the Grand Narrows area can be followed along strike to the northeast, and in Sydney map-area this unit is mapped as Grantmire member (Bell and Goranson, 1938a). In the western part of Sydney map-area, the first recognizable unit in or above the conglomerate is Lower Windsor limestone (i.e. a subzone B limestone). West of the city of Sydney the first recognizable unit is Upper Windsor limestone (i.e. a subzone C limestone). This suggests that the conglomerate and sandstone in the Grand Narrows area ascend the section to the northeast and the Grantmire member in Sydney map-area may, in part, belong to the Horton Group.

The location of the edge of the Horton basin is unknown in Cape Breton Island beyond the areal limits outlined. However, in northern Cape Breton Island, Neale (1963b) noted the A_1 Windsor limestone conformably overlying the Horton Group in the eastern part of Pleasant Bay map-area, whereas, in Dingwall map-area (Neale, 1963a), Lower Windsor limestone overlaps pre-Carboniferous rocks. It therefore seems possible that the northerly trend of the zero line of Horton deposition at the beginning of A_1 Windsor deposition continues into northern Cape Breton Island (Neale and Kelley, 1960).

Tectonics and Sedimentation

The conclusion that areas of high relief existed during deposition of the entire Horton Group is based on the fact that coarse clastic rocks of fairly similar composition, texture, and other primary features were deposited throughout the Horton section in the eastern part of Cape Breton Island. East of the Creignish Hills, and in the central and eastern part of Baddeck map-area, the Ainslie Member consists of as much as 30 per cent conglomerate. West of the Creignish Hills, however, and in the western part of Baddeck map-area, conglomerate is a relatively minor component of the Ainslie Member. The widespread vertical and lateral distribution of conglomerate in the Horton section is most logically explained by periodic renewal of source material that probably resulted from uplift in the source area or downsinking in the basin area, or a combination of the two. The nature of the movement is unknown. However, it affected only locally Horton strata already deposited, so that local unconformities resulted, such as the one west of the Mabou Highlands.

Murray (1960) did not interpret the coarse lithologies of the Horton Group as marginal facies. He interpreted the three formation units of the Horton Group as time-rock units. This was based on the assumption that the Horton Group, where fully developed, had the same threefold sequence of strata in all sections and that it as a whole was not time-transgressive because it was overlain by the A_1 Windsor limestone (a time plane). Therefore, according to this interpretation the same geological sequence of events was recorded everywhere simultaneously. To have obtained a synchronous sequence of events throughout Nova Scotia during Carboniferous time would have required synchronous uplift throughout this period. Murray (1960, p. 114) apparently accepted this requirement for he stated: "... the Carboniferous period in Nova Scotia was tectonically homogeneous."

To demonstrate the difficulty of recognizing in all parts of the Horton basin the effects of a tectonic event that occurred only in its marginal parts, an example may be cited from Murray's work. Thus in the Antigonish basin, Murray (1960, p. 69) stated that the South Lake Creek Formation of the Horton Group in most places unconformably underlies a sharpstone conglomerate designated as the Right's River Formation. The Right's River Formation is conformably overlain by the A_1 Windsor limestone, and thus it is also part of the Horton Group (Murray, 1960, p. 69). Comparing these strata to those in the type section on Southwest Mabou River, Murray stated that the upper part of the South Lake Creek Formation, the Graham Brook Member, is correlative with some part of the McIsaac Point Member of the Ainslie Formation. The Right's River Formation is also correlative with some part of the Ainslie Formation. Murray (1960, p. 90) stated that "... the Graham Brook Member probably existed on the same interface with both McIsaac Point and Right's River and represents an intermediate facies." The Right's River Formation was interpreted to be alluvial fans that formed as a result of faulting in the positive area to the north and west of the Horton basin (Murray, 1960, p. 80). Uplift, therefore, had a pronounced and easily recognized result on Horton sediments in parts of the Antigonish basin at apparently the same time as uninterrupted deposition took place in the Southwest Mabou River section. Also, there is no evidence of this uplift in any of the marginal sections of the Horton Group in eastern Cape Breton Island. Periods of uplift were therefore not of the same intensity throughout Nova Scotia. If uplift was synchronous, but not of the same intensity, it would be extremely difficult to recognize it as such because of lithological changes within each formation. As pointed out in the chapter on Lower Mississippian stratigraphy, there are wide variations of rock types within each formation as one follows them toward the basin margins. If lithological units were good criteria for time correlation in the Carboniferous of Nova Scotia, then we should still believe that all the productive coal beds were deposited at the same time, an idea long since dispelled (Bell, 1921, p. 18E).

Climatic interpretation of the Horton Group is another controversial problem. It is difficult to determine whether or not certain lithological features are due to tectonic movements or climatic changes, or both. All features used as criteria for specific climatic interpretations by Bell (1929, p. 39) can apply equally well to different climatic interpretations or can even be ascribed to uplift rather than climate. Thus, Krynine (1950, p. 130) in discussing paleoclimatic criteria stated that "... sedimentary features are not the product of a given environment, but only of certain processes, and these processes may take place in several very different environments." Horton sedimentation in central Cape Breton Island can be interpreted on the basis of relatively continuous uplift with two major periods of uplift superimposed, if we assume that the correlations discussed in the chapter on Lower Mississippian stratigraphy are correct.

The first period of uplift initiated volcanism and erosion of coarse detritus that was deposited to form volcanic and sedimentary rocks[1] and the Graham River and Skye River Members of the Craignish Formation. The arrangement of this material is such that a lower volcanic and coarse facies (volcanic and sedimentary rocks[1] and Graham River member) is overlain by a fine-grained, well-sorted facies (part of the Skye River member) that interdigitates with a coarse-grained facies (part of the Skye River member). The thinly laminated character of the grey siltstone in the Skye River Member of the Graham River section indicates deposition in quiet water (Pettijohn, 1957, p. 593), probably in a lake or on a flood plain. The coarse-grained rocks of the Graham River Member were probably deposited in proximity to their source, as suggested by the angular nature of both the smaller pebbles (i.e. less than half an inch in diameter) and the matrix of the conglomerate. The larger pebbles are subangular to well rounded. Coarse-grained, poorly sorted rocks of the Skye River Member are more common in the sections of the Southwest and Southeast Mabou Rivers than in the Graham River section. This possibly indicates that the two former sections, especially the Southwest Mabou River section, were deposited closer to their sources than was the Graham River section to its source. The abundance of carbonized plant fragments and the predominantly grey colour of the Skye River Member indicate that reducing conditions predominated in its depositional environment.

McLeod Member lithology represents a transitional facies in western Cape Breton Island and, as might be expected, it suggests active movement in the eastern part of the Horton basin. The McLeod Member type of lithology is far more widespread than that of the lower two members of the Craignish Formation, and constitutes the basal part of the Horton Group over most of central Cape Breton Island. In western Cape Breton Island the McLeod Member becomes progressively finer grained in higher parts of the section even though, in the Graham River section, conglomerate is interbedded with the fine-grained sedimentary rocks that are correlative with the McLeod Member. In Baddeck map-area, in the eastern part of the basin, conglomerate that is correlative with the McLeod Member (Fig. 2, col. 7) is distributed throughout the section. It is immaterial which part of the Grand Narrows section (Fig. 2, col. 5) correlates with the McLeod Member because, as mentioned above, the entire section consists of interbedded conglomerate and sandstone.

The conclusion that deposition of the Strathlorne Member took place under more stable tectonic conditions than those which accompanied deposition of the other Horton units in central Cape Breton Island is based on the fine-grained and thinly laminated character of Strathlorne lithology, which persists almost to the margin of the basin. It is possible that the basal contact of the Strathlorne, which invariably is fairly sharp (i.e. discernible over several feet), may represent a time plane as proposed by Murray. It must be stressed, however, that in parts of western Cape Breton Island

[1]Since designated the Fisset Brook Formation. *See* Kelley, D. G. and Mackasey, W. O., Basal Mississippian Volcanic and Sedimentary Rocks in Cape Breton Island, *Geol. Surv. Can.*, Paper 64-34 (1965).

the only difference between the upper part of the McLeod Member and some beds within the Strathlorne Member is in the colour. Also, one would expect deposition of the fine-grained Strathlorne Member to have commenced farther from the bordering uplands and to be transgressive toward these uplands. This is by no means necessary because all uplands did not necessarily contribute a significant amount of sediment to the basin.

The main characteristic of the Strathlorne Member, apart from its colour, is the presence of thinly laminated grey siltstones. These are indicative of quiet-water deposition (Pettijohn, 1957, p. 593), so that the Strathlorne was probably deposited on the flood plain of a slowly moving stream, which intermittently or continuously involved lacustrine and paludal environments. The general absence of mud-cracks, the predominantly grey colour, the inclusion of crystals of iron sulphides, and the presence of many fragments of carbonized plant remains probably indicate that drainage in the basin was poor and that the water-table was high, so that deposition of the sediments took place in a reducing environment. Swampy conditions and rich vegetation also existed on the flood plain as shown by a 6-inch seam of coal within the Strathlorne Member in Baddeck map-area, along Harris Brook.

Uplift was locally active in parts of the source area during Strathlorne deposition as is indicated by the coarse-grained sediments in the Grand Narrows area, which are correlative with the Strathlorne Member. However, the red, coarse-grained facies did not persist very far out on the flood plain where the grey, fine-grained Strathlorne strata were being deposited.

During deposition of the Ainslie Member there was more intensive uplift in the source area. This is inferred from the widespread distribution of conglomerate (laterally and vertically) in the central and eastern parts of Baddeck and Whycocomagh map-areas. The lowermost Ainslie beds are conglomeratic and in sharp contact with the Strathlorne beds along the most easterly exposures of the Strathlorne–Ainslie contact, on the peninsula north of Iona and 2 miles east of Baddeck. In the remainder of Baddeck map-area, the contact of the Ainslie and Strathlorne Members is transitional over several tens of feet of strata.

Sediments resembling those of the Strathlorne Member were deposited intermittently during deposition of the Ainslie Member. Although the areal distribution of any one Strathlorne-like unit in the Ainslie Member is unknown, the widespread areal and vertical distribution of thinly laminated grey siltstones in the Ainslie Member indicates that the quiet water, flood-plain conditions suggested for the Strathlorne Member were, at times, reproduced during deposition of the Ainslie Member. Conditions similar to those that existed during deposition of the Strathlorne Member may have been present locally throughout deposition of the Ainslie Member. This is suggested by the strata of the Mount Young area, where the Strathlorne–Ainslie Formation consists of Strathlorne-like sediments, which occupy the 1,800-foot interval between conglomerate beds and the A_1 Windsor limestone.

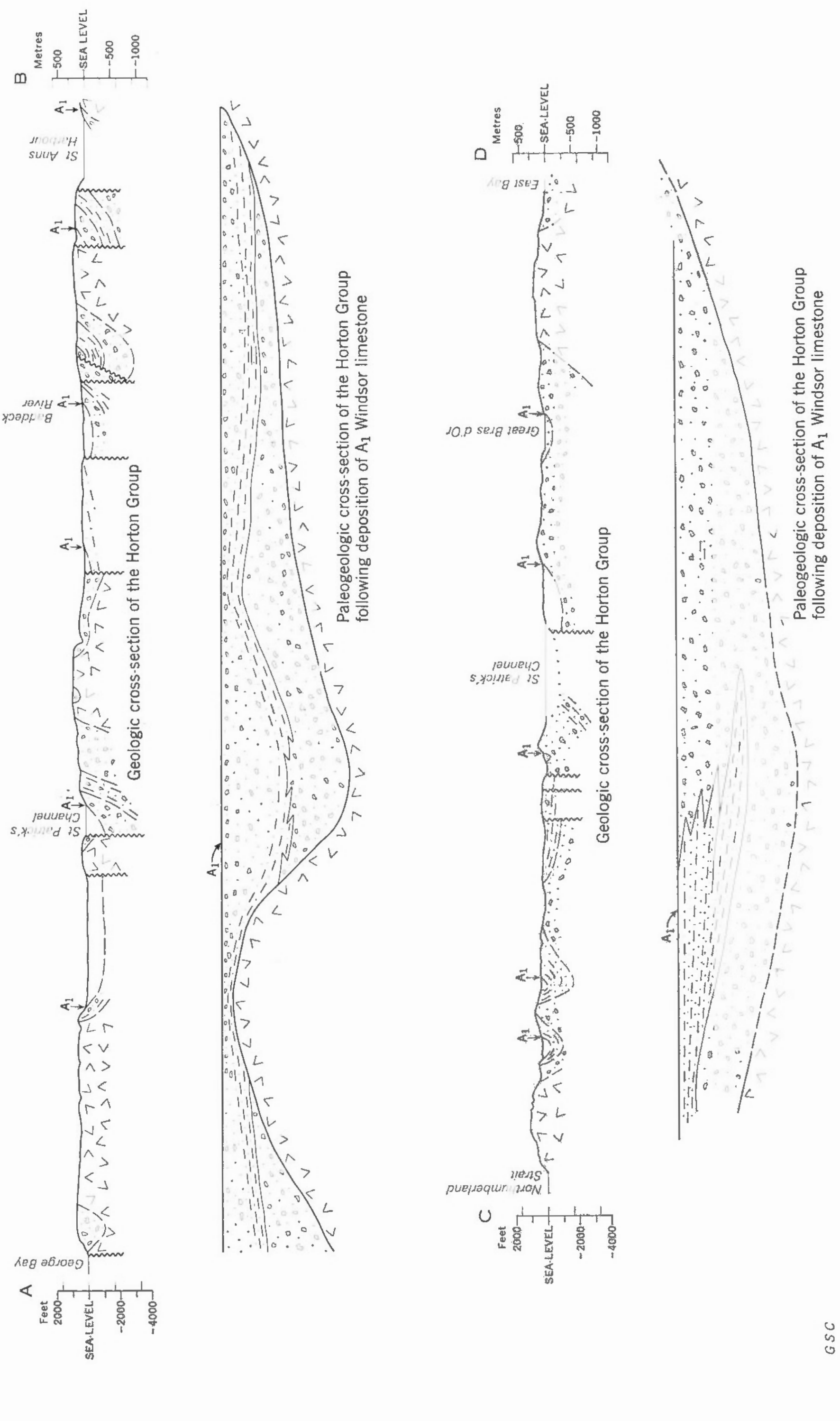
The only conglomerate reported from the uppermost part of the Ainslie Member in Lake Ainslie map-area is at two localities on the shore of Lake Ainslie (Norman, 1935, p. 35). This conglomerate occurs as local lenses, as much as 4 feet thick, and directly underlies the A_1 Windsor limestone. These pockets of conglomerate may have had their source in the area west of the Mabou Highlands, which are only 5 to 10 miles from the conglomerate outcrops. Conglomerate beds also directly underlie the A_1 limestone over the entire eastern part of the Horton basin.

The Mabou Highlands is an area where the Horton Group consists of a coarse-grained facies that could not be subdivided. Also it is not known to which part of the Horton Group the Mabou Highlands rocks belong. Norman (1935) and Phinney (1956) correlated conglomerate on the west side of the Highlands with lowermost Horton strata. Murray (1960, p. 44), however, interpreted this conglomerate as a facies of the Ainslie Formation (sic). The conglomerate is unconformably overlain by a thinly laminated limestone that is identical in lithology with the A_1 Windsor limestone, and which was also deposited directly on pre-Carboniferous rocks at McKinnon Brook on the northwest side of the present-day Mabou Highlands (Norman, 1928; Phinney, 1956, p. 36).

Relationships the author observed on Rory Brook in Whycocomagh map-area support Murray's correlation of the conglomerate with the Ainslie Formation (sic). On this brook a sequence of sharpstone conglomerate and sandstone overlies the Strathlorne Member. These beds are overlain by normal Ainslie strata and on the basis of continuity of outcrop, as determined from attitudes, the sharpstone conglomerate occupies the position of part of the Ainslie Member. It is a lens-like body, as determined from outcrop distribution and airphoto interpretation and, in its central part, is about 900 feet thick. The conglomerate does not appear to extend very far south of Rory Brook, but it extends about 3,500 feet north of this stream as interbeds in normal Ainslie strata. W. A. Bell (personal communication) stated that this conglomerate on Rory Brook is similar to conglomerate of the Mabou Highlands area. Therefore, the sharpstone conglomerate may be equivalent to conglomerate of the Mabou Highlands area, in which case the geological history of the Mabou Highlands was probably similar to that of the north and west sides of the Antigonish basin, as described by Murray (1960).

In the Antigonish basin, the sharpstone conglomerate of the Right's River Formation represented a marginal facies of strata Murray correlated with the Ainslie Formation (sic). Murray (Fig. 20, p. 89) also suggested that the sharpstone conglomerate is in conformable contact with the grey beds that he interpreted to be correlative with the Strathlorne Formation (sic). This is the relationship of the Rory Brook section. It is not known whether this marginal area west of the present-day Mabou Highlands (but a part of the old positive area) and the Antigonish–Pictou Highlands represents the western extremity of the Horton basin, or whether it was an isolated positive area with Horton sedimentation surrounding it.

Cross-sections of the Horton basin are shown on Figure 3. These sections are in pairs; one is a geological cross-section and the other is a palaeogeological cross-section following A_1 Windsor limestone deposition. The former is based on geological mapping and the latter is an interpretation based on the geological cross-sections. One pair of sections was drawn roughly parallel with the basin margin (A–B), and the other three pairs were drawn from the margin into the central part of the basin.


A
B
Feet
2000
SEA-LEVEL
-2000
-4000
Metres
500
SEA LEVEL
-500
-1000
George Bay
St Patrick's Channel
Baddeck River
St Anns Harbour
A_1
Geologic cross-section of the Horton Group
Paleogeologic cross-section of the Horton Group following deposition of A_1 Windsor limestone
C
D
Northumberland Strait
Great Bras d'Or
East Bay
Geologic cross-section of the Horton Group
Paleogeologic cross-section of the Horton Group following deposition of A_1 Windsor limestone
GSC

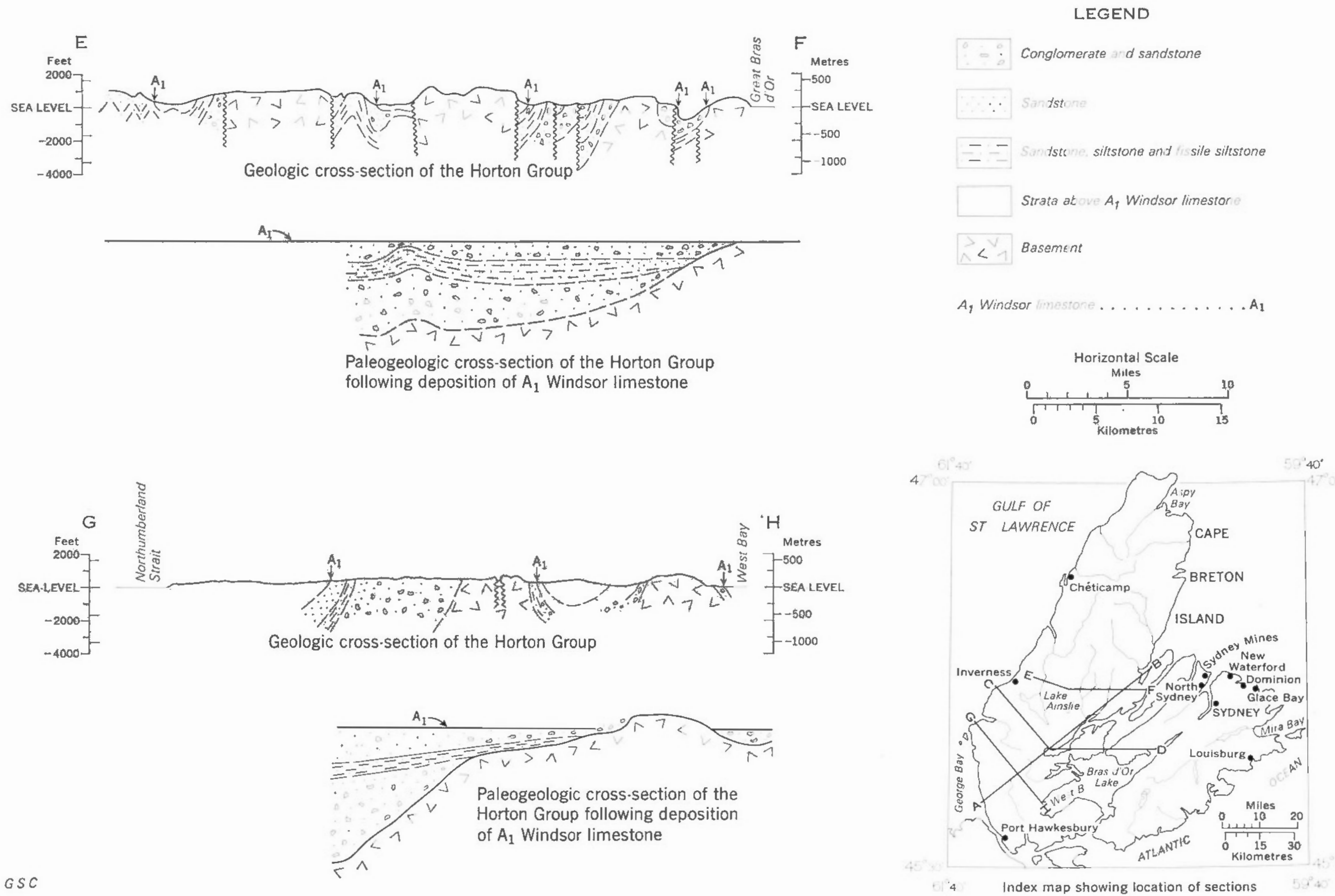


FIGURE 3. Geological and palaeogeological sections of Horton Group.

The faults are all shown with vertical dips but, in most cases, their attitudes are unknown. The locations of the cross-sections are shown on the small-scale geological map on Figure 3.

Windsor Group Deposition

Highland areas existed in or close to eastern Cape Breton Island throughout Lower Windsor and at least part of Upper Windsor sedimentation. Coarse clastic rocks are a major part of the Windsor succession in eastern Cape Breton Island, where these highland areas had their greatest effect on sedimentation.

Margin of Basin

The land area of what is today the eastern part of Cape Breton Island probably had considerable relief during deposition of the A_1 Windsor limestone. This is indicated by the coarseness of the conglomerate both beneath and correlative with the basal Windsor limestone along the eastern edge of the Horton basin. Angular blocks of granite as large as 3 feet in maximum dimension are included in the upper 30 feet of conglomerate along the west side of Kelly Mountain, and coarse clastic rocks of the Lower Windsor were mapped by Bell and Goranson (1938a) in Sydney map-area.

If we accept the probability that the land area had considerable relief during deposition of the A_1 Windsor limestone, the location of the edge of the Windsor basin would be essentially the same as that of the edge of the Horton basin during deposition of the A_1 Windsor limestone. However, as mentioned previously, where deposition of a continental facies took place at the same time as deposition of the A_1 Windsor limestone, it is nearly impossible to locate the edge of the Horton basin or the edge of the marine Windsor basin.

A restriction of the Windsor sea followed deposition of the A_1 Windsor limestone and, in some parts of the area, evaporite deposits were formed. On the basis of its widespread and sudden appearance, its lack of fossils and chert, and its laminated character, Smith (1956, p. 110) suggested that the A_1 Windsor limestone is itself an evaporite deposit.

The next major transgression of the Windsor sea was more widespread than the first. Subzone B limestone covered all areas formerly hidden by the basal Windsor limestone except one in the southern part of Whycocomagh map-area. There the A_1 Windsor limestone is covered by 10 to 15 feet of red siltstone, which is overlain in turn by grey and red siltstone of the Mabou Formation. The section is well exposed and structurally conformable. Apparently no subzone B limestone was ever deposited there.

Subzone B limestone also transgressed eastward, beyond the borders of pre-existing Windsor deposits. Along the southeastern shore of East Bay a subzone B limestone was deposited close to a positive area (Weeks, 1954, p. 75); yet outliers of subzone B limestone outcrop as far east as Louisburg. There is not enough information available, however, to indicate how far the Windsor seas transgressed. Where overlap of Windsor limestone occurred, it is usual to find conglomerate between the limestone and the pre-Carboniferous rocks. In two localities at least, subzone B limestone was deposited directly on pre-Carboniferous rocks.

The only place in Cape Breton Island where the basin margin is indicated for any part of the Upper Windsor Group is at the boundary of Glace Bay and Louisburg map-areas. There, Upper Windsor strata were deposited on pre-Carboniferous rocks. These are the most easterly exposures of Windsor strata on Cape Breton Island, but as in the case of subzone B strata, they provide insufficient evidence to establish any trend of the basin margin.

Tectonics and Sedimentation

Owing to the lack of exposures, the geological history of Windsor sedimentation in central Cape Breton Island must remain, for the most part, unknown. The condition of deposition of the Windsor limestones and gypsum has been discussed by Stacy (1953), but little is known about the clastic red beds that stratigraphically make up the major part of the Windsor Group.

The probable existence of a source area of high relief for the clastic sediments that were deposited during deposition of A_1 limestone was shown in the preceding paragraphs by the relationship of A_1 limestone to coarse conglomerate. Conglomerate beds are almost invariably associated with sections of Lower and Upper Windsor strata in eastern Cape Breton Island (Bell and Goranson, 1938b). This suggests a marginal phase of the Windsor Group.

Conglomerate is generally found at the base of a Windsor section where Windsor strata overlapped pre-Carboniferous rocks. In two localities at least, subzone B limestone was deposited directly on pre-Carboniferous rocks, and in a conformable sequence of strata suggests a marginal phase of the Windsor Group. It also suggests that where the Lower Windsor sea transgressed pre-Carboniferous rocks it followed valleys that were underlain by gravel and sand. In some places the sea transgressed beyond the valley floors to deposit limestone directly on pre-Carboniferous rocks. Although the boundaries of the Windsor basin could not be established, other than at the time of A_1 limestone deposition, there is evidence of a general west-to-east transgression of the Windsor sea. Also, all Windsor strata in eastern Cape Breton Island are indicative of a marginal phase of the Windsor Group.

In the remainder of central Cape Breton Island Windsor strata are typical of those described by Stacy (1953). Stacy (1953, p. 43) suggested that Windsor sedimentation was indicative of ". . . a complex of environments: a shallow-water offshore environment, a restricted basin type, and a deeper water, open basin environment where the bottom sediments are mainly red oozes." The present writer and his assistants saw less than 50 outcrops of Windsor red beds in Whycocomagh and Baddeck map-areas. In most cases the stratigraphic position of these beds is unknown. Several of these outcrops, along the western edge of River Denys Basin, are radically different from the normal, fine-grained, red siltstone and sandstone that are typical Windsor red beds. They are sharpstone conglomerates with a limestone matrix. The fragments, as large as 1 inch in maximum dimension, consist mainly of quartzite, quartz–muscovite schist, unstrained quartz, and fresh feldspar grains. These fragments could all have been derived from the Creignish Hills immediately to the west. They may have resulted from movement along the fault whose trace follows the eastern edge of the Creignish Hills. Such faulting may also have caused minor uplift in the southern part of the River Denys Basin, which could explain why A_1 Windsor limestone is succeeded by Mabou strata in this locality.

Mabou Formation Deposition

There is no evidence of significant crustal disturbances during the first part of Mabou deposition in central Cape Breton Island. Regional warping is the only type of crustal instability necessary to explain Mabou sedimentation. Sediments correlated with the Canso Group by previous workers in central Cape Breton Island are all fine grained. The many beds of thinly laminated siltstone throughout the section indicate deposition in quiet water.

Margin of Basin

No evidence was found in central Cape Breton Island to suggest that a margin of the Mabou basin of deposition existed near the present-day land area. From outcrop distribution and lithology, it appears that most, if not all, of central Cape Breton Island was covered by sediment during Late Mississippian time. If any positive areas existed in this region they probably had small relief.

Tectonics and Sedimentation

The Windsor–Mabou contact appears to be both conformable and disconformable in central Cape Breton Island. In Lake Ainslie map-area Norman (1935, p. 45) noted that the Mabou and Windsor strata are structurally conformable. However, the subzone of the Windsor on which rocks of the Mabou Formation were deposited varies from place to place, thus indicating a disconformity or a facies change from marine to brackish-water sediments in the Windsor Group. This relationship is also shown in Whycocomagh map-area. Along the western boundary of Mabou strata in the south-central part of Whycocomagh map-area, the A_1 Windsor limestone is overlain by 15 feet of red siltstone. This siltstone is overlain by thinly laminated, grey siltstone and more red siltstone that are part of the Mabou Formation. These Mabou strata are structurally conformable with the Windsor strata. However, a few miles northeast of this locality, Mabou strata rest on stratigraphically higher Windsor beds. A similar relationship exists along the southeastern shore of the Strait of Canso. There, Ferguson (1946, p. 11) noted that Canso strata were deposited on various stratigraphic units of the Windsor Group.

Stacy (1953, p. 27) found no evidence of a disconformity between the Canso and Windsor groups in the several sections he studied in Cape Breton Island. Bell and Goranson (1938a) apparently found no evidence of erosion between Canso and Windsor strata in the Sydney area. Bell and Goranson (1938b) mentioned that an erosional break probably exists, although Stacy (1953, pp. 36–37) considered it a conformable succession of strata. Neale (1963a) mapped the Windsor and Canso

Groups as conformable in northern Cape Breton Island; the actual contact was arbitrarily chosen.

The foregoing observations suggest two different interpretations. (1) One depends on the Mabou Formation not being older than Late Carboniferous (Namurian, as indicated by Bell, 1944, p. 5 and Fig. 11). If the entire Mabou Formation is not older than Namurian, the field observations mentioned above suggest that Windsor strata were gently warped and, in part, eroded prior to or during deposition of Mabou sediments. The fact that several Windsor–Mabou contacts are transitional suggests that sedimentation was continuous and erosion of Windsor strata was not active in the downwarped areas of Windsor strata. In upwarped areas, Windsor strata were differentially eroded to expose various stratigraphic units. Erosion of Windsor strata probably occurred *during* deposition of Mabou strata because, although erosion apparently removed more than 1,000 feet of Windsor strata in parts of the area, no coarse sedimentary rocks have been reported from the Mabou Formation of central Cape Breton Island that would suggest the existence of highland areas prior to deposition of the Mabou Formation. (2) The second interpretation depends on part of the Mabou Formation being Early Carboniferous (Visean) and correlative with the Windsor Group. Bell (1943, Fig. 10) and Copeland (1957, p. 8) have demonstrated that at least part of the Canso Group is Late Carboniferous. It is possible, however, that the lower part of the Mabou Formation may be Visean in those areas where it overlies Lower Windsor strata. Proof of this requires further palaeontological work.

If the part of the Mabou Formation that was deposited with structural conformity on Lower Windsor strata is Visean, then there is no disconformity between the Mabou Formation and Windsor Group in central Cape Breton Island. Further, part of the Mabou Formation would be a non-marine facies of the Windsor Group.

Immediately after withdrawal of the Windsor sea from any part of the region, sediment was widely deposited on a flood plain that apparently had little relief. However, if the first interpretation is correct, and the Mabou is no older than Namurian, then this flood plain was involved in regional warping and erosion contemporaneously with deposition.

The fauna and flora of the Canso Group indicate deposition under brackish-water and non-marine conditions (Copeland, 1957, p. 13). There were possibly a few minor marine transgressions during the early part of Mabou deposition, as suggested by thin algal limestones. Ripple-marks, scour-and-fill structures, pseudomorphs after salt crystals, desiccation cracks, iron-sulphide crystals, siltstone and sandstone lithology, and many thin varve-like beds together suggest shallow-water deposition with periodic subaerial weathering. These conditions would probably best be filled in a fluviolacustrine flood-plain or coastal-plain environment.

Chapter VI

STRUCTURAL GEOLOGY

Baddeck and Whycocomagh map-areas lie almost wholly within the 'late Palaeozoic folded zone' shown on the preliminary tectonic map of the Canadian Appalachian region (Neale, *et al.*, 1961). A small part of Baddeck map-area (Kelly Mountain and Boisdale Hills) is included in the 'Acadian folded zone' and the Pennsylvanian and Mississippian rocks of Boularderie Island are regarded as 'cratonic cover on Palaeozoic folded zones.'

The 'late Palaeozoic folded zone' of the two map-areas includes: (1) Precambrian folded rocks (George River Group) that were later refolded by the Taconic and/or Acadian orogenies and uplifted and faulted during the late Palaeozoic; (2) Taconic and/or Acadian folded rocks (granitic rocks) that were faulted and locally folded during the late Palaeozoic; (3) rocks that were folded only during the late Palaeozoic (Carboniferous).

The 'Acadian folded zone' is represented in the map-areas by the granitic rocks and George River Group of Kelly Mountain and the George River Group, granitic rocks, and Cambrian strata of the Boisdale Hills. These rocks are considered as Taconic folded rocks that were refolded during the Acadian orogeny. Only local folding from adjustment to block faulting affected these rocks during the late Palaeozoic.

The Mississippian and Pennsylvanian rocks of Boularderie Island are relatively flat lying and undisturbed. These rocks are regarded as 'cratonic cover on the folded zones.'

The general structure of the two map-areas is illustrated by the accompanying geological maps and cross-sections (Fig. 3). The most prominent features are the northeasterly trending structures of Carboniferous rocks interspersed by uplifted and upfaulted blocks of the older pre-Carboniferous rocks. The older blocks resemble anticlinal cores because they are surrounded by younger strata that are mainly dipping away from the cores. In the two map-areas, however, the older rocks are mainly uplifted blocks, broken on their eastern edge and tilted downward toward the west. Carboniferous strata trend north in the valleys between the ridges of the southern end of the Cape Breton Highlands, in the northern part of Baddeck map-area. These north-trending valleys possibly resulted from rotation of fault blocks.

Folds

Very little structural analysis of the pre-Carboniferous rocks was attempted in either of the map-areas. These rocks are structurally complex, marker beds were not recognized, and bedding and schistosity are commonly parallel or nearly so. In the northern part of Baddeck map-area a large antiform and synform are apparent from the schistosity attitudes. These forms plunge to the northwest.

Folds in Mississippian rocks appear to be closely linked genetically with movement in the pre-Carboniferous basement rocks. As mentioned previously, pre-Carboniferous uplands in the map-areas are commonly faulted, at least along one of their boundaries. However, the vertical movement necessary to elevate these uplands to their present position has caused doming in the overlying Mississippian rocks. The doming effect can be demonstrated by an examination of the structure of the rocks of the peninsula north of Iona. The peninsula north of Iona has a core of pre-Carboniferous rocks that are in fault contact with Mississippian rocks along the core's northwestern and southeastern boundaries. These faults may extend into Grand Narrows map-area to the south, although Weeks (1954) does not record them. In any event, the Mississippian structure is anticlinal; at the southern end of the anticline, in Grand Narrows map-area, it plunges to the southwest. At the northeastern end, in Baddeck map-area, Mississippian rocks although faulted, appear to plunge to the northeast.

Two overturned folds occur in Baddeck map-area, one in the Middle River valley and the other near St. Anns Harbour. Both are overturned away from the pre-Carboniferous upland and probably resulted from the high-angle reverse faults that flank the present day pre-Carboniferous upland.

Faults

Faults are important structures, especially in Baddeck map-area. The faults strike either northeast to north or northwest to west. There is little evidence regarding the character of the faults as only their trace is apparent at the surface. Where overturned folds are present near boundary faults between pre-Carboniferous and Carboniferous strata, the faults are probably high-angle reverse faults. In other boundary faults they are probably normal block faults. Westerly trending faults are interpreted as adjustments that resulted from stresses set up by the earlier northerly trending faults. The pattern of faults in the general area of Hunters Mountain is only one of several that could be used to explain the stratigraphic relationships in this area. Additional faults are present in that area, but their significance is not known.

On the preliminary tectonic map of the Canadian Appalachians (Neale, *et al.*, 1961) a fault was drawn across Baddeck map-area. It was located east of the peninsula north of Iona in Great Bras d'Or and trends northeast to St. Anns Bay. This fault is hypothetical. It was based in part on the change in fold character of Mississippian rocks between western and eastern Cape Breton Island. Mississippian rocks of western Cape Breton Island are commonly highly folded whereas those of eastern Cape Breton Island, except in the vicinity of faults, are gently folded. Also, on the west side of the hypothetical faults, along part of its length, there is a change in general magnetic intensity as shown on aeromagnetic maps of the area.

The only part of the supposed fault that can be checked in Baddeck map-area is in the synclinal area southwest of St. Anns Bay. The author acknowledges the possibility of the existence of a fault, but not one that cuts Mississippian rocks. A facies change across the syncline is favoured to explain the stratigraphic relationship as described in Chapter V.

It is possible that a fault was active in the region of St. Anns Bay during deposition of part of the Horton Group. The 700 feet of Horton strata on the east side of the syncline is mainly sandstone, conglomerate sandstone, and conglomerate. The upper 30 feet of these strata contain angular blocks of granitic rocks as much as 3 feet in maximum dimensions, enclosed in fairly well bedded conglomeratic sandstone and cobble- to pebble-conglomerate. These large blocks lie east of the position of the supposed fault on the tectonic map. Inasmuch as the source of Horton sediments and the edge of the basin have been shown to lie southeast of this Horton section, a fault scarp was probably located to the east also.

Chapter VII

ECONOMIC GEOLOGY

Gypsum deposits in the two map-areas have been known for many years. Gypsum is produced from an area immediately adjoining Baddeck map-area, in the vicinity of Little Narrows. This gypsum deposit continues northeastward and gypsum will be produced from the southwestern part of Baddeck map-area in the future. Gypsum was produced from an area east of Baddeck Bay in the 1930's. There are large proven reserves of gypsum in the River Denys Basin and production commenced in August, 1962.

Limestone from Marble Mountain was extensively quarried from 1906 to 1920 and minor production was obtained in Whycocomagh in the 1930's.

Prospecting of base-metal occurrences has been carried on at Whycocomagh and Lime Hill. Iron prospects were investigated around the beginning of the twentieth century at Aberdeen, Whycocomagh, and Iron Mines.

Petroleum exploration has had a long history in Cape Breton Island in the Whycocomagh and Lake Ainslie map-areas and was intermittently active from 1864 until 1960.

The following is a brief description of known occurrences of economic minerals and a brief discussion of petroleum exploration.

Industrial Minerals

Limestone

Goudge, M. F. (1934): Limestones of Canada, Part II, Maritime Provinces; Report 742, Mines Branch, *Can. Dept. of Mines.*

Slater, R. (1962): Report on Industrial Minerals; *N.S. Dept. of Mines,* Annual Report on Mines, 1961, pp. 86–93.

Limestone occurs in Whycocomagh map-area in Precambrian and Mississippian rocks, and in Baddeck map-area almost solely in Mississippian rocks. Precambrian limestone was quarried at Marble Mountain from 1906 to 1920 and was mainly used for blast furnace flux at Sydney. Increase in silica content as the quarry was extended made the limestone unsuitable and a new quarry was opened in Newfoundland.

There are numerous outcrops of limestone and dolostone at various localities in the area mapped as George River Group on North Mountain. Limestone and dolostone occur at many points in the Creignish Hills, but are most abundant in the large spur of George River Group north of Dunakin, in the vicinity of East MacPhail Brook, and in the area between Dunakin and East MacPhail Brook. Dolostone from the vicinity of Whycocomagh was quarried by a point manufacturing firm to the extent of about 100 tons a year for the manufacture of whiting substitute.

Other small quarries in several parts of the map-areas have operated at various times for short periods. These quarries were in both Mississippian and Precambrian limestones and the product was used locally, mainly as agricultural limestone and for making lime.

Silica

Cole, L. Heber (1923): Silica in Canada; Its Occurrences, Exploitation and Uses: Part 1: Eastern Canada; Report 555, Mines Branch, *Can. Dept. of Mines.*

Eardley-Wilmot, V. L. (1928): Diatomite: Its Occurrence, Preparation and Uses; Report 691, Mines Branch, *Can. Dept. of Mines.*

Goranson, E. A. (1931): Silica Deposits at Leitch Creek and Skye Mountain, Cape Breton, N. S.; *Geol. Surv. Can.*, Sum. Rept., 1930, Part D, pp. 60–66.

Guernsey, T. D. (1927): Quartz Sand and Clay Deposits, Melford, Cape Breton; *Geol. Surv. Can.*, Sum. Rept., 1926, Part C, pp. 110–124.

Silica deposits in the two map-areas occur as quartzites in the George River Group, as diatomite in lake bottoms, and as pre-glacial silica sand. Diatomite is known to be present in lake bottoms in the area underlain by pre-Carboniferous rocks, between St. Anns Bay and Upper Baddeck River. Work on these deposits was carried out between 1895 and 1917. A small treatment plant was erected and about 1,000 tons of diatomite were shipped. The diatomite was reported to be of good quality but scattered in small quantities in the various lakes.

Fairly pure looking white quartzite outcrops in the Creignish Hills half a mile northwest of Melford and in an area 1½ miles northwest of Iron Mines. Although quartzite occurs at other localities in the Creignish Hills, the above localities are probably the best areas in which to begin a search for silica as they are convenient to water and rail transportation facilities. Goranson (1931) made a Rosiwal analysis of one thin section of the quartzite from the area northwest of Iron Mines and calculated that the rock contained 93 per cent quartz and 7 per cent impurity.

Quartz sand and clay were produced from 1923 to 1935 from the stream valley of Diogenes Brook, northwest of Melford. A total of about 13,000 tons of sand was produced during this period. A small amount of sand was removed in 1944 for use as silica sand and moulding sand.

The mixture of sand and clay occurs beneath glacial drift of the valley as a bedded deposit; the beds range in thickness from a few inches to 5 feet. Clay is present in varied quantities within the sand and itself forms beds. Mica is ubiquitous in both the sand and clay. In 1927, within the tested part of the deposit Guernsey estimated there were between 120,000 and 140,000 tons of sand. Small amounts of the clay were shipped to St. John, New Brunswick for pottery.

Gypsum and Anhydrite

Cole, L. H. (1913): Gypsum in Canada, Its Occurrence, Exploitation and Technology; Report 245, Mines Branch, *Can. Dept. of Mines.*

Cole, L. H. (1930): The Gypsum Industry of Canada; Report 714, Mines Branch, *Can. Dept. of Mines.*

Goodman, N. R. (1952): Gypsum and Anhydrite in Nova Scotia; *N.S. Dept. of Mines,* Mem. No. 1.

Eighty-five to 90 per cent of Canada's gypsum production is from Nova Scotia. In 1961 Nova Scotia produced 3,982,837[1] tons of gypsum of which 413,366[1] tons came from the Little Narrows area that adjoins Baddeck map-area in the southwest corner. Gypsum and anhydrite are present in all areas underlain by the Windsor Group in Baddeck and Whycocomagh map-areas. They are most extensively developed in the Denys Basin and its continuation northeastward, in the area southeast of St. Patrick's Channel, and in the Baddeck Bay–St. Anns Harbour area. Sink-holes and karst topography indicate that gypsum and anhydrite are present in large areas west of Baddeck, in the area from Indian Bay northeastward along the west side of the Baddeck River valley, and in the Middle River valley. Island Point, on the east side of Boularderie Island, is almost completely underlain by gypsum and anhydrite.

The thickest and most extensive gypsum beds in the Little Narrows and Baddeck Bay–St. Anns Harbour area appear to be in subzone B of the Windsor Group. The stratigraphic position of the gypsum and anhydrite in the other areas mentioned above is unknown. Outcrops were too scarce to determine the stratigraphy. Only Late Windsor fossils have been identified from limestones flanking Boularderie Island. It therefore seems probable that gypsum and anhydrite at Island Point is part of the Upper Windsor.

Salt

Nova Scotia Dept. of Mines, Annual Report of the Mines, 1930, Part 2.

The presence of salt in Windsor strata was suspected for a number of years because of the numerous salt springs that issue from these rocks. Salt was discovered in 1917 at Malagash, Nova Scotia, at a depth of 85 feet and has been mined continuously since that time, first at Malagash and now at Pugwash. A salt brine was started in 1946 near Amherst, Nova Scotia. Structurally, the rocks of the Amherst area are on strike with those of Pugwash. There are also salt deposits on Cape Breton Island. Two wells drilled in Lake Ainslie map-area in search of oil encountered more than 4,000 feet of salt-bearing strata in one well and more than 2,000 feet in the other. Both wells ended in salt (N.S. Dept. of Mines, 1956, pp. 121–141). Salt is suspected in Windsor rocks of the Bras d'Or Lakes area because of salt springs in the area. Salt springs are known at Whycocomagh, Bucklaw, Baddeck Bay, and other localities.

Barite

A small barite prospect near Judique South, in the western part of Whycocomagh map-area, was explored by trenching and shallow diamond drilling in 1955. The host rock for the barite is grey siltstone of the Strathlorne Member of the Horton Group and it is probably associated with the east-trending fault shown on the geological map (*in pocket*). A 2-inch vein of barite cuts conglomerate of the uppermost Ainslie Member of the Horton Group in a stream three-quarters of a mile southwest of Melford. It is stratigraphically located at the Horton–Windsor contact.

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[1] N. S. Dept. of Mines, Annual Report on Mines, 1961, p. 118.

Metallic Minerals

Metallic minerals in the two map-areas occur mainly in pre-Carboniferous rocks. Minor amounts of malachite are present in some Horton Group conglomerate in contact with A_1 Windsor limestone, and minor amounts of specularite are contained in Horton Group conglomerate near North Side Whycocomagh Bay. Within $1\frac{1}{4}$ miles of the southern boundary of Baddeck map-area, galena, sphalerite and chalcopyrite occur in A_1 Windsor limestone (Weeks, 1954, p. 105; Kelley, 1961, pp. 69–71).

Iron

Lindeman, E. (1941): Iron Ore Occurrences in Cape Breton; Rept. 285, Sum. Rept. of Mines Branch of the Dept. of Mines for the Calendar Year 1913.

Woodman, J. E. (1909): Report on the Iron Ore Deposits of Nova Scotia; Report 20, Mines Branch, *Can. Dept. of Mines.*

Exploration for iron ore was active in the late 1800's and early 1900's in the general area of Whycocomagh. The iron minerals occur as specularite in Horton Group rocks and as magnetite in George River Group rocks. There are no promising iron prospects in the map-areas. The early flurry of activity was generated by spotty iron occurrences over a fairly large area. Magnetite around Upper Glencoe appeared the most promising and exploration was conducted on the prospect in the 1940's and again in 1956. The Glencoe magnetite was discovered in 1912 and most of the exploration was carried on by Dominion Iron and Steel Company. The magnetite occurs as lenses along the contact, mainly, of limestone in the George River Group and granitic rocks.

Copper and Zinc

Dept. of Mines, Province of Nova Scotia, Files.

Grant, R. H. (1962): M.Sc. thesis (in preparation); University of New Brunswick, Fredericton.

There are more than twenty metallic mineral occurrences in Cape Breton Island associated with the contact between the George River Group and intrusive rocks. Two of these occur in Whycocomagh map-area: zinc near Lime Hill, and iron and copper north of Whycocomagh. The chalcopyrite and magnetite occurrence near the village of Whycocomagh has been known for at least 70 years; the numerous pits and trenches and two old shafts suggest that considerable effort has been expended in the search for ore. The chalcopyrite and magnetite occur in serpentinous limestone.

The area has been examined at least twice during the last 10 years. In 1953–55 exploration work included magnetometer and electromagnetic surveys, trenching, and two shallow drill-holes. In 1959–60 detailed magnetometer surveys, a limited amount of soil sampling, and more than 2,000 feet of diamond drilling were conducted near Whycocomagh.

Sphalerite was found in the Lime Hill area in 1959 as a followup of an earlier geochemical anomaly. Zinc had been known in the general area for a number of years (Guernsey, 1928, p. 82c). The sphalerite occurs as disseminated grains and as massive bands within limestone inclusions in granitic rocks. Some pyrrhotite and pyrite are also present; they are rarely associated with the sphalerite but commonly with the serpentinized limestone. The mineralized areas assay as much as 10 per cent zinc in places up to 20 or 25 feet wide. Exploration work has included geological mapping, soil geochemical surveys, geophysical surveys, trenching, and diamond drilling.

Manganese

Hanson, George (1932): Manganese in Canada; Econ. Geol. Series 12, *Geol. Surv. Can.*

Messervey, J. P. (1939): Manganese, A Special Report on Nova Scotia Occurrences; *N.S. Dept. of Mines*, Annual Report on Mines, 1938.

Smitheringale, W. V. (1928): The Manganese Occurrences of the Maritime Provinces, Canada; Unpublished Ph.D. Thesis M.I.T., Cambridge, Mass.

There are two occurrences of bog manganese on Boularderie Island near South Side of Boularderie. One occurrence is near the lakeshore, a short distance east of the east boundary of Baddeck map-area. The other is on the gently sloping bank of a small stream that approximately parallels the shoreline. In the latter occurrence, which is within Baddeck map-area, the manganese minerals are present under the bog topsoil, and, according to Smitheringale (1928, p. 105), the manganese oxide ranges from 1 foot to 7 feet in thickness and extends over about 27 acres.

Petroleum

Bell, W. A. (1958): Possibilities for Occurrence of Petroleum Reservoirs in Nova Scotia; *N.S. Dept. of Mines*, 177 pp.

Kelley, D. G. (1958): Mississippian Stratigraphy and Petroleum Possibilities of Central Cape Breton Island, Nova Scotia; *Can. Inst. Min. Met. Trans.*, vol. LXI, 1958, pp. 175–185.

Petroleum exploration has been carried on intermittently in Cape Breton Island since the latter part of the 19th century. The most recent exploration was by the Imperial Oil Company, which commenced work in 1956 and essentially concluded with the drilling of two dry holes in Lake Ainslie map-area in 1959–60.

Traces of petroleum have been noted in sandstone at several localities near Lake Ainslie (Norman, 1935, p. 185; Bell, 1927, p. 107). In Whycocomagh map-area, some gypsum and limestone are impregnated with bituminous material and when freshly broken yield an odour of petroleum. One of the best examples of bituminous limestone seen in Baddeck and Whycocomagh map-areas is along Southwest Mabou River. It is about 300 yards downstream from the northernmost Horton–Windsor contact. The limestone is in a predominantly gypsum section. Oil seeps and bituminous strata have been reported from northern Cape Breton Island (Neale, 1963b, 1964a).

The fact that indications of petroleum have been reported from the Windsor and Horton Groups suggests that there is a possibility of both these groups containing source beds. The Lower Windsor limestones and the Strathlorne Member of the Horton Group appear to be the most likely source rocks for petroleum. One of the most promising areas for shallow tests of Windsor strata is in the Denys Basin. Little is known of the structure of the Windsor Group in this area and it may be that a suitable drilling site could be found.

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1938b: Bras d'Or map-area, Nova Scotia; *Geol. Surv. Can.*, Map 359A.

1938c: Glace Bay map-area, Nova Scotia; *Geol. Surv. Can.*, Map 362A.

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