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GEOLOGY OF SOUTHAMPTON, COATS, AND MANSEL ISLANDS, DISTRICT OF KEEWATIN, NORTHWEST TERRITORIES

W. W. Heywood and B. V. Sanford

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PREFACE

Southampton, Coats, and Mansel islands, which delimit Hudson Bay on the north, were found soon after the discovery of Hudson Strait in 1610. Until recently, although it was known that Paleozoic rocks occupied the lower, southwestern part of Southampton Island, most of Coats Island, and all of Mansel Island, and that granitoid and gneissic rocks outcropped on the rugged northeastern part of Southampton Island, little of the detailed information so necessary in evaluating the mineral resources of the area was available.

During 1969 the Geological Survey conducted a helicopter-supported study of both the Paleozoic and Precambrian rocks; some preliminary results have already been published, but this is the first comprehensive report on the geology of the area.

A major role of the Geological Survey of Canada is to provide an inventory and understanding of the geological framework of Canada, and thereby permit an estimate of the potential abundance and probable distribution of the mineral and fuel resources available to the nation. Although the chances of finding hydrocarbon accumulations in commercial amounts on any of the islands studied are not great, certain lithological and structural characteristics of the Paleozoic strata point to possible occurrences in the deeper offshore parts of the Hudson Bay Basin.

D. J. McLaren,
Director, Geological Survey of Canada

Ottawa, May 29, 1974

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GEOLOGY OF SOUTHAMPTON, COATS, AND MANSEL ISLANDS, DISTRICT OF KEEWATIN, NORTHWEST TERRITORIES

Abstract

This report presents the results of helicopter-supported geological reconnaissance mapping. Two physiographic provinces are represented in the area: the Melville Plateau, underlain largely by rocks of Precambrian age, and the Southampton Plain, underlain largely by Paleozoic strata.

Precambrian rocks, typical of the Churchill Province, occur on Southampton, Coats, and nearby islands. A wide variety of granitoid rocks and gneisses form the bulk of the Precambrian. Isolated remnants of moderately to intensely metamorphosed basic volcanic rocks, greywacke and quartzite, and lime–silicate gneisses are the oldest rocks. Small bodies of basic and ultrabasic rocks are widely distributed.

Relatively nondeformed Paleozoic strata onlap the Precambrian rocks of the Bell Arch on the northern side of Hudson Bay Basin. The stratigraphic succession consists of the Ordovician Bad Cache Rapids Group, the 'Boas River shale', the Churchill River Group, and the Red Head Rapids Formation, and the Silurian Severn River, Ekwan River, and Attawapiskat formations. These rocks consist of limestones, dolostones and minor sandstone and shale, and attain a composite thickness of approximately 1500 feet.

Numerous biohermal structures occur in the upper Ordovician rocks of Southampton Island, and Silurian Attawapiskat reefs are found on Southampton, Coats, and Mansel islands.

Résumé

Ce rapport expose les résultats des levés de reconnaissance géologique effectués par hélicoptère. On retrouve dans la région deux provinces physiographiques: le plateau Melville qui recouvre en majeure partie des roches précambriennes, et la plaine Southampton caractérisée surtout par des couches paléozoïques.

Les roches précambriennes, caractéristiques de la province Churchill, sont situées dans les îles Southampton, Coats et dans les îles environnantes. Le Précambrien est caractérisé en majeure partie par une variété étendue de gneiss granitoïdes et d'autres roches également à caractère granitoïde. Les vestiges isolés de roches volcaniques basiques de métamorphisme moyen à intense, les grauwackes et les quartzites, ainsi que les gneiss de silicate de chaux constituent les roches les plus anciennes. On trouve également des petits massifs de roches basiques et ultrabasiques largement répartis.

Des couches paléozoïques relativement non déformées débordent les roches précambriennes de la presqu'île Bell située sur la côte nord du bassin de la baie d'Hudson. La succession stratigraphique se compose du groupe ordovicien Bad Cache Rapids, des schistes de Boas River, du groupe de Churchill River et de la formation de Red Head Rapids; elle renferme aussi les formations siluriennes de Severn River, de Ekwan River et d'Attawapiskat. Ces roches se composent de calcaire, de dolostone, de petites formations gréseuses et de schistes argileux, et peuvent atteindre une épaisseur d'environ 1500 pieds.

On retrouve de nombreuses structures de bioherme dans les roches de l'Ordovicien supérieur de l'île Southampton, et les récifs siluriens de l'Attawapiskat sont situés dans les îles Southampton, Coats et Mansel.

INTRODUCTION

This report presents an account of geological reconnaissance mapping that was done in 1968, 1969, and 1970 by the Geological Survey of Canada in the northern Hudson Bay region. Investigations on Southampton, Coats, and Mansel islands, as well as on several smaller adjacent islands, are included. With an area of 15 700 square miles, Southampton Island is the largest in the group; the area of Coats Island is 2200 square miles, and that of Mansel Island is 1285.

The community of Coral Harbour, on a small inlet of South Bay on Southampton Island, is the only permanent settlement in the area; it is located about 510 miles northeast of Churchill, Manitoba, and about 450 miles west of Frobisher Bay, Baffin Island. The Ministry of Transport maintains a base and an excellent all-weather gravel airstrip 6½ miles northwest of the community. Radio, telegraph, and radio-telephone communications are available. The Hudson's Bay Company operates a well-stocked store at Coral Harbour.

Air transport provides the only year-round means of access to the northern Hudson Bay area. Chartered aircraft are available from bases at Churchill and Frobisher Bay, and scheduled passenger and freight flights are provided by Transair from Churchill, and by Nordair from Frobisher Bay. Supply ships navigate in the area from late July until mid-October. The shipping season could possibly be extended by the use of icebreakers and reinforced ships, with unloading carried out by large helicopters or air-cushioned vehicles from offshore anchorage.

Helicopters and balloon-tired, fixed-wing aircraft can be used during all seasons. Fixed-wing aircraft could be landed almost at will in the areas underlain by Paleozoic rocks, and

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in many areas of the Precambrian. Ski-equipped aircraft can be operated until mid-June in most years, and restricted float operations can be undertaken in mid-July. Large transport aircraft on skis and/or wheels could land on lake ice in many parts of the region. In most areas underlain by Paleozoic rocks, construction of landing sites would require little more than ground checking and marking, or at most, the filling of a few frost cracks.

Several types of tracked vehicles and motor toboggans can be used until mid-June, and large carriers (ATV's) may prove useful for transporting personnel and for light freighting duties.

Canoes and boats are of little use on inland waters. Rivers are shallow and small in the Paleozoic areas, and impossible to navigate in the Precambrian regions. They can be used in coastal areas during the short summer season when and where wind and ice conditions are favourable.

Brief History of Discovery and Previous Geological Investigations

Southampton Island, as now defined, was sighted by Thomas Button in 1613 during his passage into Roes Welcome Sound. The name Southampton was later loosely applied to the whole region, although it was originally given to a cape on what is now known as Coats Island. In 1615, Bylot and Baffin sailed along the north coast of Southampton Island from Seahorse Point to Frozen Strait. Middleton's voyage in 1742 to Repulse Bay and Frozen Strait via Roes Welcome Sound demonstrated that Southampton is an island. In 1864, Fisher, a whaling captain, sailed through the strait that bears his name and thereby demonstrated that Coats and Southampton are separate islands.

Many of the early explorers made reference to the physiography of the island and indirectly to the geology. Robert Bell (1885) was the first geologist to visit the area, and he noted that Seahorse Point was underlain by gneiss. During the cruise of the *Neptune*, Low (1905, 1906) made several observations on Southampton Island, described some of the rocks, and mapped the gross distribution of the Paleozoic and Precambrian rocks as exposed on the shores. Between 1907 and 1909, George Comer (1910) made a survey of Southampton Island, and published a sketch map showing the geography, the general physiography, and the distribution of the two major rock-types (limestone and granite); Munn (1919) visited the island to prospect for minerals, and he produced brief notes with an accompanying geological sketch map.

Mathiassen (1931) reported on the physiography of the area as part of the explorations carried out by the Fifth Thule Expedition. Manning (1936, 1942) led an expedition to study the area, and Bird (1953) published a report on the physical geography of the island. Daniels (1956) reported on the petrology of some of the Precambrian rocks that were collected by W. A. Deer in the Coral Harbour area. Nelson and Johnson (1966) published an account of the Hudson Bay Basin that included northern Hudson Bay.

Present Investigations and Acknowledgments

Field work on the islands in the northern part of Hudson Bay was undertaken by the Geological Survey of Canada during 1968, 1969, and 1970 (Fig. 1). In 1968, W. W. Heywood carried out a one-week preliminary reconnaissance survey of Southampton Island, using a float-equipped Cessna 180. During that same season, B. V. Sanford made a flight across the northern part of Hudson Bay, utilizing Bell Jet Ranger helicopters, and briefly examined Paleozoic rocks on Mansel, Coats, and Southampton islands. Aquitaine Company of Canada Limited gave valuable assistance and support on this preliminary reconnaissance.

Field work on Southampton Island was completed between June 15 and August 25, 1969. The Paleozoic rocks were mapped by B. V. Sanford, and the Precambrian by W. L. Davison and W. W. Heywood, the last-named being in charge of the field project. Capable assistance was rendered in the field by R. J. Joy and M. T. Masella (student assistants) and by F. Benoit (cook). A Bell 47 G-2 helicopter, chartered from Viking Helicopters Limited of Ottawa, was operated by K. Eytcheson (pilot–engineer).

Transportation from Churchill to Coral Harbour was by chartered Transair DC-4, and gas caching was completed by Transair, using a ski-wheel DC-3.

The co-operation and assistance provided by the Ministry of Transport personnel at Coral Harbour, in particular that of M. R. Kitchen, airport manager, was greatly appreciated. R. King, of the Hudson's Bay Company, and H. Stevenson, area administrator of the Department of Indian Affairs and Northern Development, extended many courtesies.

In 1970, the Ministry of Transport icebreaker CCGS *Labrador* was made available to the Geological Survey of Canada to complete the reconnaissance geological mapping of Coats, Bencas, and Walrus islands.

The field party, consisting of B. V. Sanford, T. E. Bolton, and W. W. Heywood, joined the *Labrador* at Coral Harbour, Southampton Island, on July 30, 1970, and returned there on August 5.

During the course of this field work, the *Labrador* was used as a mobile base, occupying stations around Coats Island, on the east coast south of Cairn Cove, at Shoran Bay, and at Calanus Bay. From these locations reconnaissance flights were undertaken, using a Bell 47-J helicopter based on the ship.

Personnel of the Ministry of Transport, and of the Marine Sciences Branch (then part of the Department of Energy, Mines and Resources) assisted in arranging the 1970 project. Captain P. Tooke and the crew of the *Labrador* contributed greatly to the success of the project, and A. E. Oldman was the helicopter pilot.

Physiography

Two main physiographic subdivisions reflect the underlying Precambrian and Paleozoic rocks on the islands of northern Hudson Bay. Bostock (1970) classified them as parts of the Melville Plateau (Precambrian) and the Southampton Plain (Paleozoic) (Fig. 2). Bird (1953) outlined and named many of the smaller physiographic units.

Melville Plateau

On Southampton Island the Melville Plateau rises from the south to form an undulating surface more than 1000 feet above sea level. The northeast boundary of the upland rises abruptly from Foxe Channel along a series of fault scarps and fault-line scarps that are from 500 to 1000 feet high. Near the coast this escarpment is intersected by deep valleys that locally are vertical-sided gorges. Turbulent short rivers and streams with almost continuous rapids and falls characterize this area. The rivers to the south are fast flowing but maintain more or less constant gradients in broad valleys.

Outcrops in the central part of the plateau are widely spaced and commonly deeply weathered. The mantle appears to be composed largely of the underlying bedrock with few to abundant glacial erratics (Pl. 1). For the most part there is little other direct evidence of glaciation; however, striae were noted near Cape Welsford and Cape Comfort, and drumlinoid ridges are present northeast of Big Corner Cliff.

161910

PLATE 1. Rolling topography of the Kirchoffer Upland. Frost-heaved angular boulders represent underlying bedrock.

A spine of Precambrian rocks extending from Gore Point to Seahorse Point and the low ridge from Terror Point to Saunders Point on Bell Peninsula are separated by a graben of low relief underlain by Paleozoic rocks. Rounded hills rise to about 700 feet along this spine, and Mount Minto, a prominent hill, is more than 1100 feet high. Weathering is not so extensive as in the central plateau, and glacial striations are preserved in the Seahorse Point area.

The Precambrian terrain, comprising the northeastern part of Southampton Island, was undoubtedly uplifted to its present topographical position subsequent to Middle Silurian time. This uplifted area was named Bell Arch by Nelson and Johnson (1966).

Precambrian rocks underlie about 400 square miles on the northern end of Coats Island. The Precambrian surface rises abruptly from Evans Strait to a maximum elevation of about 600 feet, then slopes gently southerly and southwesterly to the contact with Paleozoic rocks. Good exposures are present in the coastal areas, but inland outcrops are low and widely spaced.

Southampton Plain

The Southampton Plain, underlain by relatively flat-lying Paleozoic rocks, forms the western and southern part of Southampton Island, most of Coats Island, and all of Mansel Island. In general, the plain has very low relief, ranging from flat to gently undulating. Elevations rarely exceed 500 feet. The surface material is composed of shattered Paleozoic carbonates and gravels with widely distributed granitoid pebbles and boulders in a clay matrix (Pls. 2, 3, 7). The carbonate fragments range from small angular pebbles to slabs a foot or more in diameter and ½ inch to 18 inches thick. Much of the carbonate detritus reflects the lithology of the underlying bedrock.

The coastal areas of Southampton Island, underlain by Paleozoic rocks, are generally low with broad tidal mud flats that are as much as 3 miles wide on the northern shore of the Bay of Gods Mercy. Locally, as at Duke of York Bay, there is deep water close to shore. Broad swampy areas, not more than a few feet above sea level, characterize the lower reaches of the Boas River valley, and the northern part of Bell Peninsula, bordering East Bay (Pls. 4, 5 . During the early

161925

PLATE 2. Intensely fractured and frost-heaved Silurian limestone terrain, west of Munn Hills, Southampton Island.

161933

PLATE 3. Desert terrain composed of well-sorted gravels in central Bell Peninsula.

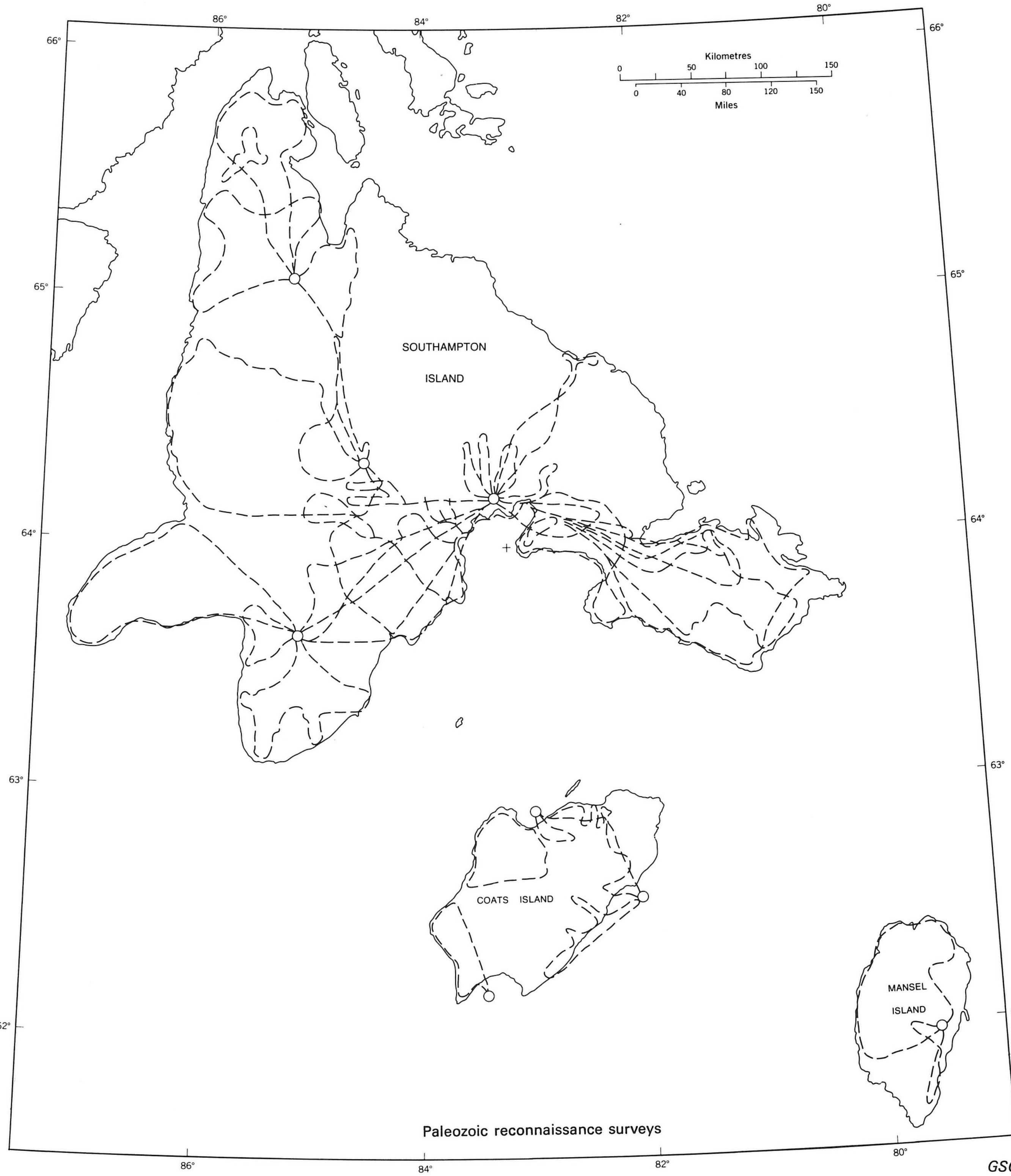
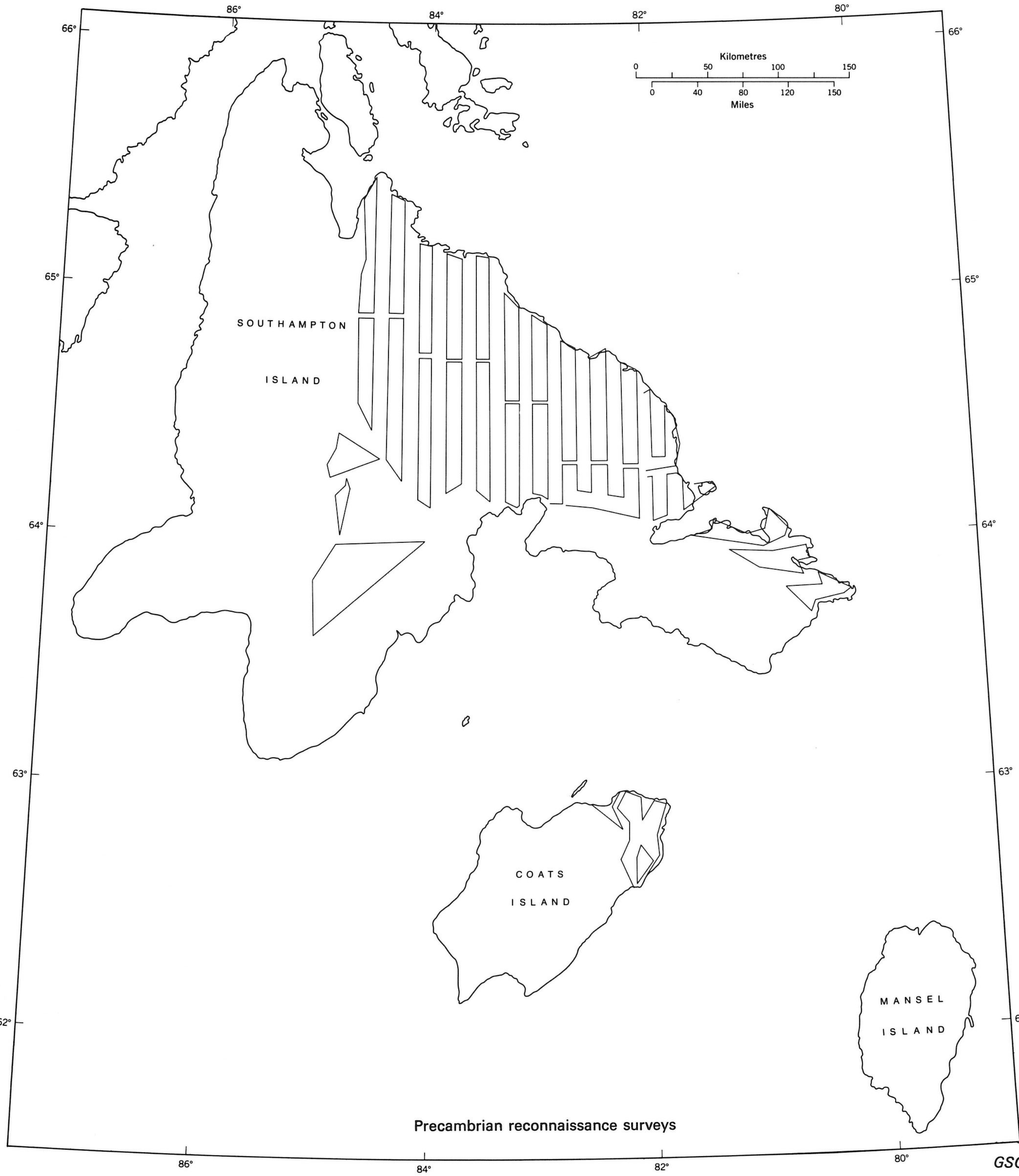


FIGURE 1. Maps of northern islands of Hudson Bay showing location of reconnaissance surveys of 1968, 1969, and 1970.



86°
84°
82°
80°
66°
65°
64°
63°
62°
Kilometres
0
50
100
150
0
40
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120
150
Miles
SOUTHAMPTON
ISLAND
COATS
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ISLAND
Precambrian reconnaissance surveys
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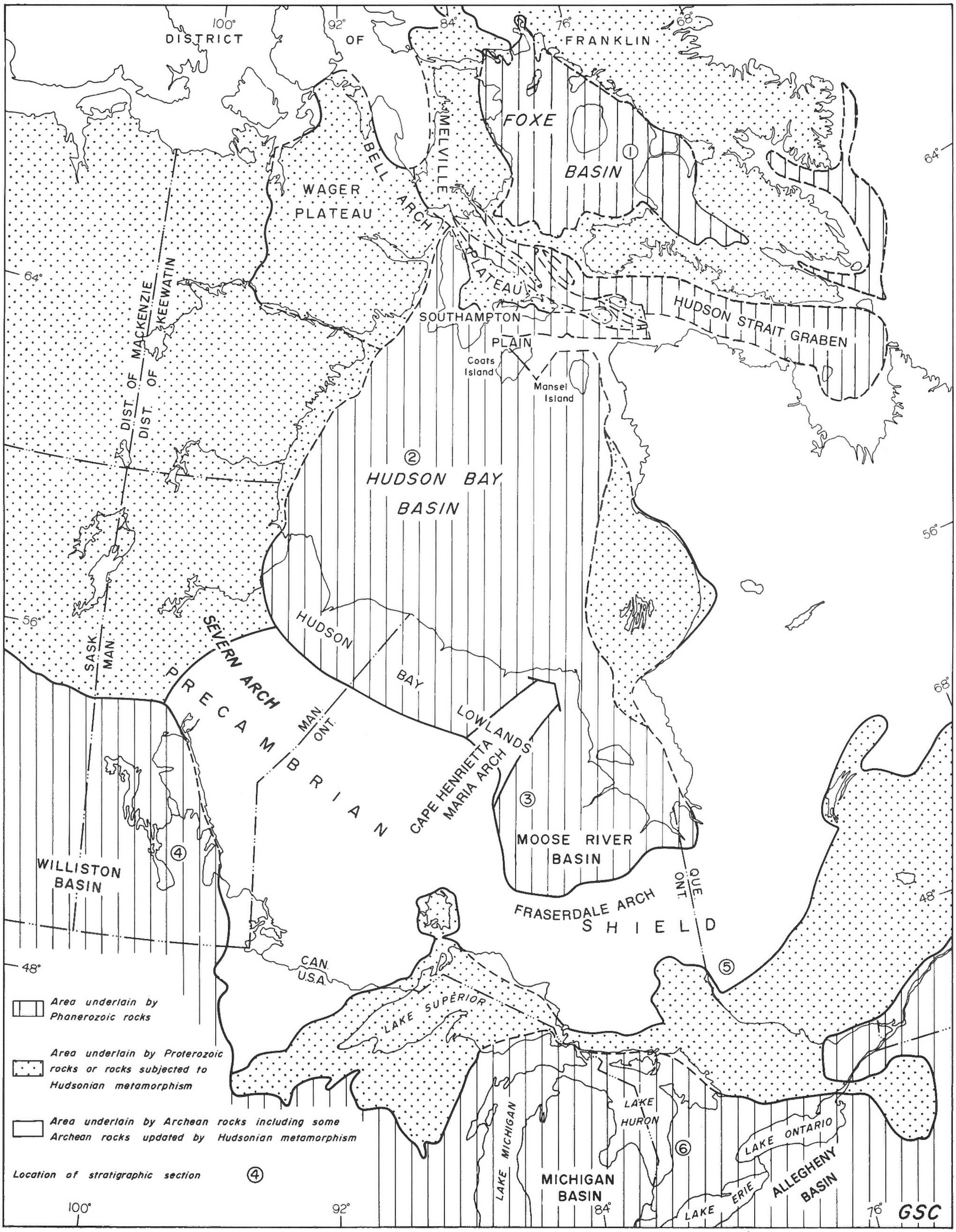


FIGURE 2. Index map showing Southampton, Coats, and Mansel islands and adjacent related areas.

161934

PLATE 4. Low swampy area bordering East Bay, showing small ponds separated by gravel bars. (Mount Minto in background).

149578

PLATE 5. Lower Boas River valley, showing low swampy terrain near Hudson Bay coast.

stages of breakup, these areas may be covered by a foot or more of water.

Boas River, which rises in the central plateau, Cleveland River, and Sutton River provide the main drainage in the plains area of Southampton Island. All flow in broad valleys and connect several large lakes. About 20 miles from the coast, Boas River divides into several distributaries and for the last 6 miles of its course has a braided pattern up to 4 miles wide (Pl. 5). Numerous small to intermittent streams drain the peripheral areas. Generally, they are in shallow valleys inland near the sea; some are entrenched in steep-sided gorges as much as 50 feet deep (Pl. 6). After the initial spring runoff, much of the drainage is underground in the frost-shattered carbonates.

The physiographic expression of the Paleozoic areas of Coats and Mansel islands is similar to that of Southampton Island. The gently undulating surface does not exceed elevations of 350 feet. Tundra ponds and muskegs characterize much of the low-lying areas on Coats Island, whereas Mansel Island is largely covered by Paleozoic gravels and minor patches of vegetation.

On all of the islands, complex patterns of abandoned beaches, bars, and terraces are spectacular features, especially

149607

PLATE 6. Typical river channel cutting through surficial deposits and Paleozoic limestones; view southward along Rocky Brook with Hudson Bay in background (note joint systems).

149604

PLATE 7. Raised beaches (Paleozoic gravels); looking northward across southwestern part of Southampton Island.

149537

PLATE 8. View westward across Mansel Island, showing extensive raised beaches composed of Paleozoic gravels.

in the Paleozoic terrain from sea level to about 150 feet above present sea level (Pls. 7, 8).

On Bell Peninsula the maximum elevation that was subjected to wave action is clearly marked at about 450 feet above sea level. Below this line the morainic material has been wave-washed and crudely sorted, in marked contrast to the undisturbed moraine above.

GENERAL GEOLOGY

The heterogeneous, metamorphosed Precambrian rocks of Southampton, Coats, and nearby islands are typical of the Churchill Province. The oldest rocks consist of isolated remnants of basic volcanic rocks, greywacke, quartzite and impure quartzite, all moderately to intensely metamorphosed, and lime–silicate gneisses, probably derived from lime-rich sediments. Granitoid rocks and various gneisses form the bulk of the Precambrian. Although these rocks have been subdivided, considerable difficulty was encountered in establishing mappable lithological units. The more distinctive characteristics are used, but the boundaries often are ill-defined or arbitrary. In general, the units have recognizable gross characteristics, but each individual specimen or outcrop might be placed in any one of several units. Scattered small bodies of basic and ultrabasic rocks are relatively young, but predate the final stages of metamorphism in the area. Diabase sills and dykes are the youngest Precambrian rocks in the region.

Paleozoic sequences of Southampton Island consist of flat-lying to gently dipping sedimentary rocks that underlie Bell Peninsula and the western part of the island; similar rocks are exposed on Coats and Mansel islands. As these rocks represent the northern part of Hudson Bay Basin, Sanford (1970) and Sanford and Norris (1973) applied the same nomenclature as that used in the Hudson Bay Lowlands (Sanford *et al.*, 1968) during Operation Winisk (Table of Formations; Table I, *in pocket*; Fig. 2).

Precambrian Geology

Southampton Island

The distribution of Precambrian rocks on Southampton Island was determined by ground observations and airphoto interpretation. These rocks occupy about 5500 square miles in the central part of the island and in the northern part of Bell Peninsula. Small inliers in the Paleozoic occur between Salmon Pond and The Points, and in the valleys of Rocky Brook and Sixteen Mile Brook.

Metavolcanic Rocks (*unit 1*)

A small outlier, about a mile in diameter, of basic and intermediate volcanic rocks (1a) occurs 16 miles north of The Points (63°51′N, 85°00′W). Outcrops are small and widely spaced, although resistant units form more or less continuous ridges or lines of low rubbly outcrops (Pl. 9). A thickness of about 2000 feet is indicated, assuming that the dips are constant, that they average about 40 degrees, and that there is no repetition due to faulting.

161913

PLATE 9. Small scattered outcrops of metavolcanic rock of unit 1.

The basic volcanic rocks, possibly derived from basalts and/or andesites, are dark green to black on fresh surfaces and dark green where weathered. Feldspar phenocrysts weather a chalky white. No primary structures were observed.

Microscopic examination shows that these fine grained rocks are completely altered, and no primary minerals are preserved. Plagioclase, biotite, chlorite, epidote, actinolite, actinolitic hornblende, and minor quartz and magnetite are present. Remnants of garnet were seen in a few thin sections. The rocks have a moderately well developed foliation derived in part from irregular lenses and layers of light and dark constituents, and from a slight preferred orientation of the elongate minerals. An altered, medium to fine grained, more or less equigranular dioritic rock is associated with the basic volcanic rocks. The relationship of the dioritic and metavolcanic rocks is not known; however, the diorite appears to be part of a thick sill.

The intermediate volcanic rocks, of dacitic to andesitic composition, are interlayered with the basic group but are most common on the north side of the outcrop-area. They weather medium to dark grey and are dark grey to greenish grey on fresh surfaces. No clearly defined primary structures were recognized; however, moderately well developed layers ranging from 4 inches to 2 feet may represent a primary feature.

These rocks are fine grained and in hand specimen appear more or less equigranular. Microscopic examination reveals that they are composed almost entirely of a felty mass of secondary minerals. The main minerals present are: quartz, plagioclase, muscovite, biotite, actinolite, chlorite, and pyrite. Remnants of garnet and sillimanite are apparently preserved from a higher grade of metamorphism. Rounded to subangular shapes, and the distribution of some of the mafic aggregates, suggest a pseudomorphic origin.

Amphibolite (1b) and basic gneiss (1c) are conformable with the basic gneisses of unit 4, and in many areas boundaries are not clear-cut. The two subunits differ in their content of quartz and feldspar, and in texture and structure.

Amphibolitic rocks (1b) also occur as sill-like bodies associated with the biotite–quartz–feldspar gneiss (4). They range from well foliated to almost massive, and are commonly dark green to black on fresh and weathered surfaces. Most are medium grained, but a few are fine grained. These

Table of Formations

ERA	PERIOD OR EPOCH		GROUP, FORMATION MAP-UNIT	
CENOZOIC	PLEISTOCENE AND RECENT			Gravel, sand, silt and clay
			Unconformity	
	MIDDLE SILURIAN	NIAGARAN	ATTAWAPISKAT FM. (175′)	Massive biostromal limestone and dolomite with bioherm reef swarms
			EKWAN RIVER FM. (300′)	Thin-bedded stromatolitic limestone at base, succeeded by biostromal and biohermal limestones, and massive thick-bedded dolomitic limestone at top
			SEVERN RIVER FM. (500′)	Thin- to thick-bedded mottled limestone and dolomite
	EARLY SILURIAN	ALEXANDRIAN		Disconformity
	LATE ORDOVICIAN	RICHMONDIAN	RED HEAD RAPIDS FM. (200′)	Uniformly bedded stromatolitic limestone and dolomite with thick, massive biostromal and biohermal facies in upper part
			CHURCHILL RIVER GP. (175′-200′)	Argillaceous limestone with lenses of orange and brown mottled algal limestone
		MAYSVILLIAN		Disconformity
		EDENIAN-BARNEVELD	'BOAS RIVER SHALE' (5′-7′)	Thin-bedded black calcareous and petroliferous shale
			BAD CACHE RAPIDS GP. (150′+)	Nodular bedded argillaceous micritic limestone with yellowish orange mottling
			Major nonconformity	
PROTEROZOIC			UNIT 8	Diabase and gabbro dykes
			Intrusive contact	
ARCHEAN			UNIT 7	Basic and ultrabasic rocks; 7a, metapyroxenite; 7b, anorthositic gabbro; 7c, anorthosite
			UNIT 6	Granodiorite and allied rocks, massive to slightly foliated, locally abundant mafic inclusions; 6a, quartz-monzonite
			UNIT 5	Granitoid gneiss and migmatite. Locally includes units 3 and 4
			UNIT 4	Biotite-quartz feldspar gneiss; 4a, well foliated, locally layered; includes granulite, basic gneiss and amphibolite, fine- to medium-grained massive to moderately foliated
			UNIT 3	Layered gneiss, fine-grained, thinly layered, locally extremely contorted; 3a, garnetiferous gneiss; 3b, hornblende-biotite gneiss
			UNIT 2	Metasedimentary rocks; 2a, quartzite and impure quartzite; 2b, lime-silicate gneiss
			UNIT 1	Basic and intermediate volcanic rocks and derived metamorphic rocks; 1a, metavolcanic rocks; 1b, amphibolite; 1c, basic gneiss. Relationship to 2 unknown

GSC

rocks consist essentially of green hornblende and plagioclase, with as much as 15 per cent quartz and 10 per cent brown biotite.

Basic gneiss (1c) occurs in a long band southeast of Mount Saorre, and near the coast north of the Porsild Mountains. The gneisses are dark grey to dark green, and are commonly medium grained although, locally, coarse grained phases are present. Thickness of the layers averages less than an inch, and ranges from ¼ inch to several feet. The dark layers form 60–75 per cent of the rock, and are composed essentially of hornblende and biotite with lesser amounts of quartz and plagioclase. The lighter coloured layers consist of about equal amounts of light and dark minerals.

Metasedimentary Rocks (*unit 2*)

The metasedimentary rocks of unit 2 are widely distributed but are preserved only as small remnants in areas of layered biotite–quartz–feldspar gneisses (4). Quartzite and impure quartzite (2a) occur in and near the Porsild Mountains, and about 10 miles south of Cape Donovan where they form resistant ridges that stand in marked contrast to adjacent gneisses. The quartzite weathers white to creamy white and is white on freshly broken surfaces. The impure quartzite ranges from white to grey and, in places, appears to be transitional between quartzite and layered gneiss. In the Porsild Mountains the quartzite is underlain by cordierite–sillimanite schist and layered gneiss that is conformable with, and apparently grades into, typical gneiss of unit 4. No primary structures other than a faint suggestion of bedding are preserved. All the quartzites are moderately to well foliated and are fine to medium grained. In thin section they are seen to be composed of 60–90 per cent interlocking quartz grains; however, no original grain boundaries or cement can be recognized. The impure varieties contain as much as 15 per cent calcic plagioclase, 7–15 per cent garnet, and up to 10 per cent biotite. Sillimanite and cordierite are abundant in the quartzite near the gneiss contact in the Porsild Mountains. Up to 3 per cent graphite is present in the quartzite near the headwaters of the east branch of Kirchoffer River.

Crystalline limestone and calc-silicate gneisses (2b) associated with quartz-rich gneisses occur about 10 miles northeast of Mount Saorre. Although outcrops are small and widely scattered, these rocks appear to be interlayered with gneisses of unit 4. The crystalline limestone generally contains some silicate minerals and apparently is interlayered with, or grades into, calc–silicate gneisses. One thin section of fine to medium grained rock showed: quartz, 7 per cent; microcline, 14 per cent; plagioclase (An_{30}), 15 per cent; calcite, 15 per cent; diopside, 33 per cent; and about 15 per cent colourless to very pale green amphibole. Epidote and sphene are accessory minerals.

These small discontinuous layers of limy and quartzose rocks in the areas of gneiss suggest a sedimentary origin for some, if not most, of the gneissic complex.

Layered Gneiss (*unit 3*)

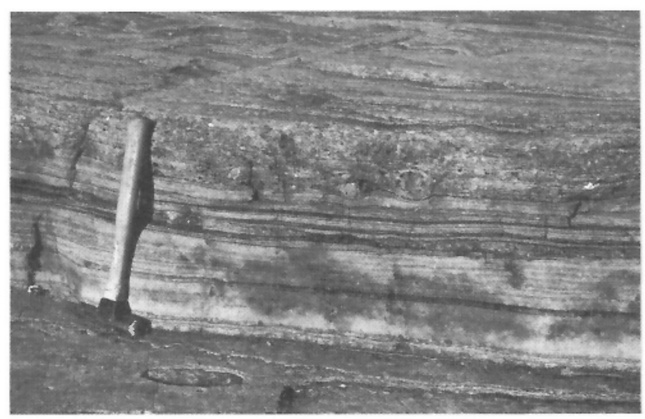
The layered gneiss of unit 3 outcrops on Bell Peninsula, Cape Donovan, Caribou Island, and in a broad basin from East Bay northerly to the vicinity of Cape Fisher. Similar rocks occur as inliers north and south of Salmon Pond in the central-western part of the island.

Characteristically, this gneiss is well layered, with thickness of the layers averaging less than an inch but ranging from ¼ inch to several feet (Pls. 10, 11). The layers can be traced for several hundred feet in some outcrops, and in others they are highly contorted and not traceable. Grey to pinkish grey weathering, felsic to intermediate gneisses predominate but, locally, mafic gneisses are common. Amphibolitic layers, 1 inch to 12 inches thick, are continuous in some places, and apparently discontinuous where they are folded, contorted, and boudinaged.

The largest area of layered gneiss occurs on the eastern side of the island. Excellent exposures along the coast clearly display the structures characteristic of this rock. Typical layered gneiss is finely layered, medium to fine grained, and equigranular. In some areas, potash feldspar porphyroblasts and aggregates of crystals up to 1 inch in diameter constitute as much as 20 per cent of the rock. Most of the foliation is straight to gently undulating; however, in places it is complexly folded, or forms swirls and various sinuous forms.

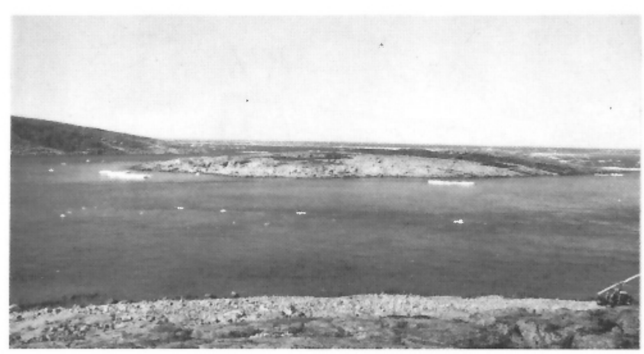
The exposures on Bell Peninsula are similar, although they appear to be more pinkish, possibly due to a slightly higher potash feldspar content.

In the Salmon Pond area, well-layered felsic gneisses are exposed along a northerly trending ridge. Thickness of the layers averages about ½ inch, and at the southern end of



161911

PLATE 10. Well-layered, fine grained gneiss of unit 3 on Caribou Island.



161912

PLATE 11. Amphibolite layers in gneiss on Seahorse Point.

the outcrop-area such layers form parts of much thicker ones that have an overall felsic or intermediate composition. In places, quartz veins and stringers are abundant, and several pegmatitic to granodioritic sills and dykes as much as 20 feet thick are present. The contacts between layers are generally sharp, and the continuity of well-defined layers suggests more or less contemporaneous origin. Quartz, plagioclase, and potash feldspar (commonly microcline) with small amounts of biotite are the major constituents.

Typical specimens examined in thin section contain minerals as listed in Table II.

TABLE II *Modal analyses of layered gneiss, unit 3*

Mineral	Percentage
Quartz	17–35, average 27
Plagioclase	20–46, average 37
Potash feldspar	12–33, average 23
Hornblende	0–2,
Biotite	8–15, average 10
Muscovite	less than 1

Muscovite and hornblende were observed in one half of the sections examined. Garnet is locally present. Accessory minerals include apatite, sphene, and iron oxide. Chlorite and epidote are common replacement minerals. The general texture of the rock is granoblastic, with the biotite and hornblende giving a distinct foliation.

Biotite–Quartz–Feldspar Gneiss (unit 4)

The rocks grouped as biotite–quartz–feldspar gneiss (4) form the largest map-unit in the area. They outcrop in a broad arcuate belt that more or less surrounds the drainage basin of Kirchoffer River. The best exposures are along the northeastern coast from Cape Bylot to Cape Fisher. In the more gently rolling upland areas the outcrops tend to be low, moderately to deeply weathered, and commonly obscured by moss and lichen. Although this unit contains a wide variety of gneisses, sufficient detailed information is not available to permit a satisfactory subdivision. Included in it are layers and zones of basic gneiss, amphibolite, and granulite.

In general, these rocks are pink to grey, medium grained, equigranular, and have a well-developed foliation. Gneissosity grades from faint to stratiform, and layers, where present, range in thickness from a few inches to several feet. Most of the foliations dip moderately to steeply; however, areas of low-dipping to horizontal gneisses (Pl. 12) do occur. Some of these low-dipping quartzofeldspathic rocks are thick bedded, and where outcrops are small and sparse they commonly appear massive. The biotite–quartz–feldspar gneiss commonly has gradational contacts with the rocks of units 3 and 5, but contacts with units 1 and 2 range from sharp to gradational over a few feet.

The main constituents are quartz and white to grey plagioclase. Biotite is the major mafic mineral, although hornblende may be locally abundant and pyroxene was observed in a few places. The modal analyses in Table III are of rocks collected from widely separated localities.

161909

PLATE 12. Well-developed jointing parallel to gneissosity in low-dipping gneiss.

TABLE III *Modal analyses of biotite-feldspathic granulite, unit 4b*

Mineral	Percentage
Quartz	33–59, average 44
Plagioclase	31–55, average 44
Potash feldspar	9–8,
Biotite	5–13, average 8
Hornblende	0–8,
Pyroxene	0–5,

Microcline is present in about half of the thin sections examined, and hornblende and pyroxene in about one third. Hornblende occurs most abundantly in the areas north and south of Mount Scotch Tom. Muscovite was observed in three widely separated localities. Minor constituents include garnet, apatite, sphene, and magnetite. Some chlorite and epidote occur as alteration products.

Unit 4b forms an east–west belt in the central part of Kirchoffer Upland. This unit differs from unit 4a in that foliation and layering are poorly developed. These rocks are generally deeply weathered, crumbly, massive quartzofeldspathic granulites, and foliated granulites. Most are medium grained, more or less equigranular, and have a granular texture. Each modal analysis given in Table IV is an average of four thin sections.

TABLE IV *Modal analyses of quartzofeldspathic granulite, unit 4*

Mineral	Percentage
Quartz	27–39, average 35
Plagioclase	24–56, average 41
Potash feldspar	0–32,
Biotite	3–10, average 7
Hornblende	0–4,
Pyroxene	4 average 2

Under the microscope quartz and plagioclase are seen in varying proportions. Potash feldspar, present in half of the thin sections examined, is in the form of discrete crystals of microcline and perthite; a minor amount of antiperthite was noted in one section. Oligoclase is the usual plagioclase.

Accessory minerals include magnetite, apatite, and sphene. The minerals in these rocks are unaltered, with the exception of rarely clouded feldspars.

Granitoid Gneiss and Migmatite (*unit 5*)

In the Cape Welsford area, granitoid gneiss and migmatite of unit 5 occur on Bell Peninsula in an elongate band that extends northerly from The Buttocks, and northerly from Coral Harbour in the drainage basin that includes the lower reaches of Kirchoffer River, Post River, and the unnamed northern tributary of Ford River.

Exposures are poor, except in the Cape Welsford area, along the western escarpment, and in the area around Coral Harbour. Outcrops are small, rounded, and commonly deeply weathered in most areas, but fresh specimens can usually be obtained in stream beds and along some scarps. Contacts could not be defined in the field as they appear to be gradational with units 3 and 4.

These rocks form a diverse group and share a number of common characteristics. Various shades of grey and pink predominate on both fresh and weathered surfaces. The grey gneisses appear to have stratiform layering and consistent foliation, whereas the pink gneisses appear to be more contorted and migmatized. All gradations exist between these two extremes, and the rocks are mixed in all proportions. Patches of massive granitic material containing mafic remnants are present in the most intensely contorted areas. Granitic sills and dykes, of composition similar to that of the irregular granitic patches, are widely distributed.

Miscroscopic examination of widely selected specimens from the granitic material reveals the varying proportions of the major constituents listed in Table V. Hornblende is present in less than half of the sections examined; pyroxene and muscovite are found in about 10 per cent. Garnet occurs in some of the mafic rocks. Accessory minerals include apatite, sphene, and magnetite. Minor alteration is evident but is largely restricted to local development of epidote.

TABLE V *Modal analysis of granitoid gneiss, unit 5*

Mineral	Percentage
Quartz	23–49, average 35
Plagioclase	24–16, average 38
Potash feldspar	2–35, average 16
Biotite	2–16, average 7
Hornblende	0–7

Mafic material occurs, in part, as elongate inclusions in the gneiss and, in part, appears to be disjointed remnants of once continuous layers. The remnants appear most commonly in the pinkish grey or grey gneisses.

Granodiorite and Associated Rocks (*unit 6*)

Granodiorite and associated rocks are mainly distributed throughout the gneissic complex as dykes and sills; however, in a few areas they are large enough to form mappable units. On Bell Peninsula, massive to slightly foliated granodiorite outcrops extensively, and numerous dykes and sills intrude the gneissic rocks. Massive granodiorite outcrops west of Coral Harbour, near the headwaters of Rocky Brook. The contacts with the larger units appear to be gradational. Pegmatitic and granitic dykes as much as 200 feet thick intrude the layered gneiss on Gore Point.

These granitic rocks resemble the gneisses (unit 5) in composition but differ in texture and structure. The composition of the larger units is not uniform but ranges from granodiorite to quartz diorite; the nature of the change, whether sharp or gradational, could not be determined from the air, and lack of time and the scattered nature of the outcrops limited ground traversing.

Porphyritic and pegmatitic granodiorite dykes outcrop extensively in the Gore Point area where they form as much as 20 per cent of the rock. The rock is medium to coarse grained, and is salmon-pink on both fresh and weathered surfaces. In places, it consists of feldspar phenocrysts, as much as 12 inches in diameter, in a matrix of quartz and feldspar. Large biotite and hornblende crystals are irregularly distributed. Elsewhere, this rock has the same composition but is more or less equigranular. Rotated gneiss inclusions in the larger dykes appear fresh and unaltered. A similar, faintly foliated pink granodiorite forms two thick, almost horizontal sills about 4 miles northwest of Teshikalik Lake. These sills consist of 30 per cent quartz, 50 per cent plagioclase (An_{24}), 15 per cent microcline, and 5 per cent biotite.

Pegmatite dykes, as much as 20 feet thick, are widely distributed, but are most common on Terror Point and in the Cape Welsford area.

Basic and Ultrabasic Rocks (*units 7a, b*)

An outcrop of metapyroxenite (7a) on the east coast of Southampton Island, near the mouth of Liver Creek, is 750 feet long and 150 feet wide and is surrounded by sand and gravel beaches that cover all contacts with adjacent gneisses. The rock is massive, medium to coarse grained, and dark brown to black on both fresh and weathered surfaces. In places it is porphyritic, with pyroxene crystals as much as 6 inches in diameter in a medium grained matrix of pyroxene. Hypersthene, the major constituent, occurs as subhedral to anhedral grains in a finer matrix of pyroxene and amphibole. The amphibole is a colourless to very pale green prismatic variety of actinolite, in part replacing pyroxene. A small amount of opaque material, possibly magnetite, is present.

Anorthositic gabbro (unit 7b) occurs in a series of outcrops, centred approximately at 64°35′N and 82°50′W, that extends for 2 miles. This rock forms a resistant ridge with no exposed contacts; however, the line of outcrops more or less parallels the trends in the enclosing rocks.

The rock is grey on both fresh and weathered surfaces, medium grained, and equigranular. Although generally massive, in places it has an ill-defined foliation and layering. Round to ovoid, ruby-red garnets, as much as one inch in diameter, are irregularly distributed throughout the outcrop. In thin section the rock is seen to be composed of calcic plagioclase. An_{54} (80%), pyroxene (12%), and hornblende (7%). Minor amounts of garnet, quartz, and biotite are present. Accessory minerals include magnetite and apatite. Mafic inclusions, as much as 2 inches wide and 18 inches long, are sparsely distributed.

Diabase and Gabbro (unit 8)

Diabase and gabbro dykes (8) occur in a few widely separated areas; outcrops are small, frost-shattered, and poorly exposed. They extend in a discontinuous line from the vicinity of Cape Bylot to the west side of the Porsild Mountains, which suggests that they may be parts of a single dyke or parts of an *en echelon* series of dykes. The only other occurrences are near the headwaters of Boas River, and east of Mount Scotch Tom. Most of these outcrops, or lines of frost-heaved boulders, indicate a northwesterly strike. Dips generally appear to be near vertical, although one outcrop in the Porsild Mountains is nearly horizontal. The dykes range in width from 60 to 210 feet, but most appear to be about 100 feet.

The diabasic rocks are massive, brownish weathering, dark green to black, and are composed of pyroxene, labradorite, and minor magnetite. Some have aphanitic to fine grained borders and medium to coarse grained central areas, commonly with typical diabasic textures.

These rocks are not metamorphosed and are probably part of the widespread diabasic intrusions of Helikian age.

Coats and Bencas Islands

The Precambrian rocks on Coats and Bencas islands consist of a wide variety of gneisses and migmatites, divided into two major units that correspond to similar units on Southampton Island. The gneiss and migmatite are commonly intimately mixed, and contacts are gradational over a few feet to several hundred feet. Within limited areas, many rock-types can be recognized, and further study may reveal their continuity and extent. The scale of mapping used on these islands permitted consideration of only gross features.

Layered Quartz–Feldspar Gneiss (unit 3)

This gneiss (3) is the principal rock-type on Coats Island. Locally, three subdivisions with gradational boundaries are recognized. Typical gneiss is commonly grey to dark grey, although individual outcrops may range from light to dark; in part, these colour variations are due to grain size and the thickness of the layers, and, in part, to slight changes in composition across the strike. The rock is fine grained, locally medium grained, more or less equigranular, and in general the texture is granoblastic. It is thinly layered, with quartz–feldspar-rich layers alternating with biotite- and/or hornblende-rich layers. The layers range in thickness from a few millimetres to several feet and from the air appear continuous for at least several hundred feet. In places the gneiss is extremely contorted; this is especially apparent in and near the boundary zone with the migmatite.

Microscopically, the quartz–feldspar gneiss is seen to be composed of quartz, plagioclase, microcline, and biotite and/or hornblende. Minor constituents include apatite, monazite, sphene, and magnetite. Muscovite is locally abundant. The plagioclase ranges from calcic oligoclase (An_{25}) to sodic andesine (An_{33}), with extensive alteration in places.

Garnetiferous gneiss (3a) probably forms mappable units. Red garnet forms up to 10 per cent of the rock and may constitute 25 to 40 per cent in layers as much as 5 feet thick. Mafic-rich gneisses (3b) are of widespread occurrence but do not appear to underlie extensive areas. Quartz, feldspar, and variable amounts of biotite and hornblende are the main constituents. Some gneisses contain pyrite and graphite zones that are commonly deeply weathered, giving rise to rusty areas (3c).

On Bencas Island, grey and pink gneisses (3) range from regularly layered to extremely contorted and migmatitic varieties. Numerous pink pegmatitic granite sills and dykes intrude the gneisses. Typical gneiss is fine to medium grained and thinly layered, with layers $\frac{1}{8}$ to $\frac{1}{4}$ inch thick, although in places they may be as much as 12 inches. Quartz comprises 35 to 50 per cent of the rock and usually shows undulatory extinction and sutured boundaries. Plagioclase, generally calcic oligoclase (An_{25} to An_{30}), forms between 30 and 45 per cent of the rock. It is generally fresh with well-defined albite twinning. Potash feldspar characteristically shows microcline twinning. Biotite consistently forms about 12 per cent of the rock, and garnet may form as much as 5 per cent.

Near the northeast end of Bencas Island, extremely contorted discontinuous garnet–gneiss layers (3a), 6 to 10 feet thick and 100 feet or more long, are interlayered with the grey gneiss. Some of the $\frac{1}{2}$- to 12-inch layers are composed of 50 to 60 per cent garnet, quartz, and feldspar.

Migmatite (unit 5)

Migmatites (5) form a unit consisting of massive to foliated, granitic-textured rocks and discontinuous patches of layered gneiss. All varieties of gneiss of unit 3 appear to be represented. In places where the gneissic rocks are intensely contorted, the outcrop has a swirly appearance. Elsewhere, angular to irregularly shaped fragments and blocks of gneiss of all sizes are present in a granitic matrix.

The granitoid part of the migmatite is generally medium grained and equigranular, but locally contains scattered to abundant potash feldspar porphyroblasts. A typical specimen is composed of quartz (29%), plagioclase (14%), microcline (34%), biotite (15%), and hornblende (6%).

Quartz Monzonite (unit 6a)

Massive to slightly foliated, pinkish biotite–quartz monzonite (6a) occurs in a few small scattered outcrops in the eastern part of the island. In thin section the rock is seen to be medium grained, equigranular, and composed of quartz (40%), plagioclase (18%), microcline (20%), biotite (16%), hornblende (3%), and minor amounts of muscovite, sphene, and apatite. The plagioclase is An_{26}; however, in some places it is extremely altered, and no determination could be made. No contacts were observed, but the distribution of the outcrops suggests that they may be large sills.

Anorthosite (unit 7c)

An anorthosite knob (7c), about 600 feet in diameter and 75 feet above the surrounding area, occurs at 62°27′N, 80°18′W, about 5 miles south of the nearest Precambrian outcrops. It is surrounded by drift composed predominantly of Paleozoic detritus. The colour of the anorthosite is dominated by medium to dark grey to bluish-grey plagioclase that weathers light to medium grey. This rock is massive, and no structures were observed in the outcrop. Its grain size ranges from 1 to 3 millimetres; however, there are numerous plagioclase grains from 1 to 5 centimetres long. Other than the essential plagioclase, which constitutes more than 90 per cent of the rock, the only primary minerals present are orthopyroxene, clinopyroxene, and magnetite in minor amounts. Secondary minerals include green amphibole, biotite, chlorite, epidote, and calcite. Some of the plagioclase is in a very fine grained mortar of plagioclase.

Walrus Island

Walrus Island (Fig. 3), in Fisher Strait about midway between Coats Island and Southampton Island, consists of two rocky knobs joined by a low gravel beach (Pl. 13). The island is about a mile long, with its highest point about 165 feet above sea level. Although little bathymetry has been done in the immediate proximity, published and unpublished soundings in adjacent areas suggest that the island rises abruptly to about 500 feet above a relatively flat sea-floor, probably not unlike the surface of the adjacent islands.

Time did not permit an extensive examination, but helicopter landings, each for about 30 minutes, were made on the north end and near the south end, and a flight was made around the island.

The rock is a grey weathering, dark grey anorthosite (7c), well layered, with consistently northerly dips. The layers range in thickness from 1 foot to 10 or more feet, and commonly are well defined by changes in texture, structure, and composition (Pl. 14). Individual layers show no grain gradation, but they do differ in grain size. Some are characterized by ½- to 6-inch augen-shaped pyroxene crystals and aggregates of crystals that constitute as much as 30 per cent of the rock (Pl. 15); other layers contain scattered pyroxene crystals as much as 2 inches in diameter. Most are aligned parallel to the layering. Some layers contain little or no pyroxene.

In thin section this rock is seen to be composed essentially of pyroxene and plagioclase. The plagioclase occurs as anhedral to subhedral crystals that average about 1 mm in length—although a few are as much as 10 mm long—in a mortar of very fine grained plagioclase. In some thin sections albite twinning is seen to be well developed, whereas in others the lamellae are vague and many are bent. The composition is more or less consistent and ranges from An_{50} to An_{54}; however, a few grains were noted between An_{38} and An_{41}.

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PLATE 13. View west toward Walrus Island.

201518A

PLATE 14. Low-dipping, layered gabbroic anorthosite on Walrus Island.

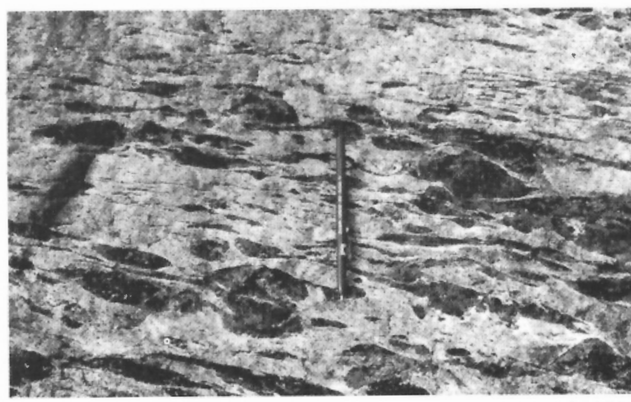

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PLATE 15. Augen-shaped pyroxene crystals in gabbroic anorthosite on Walrus Island.

Pyroxene occurs as large crystals and as aggregates of finer crystals generally flattened parallel to the layering. In one thin section the pyroxene is seen to be almost entirely altered to hornblende and biotite. Pink garnet forms microscopically visible coronas parallel to pyroxene lenses and around individual grains.

The cataclastic deformation of plagioclase and pyroxene and the development of metamorphic coronas suggest that these anorthosites have been subjected to post-magmatic regional metamorphism. These rocks do not conform to the metamorphic grade of the region; water may not have been available, or possibly could not penetrate them due to their greater competence as compared to the adjacent gneisses.

As far as was ascertained, the layering is regular over the island, with a northerly dip of 24 to 32 degrees. Jointing is the most prominent structural feature. One major set of joints strikes southwesterly, and another strikes westerly to northwesterly; both dip vertically.

Fife Rock

Fife Rock is a small low island in Foxe Channel about 20 miles northeast of Cape Comfort on Southampton Island, at approximately 65°14½'N, and 82°44'W. It was named after the member of Parry's 1819–20 expedition who first sighted the island.

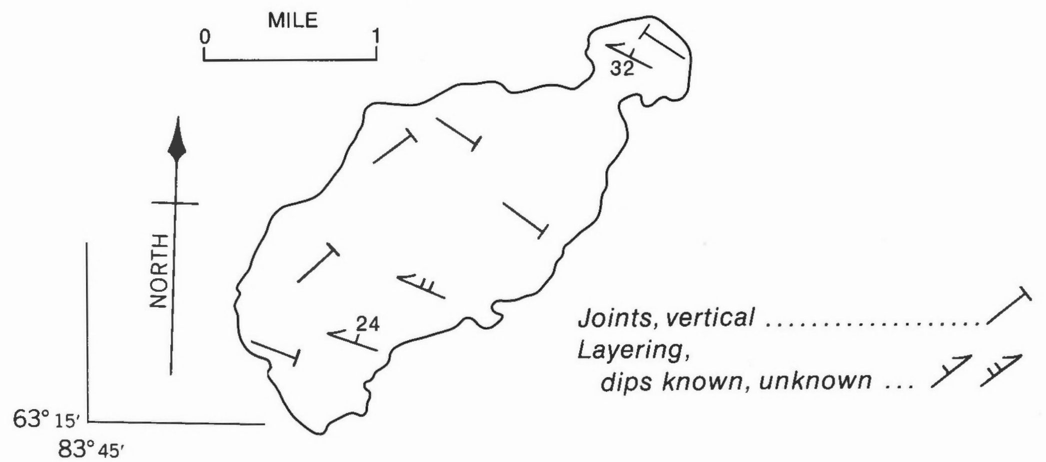

FIGURE 3. Sketch map of Walrus Island (position and orientation approximate).

In the 1970 season, samples were collected from Fife Rock by Captain P. Tooke and A. E. Oldman of the CCGS *Labrador* and sent to the Geological Survey of Canada. The rock is medium grained, more or less equigranular, and pink on both fresh and weathered surfaces. Foliation is well developed, and layering is moderately so. Layers in the hand specimens are discontinuous, and are from 2 to 10 mm thick. The thicker layers generally contain more quartz and feldspar, whereas the thinner layers contain abundant hornblende.

Microscopic examination reveals that these rocks consist of quartz (35%); calcic oligoclase (22%); microcline (38%), in part perthitic; hornblende (3%); and biotite (2%). Minor constituents include muscovite, apatite, and magnetite. Chlorite and epidote appear to be alteration products of biotite, hornblende, and feldspar.

These rocks are similar to the gneisses and granitoid gneisses of Southampton and Vansittart islands.

Paleozoic Geology

Although the presence of Paleozoic rocks on Southampton, Coats, and Mansel islands has been known since the turn of the century, the first accurate descriptions of the strata were made by Nelson and Johnson (1966). During their investigations, they established a generalized classification for the Ordovician and Silurian strata on Southampton, Coats, and Mansel islands. In 1968, B. V. Sanford visited these islands by helicopter; he examined many of the sections and made extensive fossil collections. Three significant items of new information were forthcoming from this survey: discovery of (1) numerous biohermal structures in Upper Ordovician rocks on Southampton Island, (2) Ordovician rocks outcropping along the margin of Precambrian terrain in the northern part of Coats Island, and (3) Silurian Attawapiskat reefs on Southampton, Coats, and Mansel islands. In the summers of 1969 and 1970 B. V. Sanford revisited Southampton and Coats islands and mapped the Paleozoic rocks at a scale of 1:250,000. In 1971, B. V. Sanford and C. F. M. Lewis carried out a reconnaissance marine survey in Hudson Bay using the MV *Hudson Handler*, owned and operated by International Hydrodynamics Limited of Vancouver, British Columbia. The vessel was equipped with a two-man submarine, a portable remote-controlled core drill, shallow-reflection seismic profiling equipment, side-scan sonar, and various soft-sediment sampling and coring devices. The results of this survey have greatly facilitated the mapping of bedrock formations in the offshore areas adjacent to the northern islands of Hudson Bay, and have permitted the construction of regional geological maps of the entire Hudson Bay Basin.

T. E. Bolton of the Geological Survey of Canada identified many of the megafossil collections and assisted in dating the Silurian sequences. C. R. Barnes, University of Waterloo, and T. T. Uyeno of the Geological Survey of Canada, Calgary, studied the Ordovician and Silurian conodont samples. L. M. Cumming of the Geological Survey of Canada, Ottawa, and J. Riva, Laval University, Quebec, identified the graptolites, and Dr. Riva suggested correlation of an Ordovician petroliferous shale unit ('Boas River shale').

The Paleozoic terrain of Southampton, Coats, and Mansel islands is underlain by limestones, dolostones, and minor sandstone and shale of Late Ordovician and Middle Silurian age (Map 1404A). These relatively nondeformed strata onlap Precambrian crystalline rocks of Bell Arch, dip gently southward at 1 or 2 degrees, and are ultimately succeeded in the offshore areas of Hudson Bay by carbonates and shales of Late Silurian and Devonian age.

The Ordovician and Silurian rocks exposed on the northern islands of Hudson Bay are remarkably similar to those in the Hudson Bay Lowlands of northern Ontario and Manitoba; consequently, the same stratigraphic nomenclature is applicable to both of these widely separated areas (*see* Sanford and Norris, 1973; Table I, *in pocket*). On Southampton and Coats islands, each of the Ordovician and Silurian rock-units shown in Figure 4 and Figure 5 (*in pocket*) is represented and exposed to good advantage. On Mansel Island, only the Middle Silurian Ekwan River and Attawapiskat formations are represented.

On the northeast coast of Southampton Island, at Cape Donovan, each of the Upper Ordovician units is represented, but the Silurian is represented only by the Severn

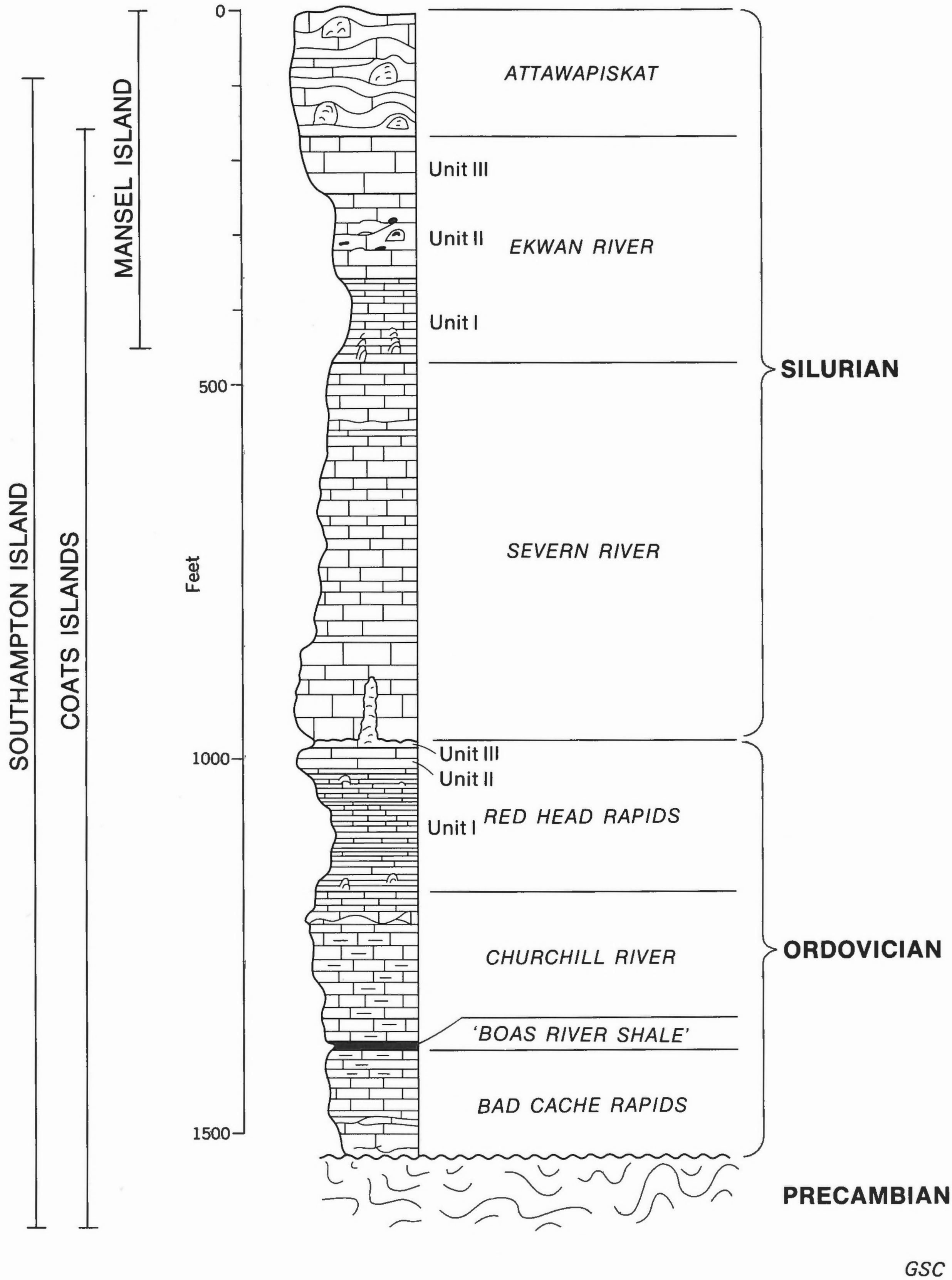

FIGURE 4. Composite Paleozoic stratigraphic column, northern Hudson Bay Basin (symbols defined on Figure 5, *in pocket*).

River Formation. The rock-units at this locality are lithologically similar to those on the southern part of the island; thus it is concluded that the Paleozoic succession at one time formed a continuous blanket across Southampton Island from Hudson Bay Basin to Foxe Basin, and that it was subsequently eroded (Table I). With the exception of the region immediately north and west of Coral Harbour, Paleozoic rocks are in fault contact with Precambrian terrain extending from Bell Peninsula on the east end of the island, to Comer Strait at the northern extremity. The present high topographical relief of the Precambrian in northern Southampton Island is a result of uplift (block faulting) in post-Middle Silurian time.

The topographical relief of Coats Island above the surface of Hudson Bay is also a result of uplift (block faulting) during the Paleozoic or later. Ordovician and Silurian strata in this region onlap Precambrian gneisses and dip gently to the southwest; however, the Precambrian terrain immediately offshore at the northern end of the island is in fault contact with Paleozoic rocks beneath Fisher Strait, the latter area forming a half-graben between Coats Island and Bell Peninsula. In contrast, Mansel Island owes its present topographical relief largely to the hard resistant nature of the underlying Middle Silurian carbonates (Pl. 16). The island forms the emergent part of an elongated cuesta and shoal that extends some 450 miles along the east side of Hudson Bay from Mansel Island to Cape Henrietta Maria in the Hudson Bay Lowlands.

Ordovician

Rocks of Ordovician age on Southampton and Coats islands are divided into Bad Cache Rapids Group, Churchill River Group, and Red Head Rapids Formation, in ascending sequence (Figs. 4; 5, *in pocket*). On Southampton Island, these rocks form the bedrock and are exposed at a number of widely separated areas south and west of the Paleozoic–Precambrian boundary: (i) near Salmon Pond bordering Precambrian inliers, (ii) along the south coast of Bel

149534

PLATE 16. Escarpment in Ekwan River limestones near east coast on Mansel Island (similar escarpments in these strata can be traced offshore southwards from Mansel Island along east side of Hudson Bay).

149618

PLATE 17. Paleozoic–Precambrian contact; Ordovician limestones dipping westward off Precambrian terrain (Precambrian upland in background).

Peninsula, (iii) at Hansine Lake and vicinity, and (iv) on the northeast coast of Southampton Island at Cape Donovan and vicinity.

On Coats Island, Ordovician rocks onlap Precambrian terrain at the northern end of the island, and extend into the offshore areas of Hudson Bay on the east and west sides of the island.

As of 1973, there had been no exploratory drilling in the northern Hudson Bay Basin, and the precise thickness of Ordovician rocks in this region is not known. On the basis of many sections measured, principally along the Paleozoic–Precambrian boundary, Ordovician rocks are believed to have an aggregate thickness of up to 525 feet. In general, the rocks dip regionally south and southwestward beneath younger Silurian and ultimately Devonian rocks, with thickness gradually increasing southward to an estimated 1000 feet in subsurface beneath central Hudson Bay.

Bad Cache Rapids Group

Definition. The term Bad Cache Rapids Group was proposed by Nelson (1963, 1964) for Ordovician strata of the northern Hudson Bay Lowlands that rest on the peneplaned surface of the Precambrian Shield, and are succeeded by limestones of the Churchill River Group. In the Hudson Bay Lowlands, the Bad Cache Rapids is divided into the Portage Chute and Surprise Creek formations, in ascending sequence. The term Bad Cache Rapids, as originally defined, was applied by Nelson and Johnson (1966) to a relatively similar Ordovician sequence on Southampton Island, except that the formations applicable to the Hudson Bay Lowlands were not recognized in the latter region. Similarly, during the course of geological mapping on Southampton and Coats islands. B. V. Sanford applied the name Bad Cache Rapids Group to limestones of late Middle or Late Ordovician age that onlap Precambrian gneisses and are gradationally succeeded by oil shales ('Boas River shale'), or in the absence of the oil shales, unconformably by limestones of the Churchill River Group (Figs. 4, 5).

Distribution and thickness. On Southampton Island, the Bad Cache Rapids Group is well exposed in numerous outliers bordering South Bay and to the north in the vicinity of Coral Harbour. From South Bay, eastward to Junction Bay on Bell Peninsula, Paleozoic and Precambrian rocks are in fault contact, and the Bad Cache Rapids Group is only intermittently preserved as remnants on the uplifted surface of Precambrian terrain. To the west of South Bay, the Bad Cache Rapids Group onlaps Precambrian terrain to the vicinity of The Buttocks, but from there northward to Comer Strait, Paleozoic strata are again in fault contact with the Precambrian; consequently, the Bad Cache Rapids Group is only intermittently present as erosional remnants on the uplifted margins of the Precambrian.

Near Salmon Pond, some 50 miles northwest of Coral Harbour, the Bad Cache Rapids Group is exposed around the margins of Precambrian inliers along a north–south-trending belt some 35 miles long. About 12 miles farther south of the Salmon Pond exposures is another isolated occurrence of Bad Cache Rapids strata, bordering a Precambrian inlier that has been uplifted to the surface as a result of normal faulting.

In addition to the numerous outliers north of Coral Harbour, two isolated remnants of Bad Cache Rapids strata occur at Mount Scotch Tom and at a point about 10 miles due south of Cape Welsford in the northern part of the island.

On the northeast coast of Southampton Island, at Cape Donovan, the Bad Cache Rapids Group is exposed at a number of localities in downfaulted blocks along the northern margin of Bell Arch. It is presumably present also in the immediate offshore areas to the north, where it forms the basal Paleozoic unit in a succession of elongated graben structures that trend in a southeast-northwest direction beneath Foxe Channel.

On Coats Island, Bad Cache Rapids strata onlap Precambrian gneisses at the northern end of the island and are also exposed at two places in stream-cuts near the west coast.

The Bad Cache Rapids Group is perhaps the best exposed of all the Paleozoic rock-units (particularly on Southampton Island) and has therefore been examined in fair detail at many localities. Because of incomplete sections, however, its total thickness of about 150 feet is, at present, only an estimate.

Lithology and stratigraphic relations. The Bad Cache Rapids Group is a relatively uniform lithological sequence of light to medium brown micritic limestone that weathers medium greyish brown with extensive light yellowish-orange mottling. With the exception of microgranular yellowish-orange zones, the rocks are extremely fine grained, but sporadic echinoderm ossicles embedded in the limestone are a common characteristic of the unit. The zones of yellowish-orange mottling occur sporadically throughout Bad Cache Rapids strata, and these presumably formed as a result of incipient secondary dolomitization in extensively bioturbated strata, principally in the lower part of the group.

The lower 50 to 75 feet of the Bad Cache Rapids Group is highly algal, with thin anastomosing beds 1 inch to 3 inches thick at the base, gradually increasing to 4 inches thick higher in the section (Pl. 18). The lower part of the group is also commonly argillaceous with medium to dark grey shale laminations and interbeds. Prolonged weathering of the alternating shaly bands and of the more resistant succeeding limestone beds has resulted in the development of hoodoo structures; these can be observed at numerous localities along the Bad Cache Rapids outcrop belt.

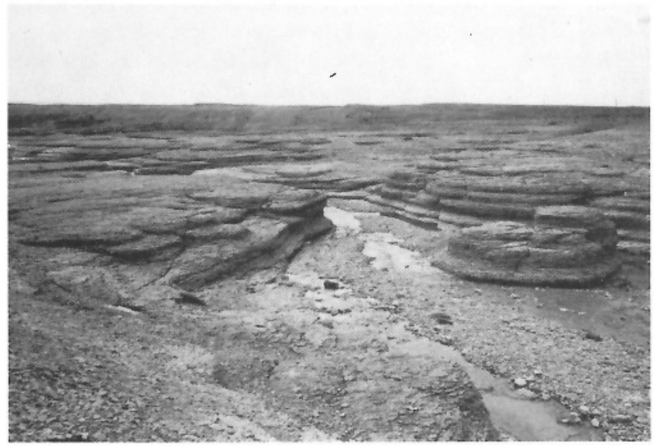

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PLATE 18. Lower Bad Cache Rapids strata exposed in stream-cut, 1 mile west of Ministry of Transport runway, Coral Harbour.

As the Bad Cache Rapids Group is the oldest Paleozoic unit on the islands of northern Hudson Bay, the initial few feet of strata, which rests directly on Precambrian crystalline rocks, is generally sandy and conglomeratic. At a few localities, a well-developed orthoquartzitic sandstone up to 2 feet thick occurs at the base; this unit was observed in some of the outliers north of Coral Harbour and in an isolated section 26 miles due south of Salmon Pond.

The upper part of the Bad Cache Rapids Group consists of relatively uniform microcrystalline limestones, in beds up to 4 inches thick, that weather dark brownish grey. Except for one or two places near The Buttocks and on Cape Donovan on Southampton Island, these beds are poorly exposed, and are for the most part obscured beneath younger Ordovician and Silurian strata along the faulted Paleozoic–Precambrian boundary. On Coats Island, the Bad Cache Rapids Group is poorly exposed, with only the lower part of the group visible in outcrop.

The Bad Cache Rapids Group everywhere rests directly on Precambrian gneisses; this contact, which is exposed at numerous localities on Southampton Island and at one locality on Coats Island, is abrupt and nonconformable (Table I). The contact of the Bad Cache Rapids limestones with the succeeding black, petroliferous shales of the 'Boas River beds' exposed near The Buttocks is gradational over an interval of 1 or 2 inches. In the absence of the petroliferous shale unit, the Bad Cache Rapids Group is succeeded paraconformably by limestones of the Churchill River Group. During Operation Winisk, a reconnaissance survey of the Hudson Bay Lowlands carried out in 1967, Sanford *et al.* (1968) reported a paraconformity at a horizon identical to that described above. It is therefore concluded that an erosional hiatus, which had wide regional implications throughout the Hudson Platform, did exist during a mid-Late Ordovician interval.

Age and regional correlation. The Bad Cache Rapids Group is abundantly fossiliferous and contains cephalopod, brachiopod, coral, and gastropod faunas that permit correlation with rocks that bear the same nomenclature in Hudson Bay Lowlands and the Red River Formation of southern Manitoba (Table I). Assemblages containing *Receptaculites, Maclurites, Hormotoma, Rafinesquina, Catenipora,* and a host of other genera are readily recognizable in most Bad Cache Rapids sections. Of 27 samples that Barnes analyzed for conodonts (GSC Fossil Report No. 01-1971-CRB), most contained long-ranging species of *Panderodus, Belodina,* and *Drepanoistodus.* According to Barnes (1973) however, the species of *Belodina,* together with *Oistodus venustus* Stauffer and *Acodus mutatus* (Branson and Mehl), indicates a late Middle Ordovician (post-Chazyan) or early Upper Ordovician age.

The only graptolites observed in the Bad Cache Rapids Group of northern Hudson Bay region are fragments of two genera recovered by T. T. Uyeno during the preparation of limestone specimens for conodont analysis. L. M. Cumming (pers. com., 1971) identified those as *Glossograptus* and *Climacograptus.*

According to G. W. Sinclair (pers. com., 1969), the faunas of the Bad Cache Rapids Group are of Middle to Late Ordovician age, and probably correlative to the Farr Formation of Lake Timiskaming outlier and the upper Cobourg beds of the Trenton Group in south-central and eastern Ontario.

'Boas River shale'

Definition. On Southampton Island the Bad Cache Rapids Group is stratigraphically succeeded by a distinctive petroliferous shale unit, which because of its limited known distribution is here informally named 'Boas River shale.' So far as the writer has been able to determine, the unit is exposed at a single locality on the upper reaches of Boas River, near the Paleozoic–Precambrian boundary near The Buttocks. There the unit overlies the Bad Cache Rapids Group and in turn is overlain by the Churchill River Group (Figs. 4, 5).

Nelson and Johnson (1966) described an Ordovician "oil shale interval" some 50 feet thick which overlies limestones containing a Late Ordovician Churchill River fauna. This "oil shale interval", much younger than the 'Boas River shale', is included in the sequence herein defined as Red Head Rapids Formation (*see* description of Red Head Rapids Formation).

Distribution and thickness. The 'Boas River shale' is exposed at only one locality, in a stream-cut of Boas River, approximately 2 miles south of the Paleozoic–Precambrian boundary. The unit may have wider distribution, but because of its relatively nonresistant weathering character is apparently obscured by drift cover in adjacent areas, and thus is not shown as an individual map-unit on Map 1404A. In other areas of Southampton and Coats islands, the unit has undoubtedly been removed by erosion during a mid-Late Ordovician (Maysvillian) hiatus. Similar black shales of the same age occur on Akpatok Island in Ungava Bay, and future deep drilling in Hudson Bay may possibly encounter similar shales at this horizon that were more likely to have escaped erosion in the deeper part of the Hudson Bay Basin.

Total thickness of the 'Boas River shale' at the type section is unknown because the outcrop is largely obscured by surficial deposits, but 5 to 7 feet of strata is present at this locality.

Lithology and stratigraphic relations. The 'Boas River shale' consists of black calcareous and petroliferous shale, in uniform beds ½ to 1 inch thick, that weathers light to medium greyish brown. The beds are highly organic and emit a distinct petroliferous odour when fractured. At the type section, the 'Boas River shale' is gradational with the underlying petroliferous limestones of the Bad Cache Rapids Group. If the 'Boas River shale' is present in the subsurface to the south, it would presumably be overlain disconformably by limestones of the Churchill River Group.

Age and regional correlation. Single species of trilobite and graptolite casts are found in abundance in the 'Boas River shale.' According to J. Riva (pers. com., 1972), the graptolite is "the *Amplexograptus* Jackson refers to on p. 478" (Palaeontology, 1971, v. 14, pt. 3, p. 478–486). Riva assigns an age of "somewhere in the Lorraine, or to the *C. manitoulinensis* zone." The trilobite is *Pseudogygites* sp. cf. *P. latimarginata* (Hall), and this species in association with *Climacograptus* sp. is typical of the upper Cobourg and Collingwood faunas of southern Ontario, which are of Late Middle to Late Ordovician age (Sinclair, pers. com., 1969) (Table I).

Churchill River Group

Definition. The term Churchill River Group was proposed by Nelson (1963, 1964) for limestones of Ordovician age in the northern Hudson Bay Lowlands that overlie the Bad Cache Rapids Group and are, in turn, succeeded by limestones of the Red Head Rapids Formation. As a result of the investigations of the writer (B.V.S.) on Southampton and Coats islands, the term Churchill River is also applied (in the same context as originally used by Nelson in the Hudson Bay Lowlands) to those beds that lie between the Bad Cache Rapids Group below and the Red Head Rapids Formation. Although the Churchill River Group in the Hudson Bay Lowlands is further divisible into Caution Creek and Chasm Creek formations in ascending sequence, no such distinction can be made between these units on Southampton and Coats islands, and equivalent strata are simply referred to Churchill River Group (Figs. 4, 5).

Distribution and thickness. The Churchill River Group is not as consistently well exposed on Southampton Island as the underlying Bad Cache Rapids Group due to extensive erosion of the uplifted margins of Precambrian terrain along the Paleozoic–Precambrian boundary. The Churchill River Group was not recognized in outcrop on Bell Peninsula, although it is undoubtedly everywhere present in subsurface beneath Red Head Rapids strata and lies in fault contact with Precambrian rocks along the northern margin of the peninsula. West of Coral Harbour, the group forms an outcrop belt parallel to the subjacent Bad Cache Rapids to within about 10 miles of The Buttocks. From this area northward to Duke of York Bay, the group, with one or two exceptions, is largely obscured beneath younger strata along the Paleozoic–Precambrian boundary due to normal faulting. In the vicinity of Salmon Pond, Churchill River strata are exposed to form a north–south-trending halo, some 40 miles long, around the margins of Precambrian inliers. At Cape Donovan and vicinity these rocks are well exposed in cliff sections facing Foxe Channel, and are assumed to be present also in subsurface in adjacent offshore areas.

On Coats Island, the Churchill River Group forms an outcrop belt across the northern end of the island, but is exposed at only one locality on a stream-cut near the west coast.

Most of the Churchill River sections on Southampton and Coats islands contain only a few feet of strata, although nearly complete sections occur near Duke of York Bay and at Cape Donovan where about 175 feet of strata is exposed. In addition, excellent outcrops, although incomplete, are exposed in a prominent escarpment, 17 miles west of Coral Harbour, and in a stream-cut, 10 miles south of The Buttocks.

Lithology and stratigraphic relations. The Churchill River Group is composed of dark greyish-brown, argillaceous, microcrystalline limestone, in relatively uniform beds 2 to 6 inches thick, that weathers light grey with minor yellowish-orange mottling (Pls. 19, 20). The mottled areas have microgranular texture and, as in the Bad Cache Rapids Group, are assumed to comprise incipient dolomitized patches that would appear to coincide with intensely bioturbated zones. At the top of the Churchill River Group, the uniformly bedded limestones give place to anastomosing beds of medium brown, algal, micritic limestones, a unit 7 to 10 feet thick.

The Churchill River Group succeeds the Bad Cache Rapids with disconformable contact except in the possible presence of 'Boas River shale,' where it presumably rests disconformably on that unit (Figs. 4, 5). The upper contact of the Churchill River Group with the succeeding Red Head

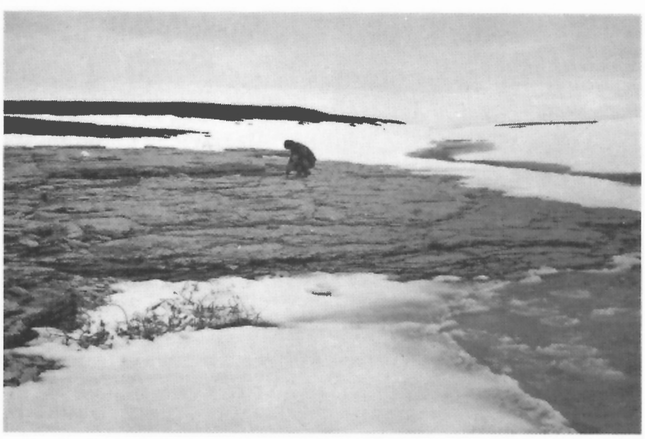

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PLATE 19. Churchill River limestones exposed near mouth of Rocky Brook (photo taken in late June, 1969).

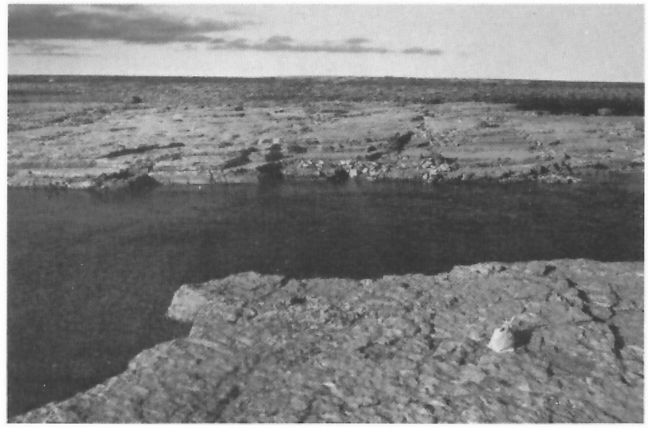

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PLATE 20. Churchill River limestones exposed in the vicinity of mouth of small creek, near northwest coast of Coats Island.

Rapids Formation was observed at one locality (17 miles west of Coral Harbour) where the contact is conformable and gradational.

Age and regional correlation. The Churchill River Group contains megafossils (principally cephalopods and corals), particularly in the lower part of the group, that suggest a Late Ordovician (Richmondian) age. Many of the fossils found in the Churchill River Group are a repeat of those that occur in the underlying Bad Cache Rapids Group; however, the presence of *Favosites* and *Palaeofavosites*, in contrast to the complete absence of such genera as *Receptaculites*, *Hormotoma*, and *Rafinesquina*, indicates that these strata are high in the Late Ordovician and coeval with the Churchill River Group of northern Hudson Bay Lowlands and the Stony Mountain Formation of southern Manitoba (Table I).

Of the 21 samples of the Churchill River strata submitted to C. R. Barnes for conodont analysis, two were barren, but most of the remainder yielded abundant faunas (GSC Fossil Report No. 01-1971-CRB). According to Barnes, the conodonts comprise the following diagnostic taxa: *Amorphognathus ordovicicus* Branson and Mehl, *Belodina profunda* (Branson and Mehl), *Cordylodus robustus* Ethington and Furnish, *Plegagnathus dartoni* Stone and Furnish, and *P. nelsoni* Ethington and Furnish. *Belodina profunda*, in association with *Plegagnathus dartoni*, *P. nelsoni*, and *Cordylodus robustus*, is diagnostic of fauna 12 of Sweet *et al.* (1971), i.e., late Maysvillian to Richmondian.

T. T. Uyeno (GSC Fossil Report No. MP2-TTU-1972) processed one sample of the Churchill River Group from a locality 17 miles west of Coral Harbour that yielded a variety of taxa, including *Plegagnathus nelsoni* Ethington and Furnish, *P. dartoni* Stone and Furnish, *Belodina profunda* (Branson and Mehl), *B. compressa* Branson and Mehl, *Ambalodus triangularis* Branson and Mehl, *Amorphognathus ordovicicus* Branson and Mehl, *Drepanodus homocurvatus* Lindstrom, *Panderodus* sp., *Oistodus inclinatus* Branson and Mehl, *Paltodus* (?) sp., *Tetraprioniodus superbus* Rhodes, *Keislognathus gracilis* Rhodes, and *Coelocerodontus trigonius* Ethington. According to Uyeno, this fauna is similar to that described by Ethington and Furnish (1959, 1960) from loose slabs that were assigned to the Shamattawa limestone from near the mouth of Knife River, northern Manitoba, and from the Gunn Member of the Stony Mountain Formation near its type locality in southern Manitoba. This dating coincides with the conclusions established on the basis of megafossils and lithological comparison to the Churchill River Group of northern Manitoba.

Red Head Rapids Formation

Definition. The term Red Head Rapids Formation was originally defined by Nelson (1963, 1964) for the limestones and dolostones in the northern Hudson Bay Lowlands that overlie the Churchill River Group, and are succeeded by limestones of Silurian age (Severn River Formation). Rocks that are similar in lithology and age to those of the Red Head Rapids Formation of Hudson Bay Lowlands are widely exposed on Southampton and Coats islands; consequently, that formational term is also applied herein (Figs. 4, 5).

This formation undoubtedly includes the "oil shale interval" described by Nelson and Johnson (1966), although the present writers were unable to find significant oil shale deposits in this particular part of the Ordovician succession.

Distribution and thickness. The Red Head Rapids Formation is well exposed at numerous localities on Southampton Island. On Bell Peninsula, it forms the bedrock surface in a broad belt along the faulted Paleozoic–Precambrian boundary from Junction Bay to South Bay. West of South Bay, it forms a relatively narrow outcrop belt in a northwestward direction to the vicinity of The Buttocks. West of The Buttocks it forms the bedrock surface in a broad north–south belt, some 65 miles long, bordering Precambrian inliers of the Salmon Pond area. The formation is also intermittently exposed in uplifted fault blocks along the Paleozoic–Precambrian boundary between The Buttocks and Comer Strait, and in a large tilted block that trends in a northwest-southeast direction from Roes Welcome Sound to Duke of York Bay. Red Head Rapids strata also form the bedrock surface along the south coast of Bell Peninsula between Native Point and Leyson Point, and at a number of localities at Cape Donovan and vicinity. At the latter locality the formation is probably also present in adjacent offshore regions of Foxe Channel.

On Coats Island, the Red Head Rapids Formation is exposed at two widely separated places in the northern part of the island.

At no single locality is this formation completely exposed, although the most complete sections are at Cape Donovan, and on the headwaters of Cleveland River at the Paleozoic–Precambrian boundary near Duke of York Bay. Although the formation is poorly exposed at Little Corner Cliff and near Big Corner Cliff east of Coral Harbour, a thickness of at least 200 feet was established at those localities.

Lithology and stratigraphic relations. The Red Head Rapids Formation is a consistent lithological unit that can be readily recognized from place to place on the basis of its unique laminated bedding, colour, and texture. On Southampton Island it contains three distinct units (in ascending sequence): unit 1 (laminated beds), unit 2 (biostromal beds), and unit 3 (biohermal beds). Unit 1 is composed of light to medium tan, microcrystalline to microgranular, finely laminated limestone and dolostone, in uniform beds ¼ inch to 4 inches thick, that weather orange tan (Pl. 21). These uniformly bedded strata, up to 175 feet thick, contain a number of stromatolitic intervals that alternate sporadically with the uniformly bedded carbonates (Pl. 22).

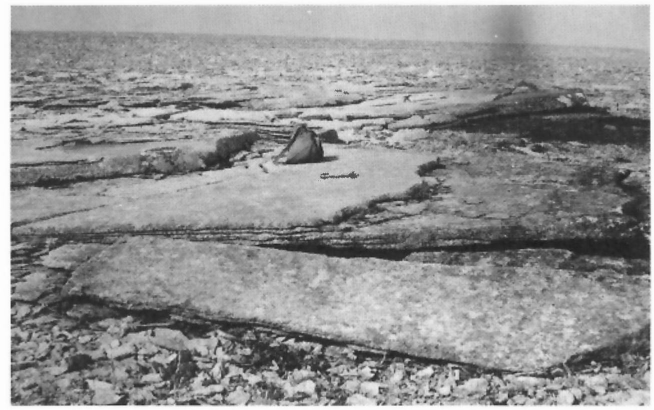

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PLATE 21. Deeply weathered Red Head Rapids limestones (unit 1) near Little Corner Cliff, Southampton Island.

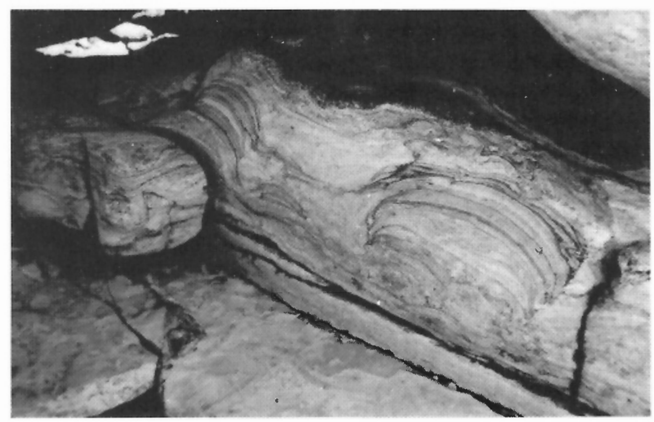

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PLATE 22. Stromatolite mats in Red Head Rapids strata (upper part of unit 1), south coast of Bell Peninsula.

Locally associated with the stromatolites are flat pebble-conglomerates; these also occur sporadically throughout the section. At several localities the upper carbonates of unit 1 were observed to contain thin dark brown platy interbeds that when fractured emit a distinctive petroliferous odour. However, the writer (B.V.S.) did not find the thin oil shale interbeds referred to by Nelson and Johnson (1966) anywhere in situ, although Ordovician sections were examined over wide areas of Southampton Island, including Sixteen Mile Brook. The beds referred to, wherever present, must therefore be a relatively minor constituent of the Red Head Rapids Formation. The limestones of unit 1 also contain random blade-shaped cavities, presumably moulds of glauberite crystals that have been removed by solution.

The succeeding unit 2 is a distinct, massive, algal, biostromal carbonate, 20 feet thick, consisting of medium to dark brown, vuggy microcrystalline limestone, in beds 4 to 6 feet thick, that weathers white to ash grey (Pls. 23, 24). This unit is best exposed on Bell Peninsula, particularly along its south coast where the beds are intensely dolomitized, sucrosic, and contain fair intergranular porosity. In contrast to the lower recessive weathering, thin bedded unit of the Red Head Rapids Formation, the massive algal unit is resistant to erosion, and in at least two localities, it forms the platform for prominent monadnocks capped by Silurian limestones that rise to 300 feet above the lowlands (Map 1404A). These are conspicuous topographical features that form Little Corner Cliff and an unnamed pinnacle that lies 8 miles southeast of Big Corner Cliff, both located a short distance east of Coral Harbour.

Unit 3 forms the uppermost part of the Red Head Rapids Formation and is composed of light to medium brown, thin bedded, microcrystalline limestone (inter-reefal facies), 4 to 5 feet thick, that weathers light grey tan. This unit contains numerous biohermal structures, some of which have a vertical relief of 10 feet or less, whereas others have an estimated relief of up to 75 feet, and a base one mile or more in diameter. The framework of the reef cores is composed entirely of dark brown algal limestone that weathers light grey tan. The bioherms have wide regional distribution on Southampton Island and extend from Bell Peninsula to Comer Strait, and it is in the latter area that they are concentrated in greatest numbers (Pls. 25–27). They are not confined only to the outcrop belt of the Red Head Rapids Formation, but also occur in Middle Silurian terrane where they project upwards through the Severn River Formation. The best exposed bioherm observed by the writer is about 16 miles west of Coral Harbour (Pl. 28). Only the top of the reef is exposed above the lowlands. The reef is pinnacle-shaped, rising to about 50 feet and extending over a square

161928

PLATE 24. White weathering, massive algal limestone of Red Head Rapids (unit 2) near Junction Bay, Bell Peninsula (note helicopter for scale).

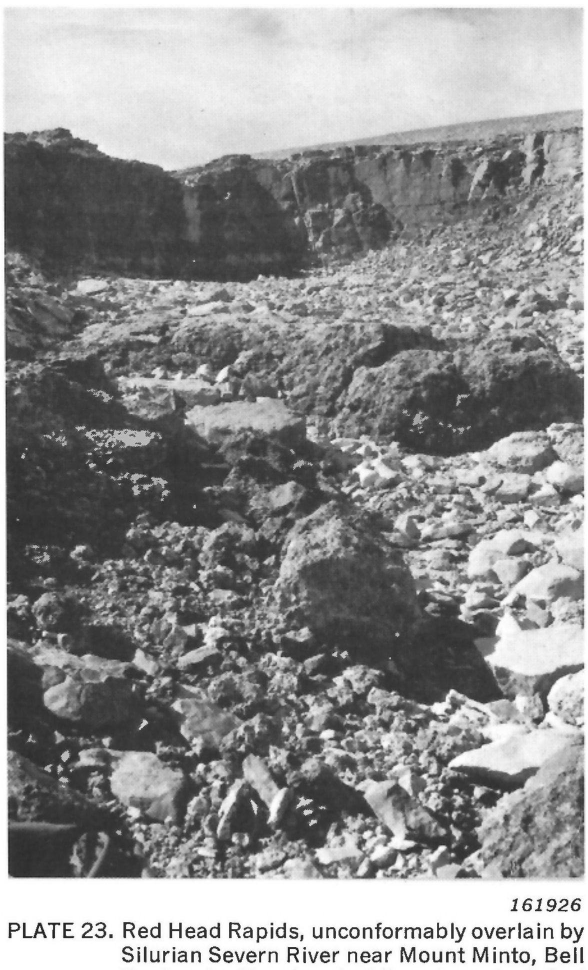

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PLATE 23. Red Head Rapids, unconformably overlain by Silurian Severn River near Mount Minto, Bell Peninsula. Massive algal limestone (unit 2 of Red Head Rapids) in foreground, succeeded by grey-tan, inter-reefal limestones (unit 3 of Red Head Rapids) at base of escarpment. Upper massive beds are Severn River limestones.

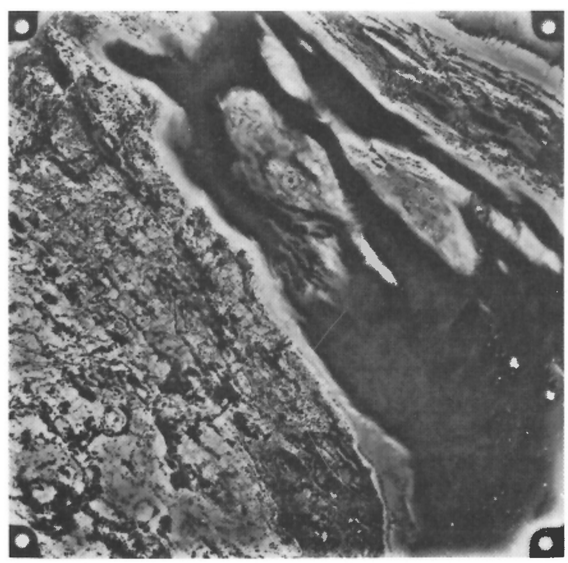

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PLATE 25. Airphoto of Comer Strait between Southampton and White islands showing numerous concentric features interpreted as biohermal structures in unit 3 of Red Head Rapids Formation.

161936

PLATE 26. Biohermal structure in unit 3 of Red Head Rapids Formation (reef core obscured by tundra and gravel) near Comer Strait.

149612

PLATE 27. Small isolated algal bioherm in unit 3 of Red Head Rapids Formation, near The Buttocks.

161937

PLATE 28. Large algal bioherm in unit 3 of Red Head Rapids Formation, 16 miles west of Coral Harbour.

mile. Some parts of this reef-core contain good vuggy porosity, and some of the smaller reefs examined farther northward contain large vugs with sporadic dead oil infilling many of the voids.

An almost identical sequence of limestones and dolostones comprises the Red Head Rapids Formation on Coats Island, although the formation is not nearly so well exposed. Unit 1 is exposed at a single locality in a small stream-cut in the western part of the island. The succeeding massive algal limestone (unit 2) is well exposed near the east coast of Coats Island, but the overlying biohermal facies (unit 3), so common to Southampton Island, is nowhere exposed.

The lower contact of the Red Head Rapids Formation is exposed in a prominent escarpment 17 miles west of Coral Harbour, where the formation lies in conformable and gradational contact with the underlying Churchill River Group. In contrast, the Red Head Rapids Formation is in abrupt and disconformable contact with the succeeding Middle Silurian Severn River Formation. This contact is particularly well exposed at Cape Donovan on the northeast coast of Southampton Island (Pl. 29), and on Bell Peninsula, about 10 miles due west of Mount Minto (Pl. 23).

Age and regional correlation. The Red Head Rapids Formation is sparsely fossiliferous. A few brachiopods, gastropods, and stromatolites were collected, but none is diagnostic of either an Ordovician or a Silurian age.

Of the 25 samples from this formation submitted to T. T. Uyeno for conodont analysis (GSC Fossil Report No. MP2-TTU-1972), most were barren; however, two samples yielded faunas that confirm an Ordovician age. One sample contained *Prioniodina* cf. *furcata* (Hinde), and the other, *Icriodella*? sp. (highly fragmentary). According to Uyeno, these forms range in age from Middle through to Late Ordovician. Since the underlying Churchill River Group is precisely dated as Richmondian on the basis of megafossils and conodonts, then the succeeding Red Head Rapids Formation must also be of Late Ordovician (Richmondian) age (Table I).

Although the Red Head Rapids Formation is dated as Ordovician (Richmondian, on the basis of stratigraphic position) at only two localities, the formation is a unique rock-unit that is lithologically consistent over wide regions of Southampton and Coats islands. It is also lithologically similar and undoubtedly coeval to the strata which were defined by Nelson (1963, 1964) as Upper Ordovician Red Head Rapids Formation in northern Hudson Bay Lowlands. The Red Head Rapids Formation is, in turn, tentatively correlated with the Upper Ordovician (Richmondian) Stonewall Formation of southern Manitoba, and the Kagawong and Queenston formations of southern Ontario.

In describing the "oil shale interval" (Red Head Rapids Formation of present paper), Nelson and Johnson (1966, p. 567) state: "The interval is almost completely unfossiliferous. On the beach south from Sixteen Mile Brook graptolite and trilobite fragments were found in oil shale rubble. The trilobites were identified by D. E. Jackson, University of Alberta, as cf. *Pseudogygites latimarginata* (Hall), and the graptolites as a possible new species of *Amplexograptus*. Dr. Jackson interpreted a Late Ordovician

(Richmondian) age for the interval." Subsequently, Jackson (1971) described *Glyptograptus hudsoni* sp. nov. in association with *Amplexograptus* sp. indet. and several pygidia of ?*Pseudogygites*, and allied the new form with late Middle to early Upper Ordovician glyptograptus of eastern North America.

The present writers, however, were unable to find the faunas described by Nelson and Johnson (1966) in any of the numerous Red Head Rapids sections studied on either Southampton or Coats Island. As this fauna is known to occur in considerable profusion in the 'Boas River shale', it can only be concluded that the above fossils were collected from rubble that is representative of the lower unit, and not the uppermost Ordovician, as reported by Nelson and Johnson (1966).

Ordovician Depositional Environments

The Bad Cache Rapids and Churchill River groups are, for the most part, a product of normal marine subtidal depositional environments. They contain relatively abundant and diverse faunas, and bioturbated zones are common throughout most of the sequence. However, a totally different facies and biota prevail within the succeeding Red Head Rapids Formation. The beds that comprise this formation are totally undisturbed by burrowing organisms, and with the exception of stromatolites and a few brachiopods and gastropods, are largely barren of fossils. A logical explanation for the origin of the Red Head Rapids is deposition in a tidal flat environment. However, the presence of thick shelf-edge deposits in the upper part of the formation, upon which bioherm pinnacle reefs flourished, requires an alternative explanation (Fig. 5).

The rapid facies change and decline of biota that brought about development of the Red Head Rapids Formation could have resulted only from increased salinity due to regression of the Ordovician sea and the consequent restriction of the Hudson Bay Basin during the closing phase of the Ordovician period. Instead of conventional intertidal environment, however, the writer (B.V.S.) suggests that the Red Head Rapids may have been the product of a subtidal environment in up to 100 feet of water. Such a depth is not unrealistic considering that the succeeding shelf-edge deposits and pinnacle reefs have a vertical relief of upwards to 75 feet, with less than 5 feet of inter-reefal facies.

Silurian

Rocks of Early Silurian (Alexandrian) age are absent from the northern islands of Hudson Bay, and the oldest Silurian strata are of Middle Silurian (Niagaran) age, comprising the Severn River, Ekwan River, and Attawapiskat formations, in ascending sequence. On Southampton Island these rocks have wide distribution on the south and west parts of the island, extending from Bell Peninsula on the east, to Cape Low and Cape Kendall on the west, and to Cape Munn in the north. On Coats Island, Severn River, Ekwan River, and questionable Attawapiskat strata underlie the southern two thirds of the island, and Mansel Island consists entirely of the Ekwan River and Attawapiskat formations.

Because of the relatively incomplete and widely separated sections, the writer was unable to establish a precise thickness for the Middle Silurian succession, but 975 to 1000 feet may be a reasonable estimate; it thickens southward to an estimated 1500 feet beneath central Hudson Bay.

Rocks of Late Silurian age (Kenogami River Formation) that form the bedrock surface in the southern part of the Hudson Bay Basin, in northern Hudson Bay Lowlands, were not recognized in any of the islands comprising the present map-area. As the Attawapiskat Formation is normally succeeded by the Kenogami River Formation, the latter beds are presumably present in immediate adjacent offshore areas bordering the southern extremities of Southampton, Coats, and Mansel islands.

Severn River Formation

Definition. The term Severn River Formation was proposed by Savage and Van Tuyl (1919) for the thin bedded, fine grained limestones typically exposed along Severn River in northern Hudson Bay Lowlands for about 20 miles above its intersection with Fawn River. The formation was redefined by Sanford *et al.* (1968) to include the Severn River limestones described by Savage and Van Tuyl, as well as the underlying Nelson River Formation of the same authors, and the upper member of the Red Head Rapids Formation of Nelson (1963, 1964). In light of subsequent investigations by Sanford (*in* Sanford and Norris, 1973), it became readily apparent that the Red Head Rapids should not have been included in the Severn River. Consequently, the Severn River Formation was redefined to include the basal Middle Silurian limestones that rest unconformably on Late Ordovician Red Head Rapids strata and are, in turn, succeeded by strata of the Ekwan River Formation (Figs. 4, 5).

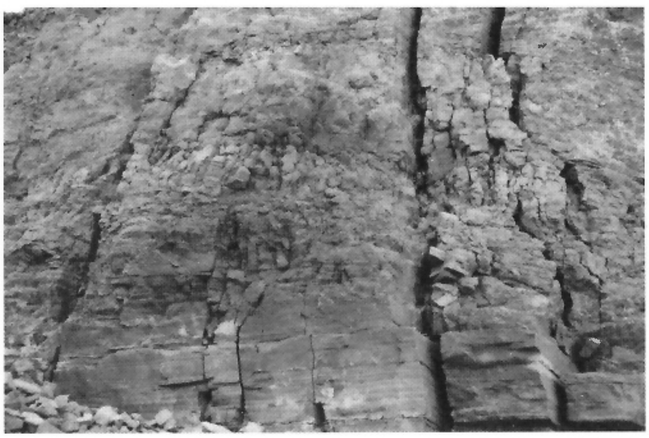
Distribution and thickness. On Southampton Island, the Severn River Formation forms the bedrock surface in a broad concentric belt extending from Junction Bay on Bell Peninsula to Cape Munn at the extreme northern end of the island. On Bell Peninsula the formation dips regionally southward beneath Fisher Strait, and to the northwest of Coral Harbour it dips westward towards Roes Welcome Sound beneath younger Ekwan River strata. Isolated occurrences of Severn River limestone are present in down-faulted blocks at Cape Donovan on the northeast coast of the island, and probably also occur beneath adjacent offshore areas of Foxe Channel. The formation is also present in graben structures within the Precambrian terrain, at Gordon Bay in northern Bell Peninsula.

On Coats Island, the Severn River Formation forms the bedrock surface in a relatively broad belt trending in a northwest-southeast direction across the central part of the island.

The oldest rocks exposed on Mansel Island are limestones of the Ekwan River Formation, but the underlying Severn River strata are presumably present in the immediate offshore areas of Hudson Bay along the east side of the island.

The Severn River Formation is nowhere exposed in complete sections on Southampton or Coats Island, and its thickness is not precisely known, but is probably about 500 feet.

Lithology and stratigraphic relations. The Severn River Formation consists primarily of light to medium brown microcrystalline limestone and dolostone that weather light tan and yellowish orange mottled. It commonly contains alternating light brown, fine to medium crystalline bioclastic limestones and light tan microgranular dolomitic limestones or dolostones. The strata vary from uniformly bedded to irregular and wavy, the latter containing varying amounts of algal material (Pl. 30). Generally, the lower beds of the formation are fairly massive (up to a foot thick) but become thinner bedded (2 to 8 inches thick) throughout most of the formation (Pls. 23, 29). At a number of localities, Severn River strata have been intensely dolomitized; in such places the beds contain microsucrosic to sucrosic textures, and are light tan and yellowish orange tan mottled.



161931

PLATE 29. Severn River limestones resting unconformably on unit 2 of Ordovician Red Head Rapids Formation (unit 1) on Cape Donovan.

161924

PLATE 30. Severn River limestones exposed on shore of unnamed lake at The Points, Southampton Island.

The lower contact of the Severn River Formation with the Ordovician Red Head Rapids Formation is exposed at two places on Southampton Island: (1) on Bell Peninsula, about 10 miles due south of Mount Minto (Pl. 23); and (2) at Cape Donovan, on the northeast coast of the island (Pl. 29). At both places, the contact is abrupt and irregular, which suggests an erosional unconformity. The upper contact of the Severn River Formation with the Ekwan River Formation is nowhere exposed, and thus the stratigraphic relationship between these two formations has not been precisely established.

Age and regional correlation. The Severn River is generally sparingly fossiliferous, certain of the forms being representative of the early Middle Silurian (Niagaran) of southern Manitoba, and of the Great Lakes region of Canada and the United States.

All the megafossil collections of Sanford have been examined by T. E. Bolton, and the following lists of genera or species and biostratigraphic notations are based on his studies of the faunas (GSC Fossil Report No. S-1-1970).

Important elements contained within the Severn River are *Virgiana* sp., *Dihogmochilina latimarginata* (Jones) (Middle Llandoverian), and *Costistricklandia* sp. (Late Llandoverian). The formation also contains *Cystihalysites* sp., *Favosites favosus* (Goldfuss), *Palaeofavosites poulseni* Teichert, '*Streptelasma*' *kukense* Teichert, *Clathrodictyon* sp. cf. *C. drummondense* Parks, and *Stegerhynchus* (?) *winiskensis* (Whiteaves), in addition to a host of other forms.

It is important to note that the brachiopod *Virgiana* is characteristic of the lower part of the Severn River Formation (Port Nelson limestone of Savage and Van Tuyl, 1919) of the Hudson Bay Lowlands, Fisher Branch Formation (lower Interlake Group) of southern Manitoba, Maysville–Lime Island–Dyer Bay formations of Wisconsin, northern Michigan, and southern Ontario respectively, and the Becscie Formation of Anticosti Island (Table I).

The brachiopod *Stegerhynchus*(?) *winiskensis*, frequently in association with the ostracode *Dihogmochilina latimarginata*, is characteristic of the Severn River Formation of Hudson Bay Lowland, the East Arm and Cedar Lake formations of southern Manitoba, both the upper Wabi and lower Thornlow formations of Lake Timiskaming outlier, and the Hendricks and St. Edmund formations of northern Michigan and southern Ontario.

Of the 41 samples of Severn River strata submitted to T. T. Uyeno for conodont analysis, none yielded diagnostic faunas. Consequently, the age and regional correlation of these strata are based entirely on the megafossils identified by T. E. Bolton.

Ekwan River Formation

Definition. The term Ekwan River Formation was proposed by Savage and Van Tuyl (1919) for the 73 to 88 feet of pre-Attawapiskat coral reef beds typically exposed on Ekwan River. In the present report, the term is applied in approximately the same context as originally described by Savage and Van Tuyl, and Sanford *et al.* (1968), namely for the strata that succeed the Severn River Formation and are, in turn, overlain by the reef-bearing carbonates of the Attawapiskat Formation (Figs. 4, 5).

Distribution and thickness. The Ekwan River has wide distribution on Southampton, Coats, and Mansel islands. On Southampton Island, the formation is confined to the western part of the island, rising to form the bedrock surface from Cape Low and Cape Kendall in the southwestern part of the island and extending northward along the east side of Roes Welcome Sound to the vicinity of Hansine Lake. On the west side of the island, the slope of the land drops off at a slightly greater angle than the regional dip of Ekwan River strata. Thus, excellent sections are exposed along the walls of most of the streams flowing westward into Roes Welcome Sound. Particularly spectacular are the numerous waterfalls that occur at scattered localities along most of the stream systems.

On Coats Island, Ekwan River strata form the bedrock surface of the southern part of the island and dip regionally southwestward beneath the water of Hudson Bay. The regional dip is interrupted locally by normal faults (particularly on the southern end of the island at Cape Southampton) where Ekwan River strata dip at a steep angle eastward.

On Mansel Island, the formation underlies the central and eastern parts of the island where it forms a succession of cuestas (Pl. 8); low escarpments up to 75 feet face eastward, with rock strata dipping gently westward. On hydrographic charts of the area southward from Mansel Island, the Ekwan River and succeeding Attawapiskat formations can be readily mapped on the basis of bottom physiography (cuestas and elongate shoals). Similarly, on the west side of Hudson Bay, prominent cuestas can be observed on hydrographic charts that extend from Southampton Island to Hudson Bay Lowlands; similar cuestas are known to be formed also in Ekwan River and Attawapiskat formations.

Although the Ekwan River Formation is nowhere exposed in a complete section on any of the islands in northern Hudson Bay, the formation probably contains a composite thickness of upwards to 300 feet.

Lithology and stratigraphic relations. The Ekwan River Formation is divisible into three lithological units, which have been identified in widely separated parts of Southampton, Coats, and Mansel islands.

(*Unit 1*). The lower unit is composed of medium to dark brown algal limestones that locally contain columnar stromatolitic zones up to 30 feet thick (Pls. 31, 32). The laterally equivalent strata are brown laminated limestones with sporadic intervals of flat pebble-conglomerate, with stromatolite mats locally present throughout the unit (Pl. 33).

161939

PLATE 31. Thin-laminated limestones of unit 1, Ekwan River Formation (note stromatolite mats), west coast of Mansel Island.

149687

PLATE 32. Columnar stromatolites in unit 1 of Ekwan River Formation, near west coast of Coats Island.

161940

PLATE 33. Stromatolite mats in unit 1 of Ekwan River Formation, Mansel Island.

Unit 1 of the Ekwan River Formation is, for the most part, thin bedded (2 to 4 inches thick), weathers dark brownish grey, and is massive. These, and the underlying Severn River strata, have eroded more rapidly than the succeeding thicker bedded units of the Ekwan River, which account for the prominent escarpments that have formed on Mansel and Coats islands and adjacent offshore regions.

(*Unit 2*). The succeeding Ekwan River strata are composed of hard, resistant, light to medium brown limestones that weather grey tan (Pl. 34). The beds, 3 to 10 inches thick, vary from uniform to lenticular, the latter being composed of algal, stromatoporoid, or coral biostromes (Pl. 36). Light grey chert nodules occur locally in these beds, and are also found in great profusion in the reworked Paleozoic gravels that overlie the Ekwan River terrain.

The unit contains a preponderance of normal marine faunas (brachiopods, corals, echinoderms, and stromatoporoids); these form the framework for small isolated biohermal masses (Pl. 35) that occur along the Ekwan River outcrop belt.

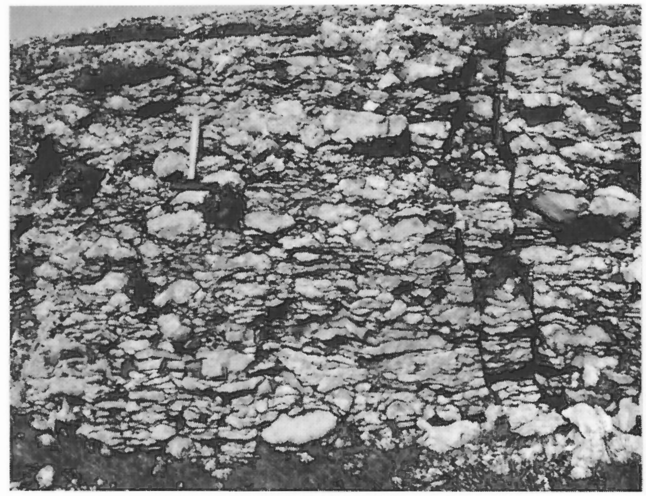
(*Unit 3*). The upper unit of the Ekwan River Formation is generally a hard, massive bedded sequence (beds up to 18 inches thick) composed of light brown, cream, white and blue-grey, fine to medium crystalline crinoidal limestones and dolostones that weather white to greyish brown (Pl. 37). Small algal biohermal masses also occur locally in this interval, particularly in the lower beds.

149652

PLATE 34. Ekwan River dolostones (unit 2) near Cape Southampton, Coats Island. Tilting of beds is due to normal faulting.

149533

PLATE 35. Small bioherm composed of stromatoporoid and coral framework in unit 2 of Ekwan River Formation, Mansel Island.



149679

PLATE 36. Stromatoporoid biostrome in unit 2 of Ekwan River Formation, Coats Island.

161915

PLATE 37. Massive, white weathering crinoidal dolostones of unit 3, Ekwan River Formation, southwest coast of Coats Island.

The writer (B.V.S.) is unaware of any locality on Southampton or Coats Island where the Ekwan River Formation and underlying Severn River Formation are in direct contact, although if such a contact were anywhere exposed, it should readily be recognized by the slight differences in composition, colour, and bedding characteristics. The upper boundary of the Ekwan River Formation with the overlying Attawapiskat reef-bearing unit is exposed at a number of localities on Cape Low and Cape Kendall, where these formations are in gradational contact over an interval of 1 to 2 feet.

Age and regional correlation. The Ekwan River Formation (particularly unit 2 as described above) contains numerous fossils that confirm an early Middle Silurian (Niagaran) age. According to T. E. Bolton (GSC Fossil Report No. 5-1-1970), important faunal elements of the writer's collections are the brachiopods *Eopholidostrophia*, *Pentamerus-Pentameroids*, *Glassia variabilis* Whiteaves, and *Eospirifer-Macropleura*.

The Ekwan River strata of Southampton, Coats, and Mansel islands are everywhere composed of hard resistant carbonates (particularly units 2 and 3), and because of the brief time available to study each outcrop section, the fossil collections obtained were often less than adequate for proper dating and regional correlation. However, the Pentameroid brachiopods provide a reliable Middle Silurian (Niagaran) age, and imply rough correlation with the Ekwan River Formation of Hudson Bay Lowlands, the Thornloe Formation of Lake Timiskaming outlier, the Fossil Hill Formation, and possibly part of the Amabel Formation of southern Ontario (Table I).

Some 23 Ekwan River samples were analyzed for conodonts by T. T. Uyeno (GSC Fossil Report No. MP2-TTU-1972). These, for the most part, contain such long-ranging genera as *Panderodus*, although three of the samples contained *Ozarkodina* sp. cf. *O. typica* Branson and Mehl, and *Ozarkodina* sp. cf. *O. edithae* Walliser, forms similar to those that have been reported from the Silurian Brassfield Formation of the Cincinnati Arch area of Ohio.

Attawapiskat Formation

Definition. The term Attawapiskat Coral Reef was proposed by Savage and Van Tuyl (1919) for the biohermal development exposed along the lower reaches of Attawapiskat River in the Hudson Bay Lowlands. There the Attawapiskat Formation succeeds the Ekwan River Formation, and is in turn succeeded by the Kenogami River Formation. Although the Kenogami River Formation is nowhere present on Southampton, Coats, or Mansel islands, it is assumed to be present in the immediate adjacent offshore regions of Hudson Bay. The reef-bearing beds succeeding the Ekwan River Formation on Southampton, Coats, and Mansel islands presumably occupy a stratigraphic position similar to that of the Attawapiskat Formation of Hudson Bay Lowlands, and that term is therefore considered applicable also for the northern part of Hudson Bay Basin (Figs. 4, 5).

Distribution and thickness. The Attawapiskat Formation is the youngest rock-unit exposed on the islands of northern Hudson Bay. On Southampton Island, the formation underlies the southern extremities of Cape Low and Cape Kendall in the extreme southwestern part of the island. From there the beds dip south and southwestward beneath Hudson Bay proper and Roes Welcome Sound, respectively. On Coats Island, there is some doubt as to the presence of Attawapiskat strata, although rocks exposed in the extreme southwestern part of the island have tentatively been assigned to that formation. Attawapiskat rocks are well developed on the west and north coasts of Mansel Island, and dip regionally westward beneath Hudson Bay.

Thickness of the Attawapiskat Formation cannot be accurately determined because of the highly irregular and undulating nature of the beds. However, a thickness of 175 feet is a possibility.

Lithology and stratigraphic relations. The Attawapiskat Formation is composed of light to medium brown inter-reefal dolostones and dolomitic limestones that weather dark orange brown. The dolostones, often cherty, are fine to medium crystalline in beds generally massive (up to 18 inches thick) and highly undulating that locally give place to small biohermal swarms (Pl. 38). The reefs, composed of algal, coral, and stromatoporoidal framework, are highly variable in size and distribution. Generally, they are small and stunted (less than 5 feet in diameter and thickness), but at one locality about 10 miles west of the mouth of Boas River (between Cape Low and Cape Kendall) a number of reef cores up to 20 feet high rise above the lowland and are exposed to good advantage (Pl. 39).

The contact between the Attawapiskat Formation and underlying Ekwan River Formation is an arbitrary boundary that is conformable and gradational.

Age and regional correlation. Fossils are not particularly abundant in the Attawapiskat Formation, and because of its limited areal extent, very meagre collections were obtained. The beds are unquestionably of Middle Silurian (Niagaran) age, and although they locally overlie Ekwan River strata, they are also considered by the writer to be equivalent, in part, to the Ekwan River Formation.

Seven samples of Attawapiskat strata were submitted to T. T. Uyeno for conodont analysis (GSC Fossil Report No. MP2-TTU-1972), none of which yielded diagnostic fauna. One sample yielded *Panderodus* sp., another *Ozarkodina* sp.

161921

PLATE 38. Algal bioherms in Attawapiskat Formation, Cape Low, Southampton Island.

149673

PLATE 39. Small bioherm in the Attawapiskat Formation composed of stromatoporoid and coral framework, on south coast of Southampton Island, west of mouth of Boas River.

cf. *O. simplex*, a form similar to that reported from the Bainbridge Formation (Ludlow age) of Missouri.

Silurian Depositional Environments

The Middle Silurian rocks of Southampton, Coats, and Mansel islands would provide an excellent opportunity for classic carbonate studies because of the wide lateral facies changes that can be directly related to a variety of depositional environments. During the present investigations, the main concern was regional reconnaissance mapping, and thus only some of the more obvious facies changes were recorded.

Although there are obvious vertical and lateral facies changes in the Severn River Formation, they are minimal, and the formation invariably consists of a relatively uniform normal marine carbonate sequence of subtidal origin (Fig. 5, *in pocket*). The Severn River sea did not contain a rich and varied fauna, and therefore lacked the organic framework to bind and accumulate an abnormally thick carbonate barrier along the shelf-edges of the Hudson Bay Basin as did the succeeding carbonates of the Ekwan River Formation. Instead, the Severn River carbonate detritus (lime muds) behaved in a manner similar to that of fine terrigenous sediment deposition that normally becomes progressively thicker from the shelf margins towards the basinal depocentre.

In contrast to the Severn River Formation, the succeeding Ekwan River and Attawapiskat formations contain thick shelf-edge deposits around the margins of the Hudson Bay Basin, and these apparently thin towards the central part of the basin. Within this combined sequence, three distinct depositional environments were recognized: (1) shelf lagoon and tidal flat, characterized by finely laminated stromatolitic limestones with a sparse fauna (unit 1 of Ekwan River Formation); (2) stable shelf-edge, characterized by clean, high energy carbonates with an abundant and diverse fauna (units 2 and 3 of the Ekwan River Formation); and (3) outer shelf, with bioherms (Attawapiskat Formation) that flourished along the seaward margin of the shelf-edge (Fig. 5). The conditions described above are similar to the facies changes that are known to have occurred around the margins of the Michigan Basin in the Middle Silurian period (Sanford, 1969b).

METAMORPHISM

The Precambrian rocks of Southampton Island that are older than the diabase show the results of the widespread regional metamorphism characteristic of the Churchill Province. Both the amphibolite and the granulite facies are represented, and locally the rocks have been subjected to later retrograde metamorphism. The areas indicated as hornblende granulite on Figure 6 are those in which pyroxene was noted either from hand specimens or from thin sections. The remaining areas have been arbitrarily placed in the amphibolite zone. Because of the reconnaissance mapping techniques used, no isograds are considered to be well enough established to be shown on the map (Fig. 6); however, further microscopic study would probably refine the boundaries.

The hornblende granulite subfacies rocks of the granulite facies occur around Coral Harbour and in a broad band extending from Mount Saorre to Cape Fisher and northerly to Cape Bylot. These rocks are generally medium grained, and range from massive to well foliated or layered. The main rock-types, quartzofeldspathic gneiss and migmatite, consist of apparently stable assemblages containing orthopyroxene, as well as biotite and/or hornblende. Many of these rocks, especially those with a low mafic content, have a distinctive greasy greenish lustre. The mineral assemblages are:

quartz–plagioclase–microcline–hornblende–pyroxene
quartz–plagioclase–biotite–hornblende–pryoxene
quartz–plagioclase–biotite–garnet–pyroxene
quartz–plagioclase–biotite–pyroxene

Typical mineral assemblages from the mafic rocks are:

plagioclase–garnet–pyroxene
plagioclase–hornblende–pyroxene.

In the rocks of the hornblende granulite subfacies, both clinopyroxene and orthopyroxene are present; the plagioclase ranges from calcic oligoclase to sodic andesine and only rarely is more calcic than andesine. Biotite is commonly brick-red, and hornblendes tend to be in shades of brown, although many are green.

The amphibolite facies rocks occur between Mount Saorre and Cape Fisher and extend southeasterly to Bell Peninsula, with the exception of the area around Coral Harbour, and from the Duke of York Bay area southerly to the headwaters of Kirchoffer River. Most of the layered gneiss of unit 3, as well as parts of the other quartzofeldspathic units, are represented in this facies. The most common mineral assemblages are:

quartz–plagioclase–biotite–hornblende
quartz–plagioclase–microcline–biotite

Less common but still widespread are:

quartz–plagioclase–biotite–sillimanite–garnet
quartz–plagioclase–sillimanite–muscovite
quartz–plagioclase–biotite–sillimanite
quartz–plagioclase–muscovite–sillimanite–garnet
quartz–plagioclase–muscovite–biotite–garnet–cordierite
quartz–garnet–sillimanite.

STRUCTURAL GEOLOGY

The main structural elements of the islands of northern Hudson Bay are shown on Figure 7. Paleozoic rocks were deposited on an erosion surface that transected various structures formed in Precambrian times.

The Paleozoic rocks of Southampton, Coats, and Mansel islands were deposited on the northern margin of the Hudson Bay Basin. Lateral facies variations in Middle Silurian rocks clearly indicate a paleoslope dipping south from Southampton and Coats islands, and westward from Mansel Island into a basin depocentre possibly lying in the central part of Hudson Bay. In addition, the present-day Precambrian surface of Southampton and Coats islands dips regionally southward beneath Paleozoic strata at a low angle and ultimately reaches a depth of 8000 feet below sea level in the central part of the basin. Although the present-day structural attitude of the Paleozoic rocks is

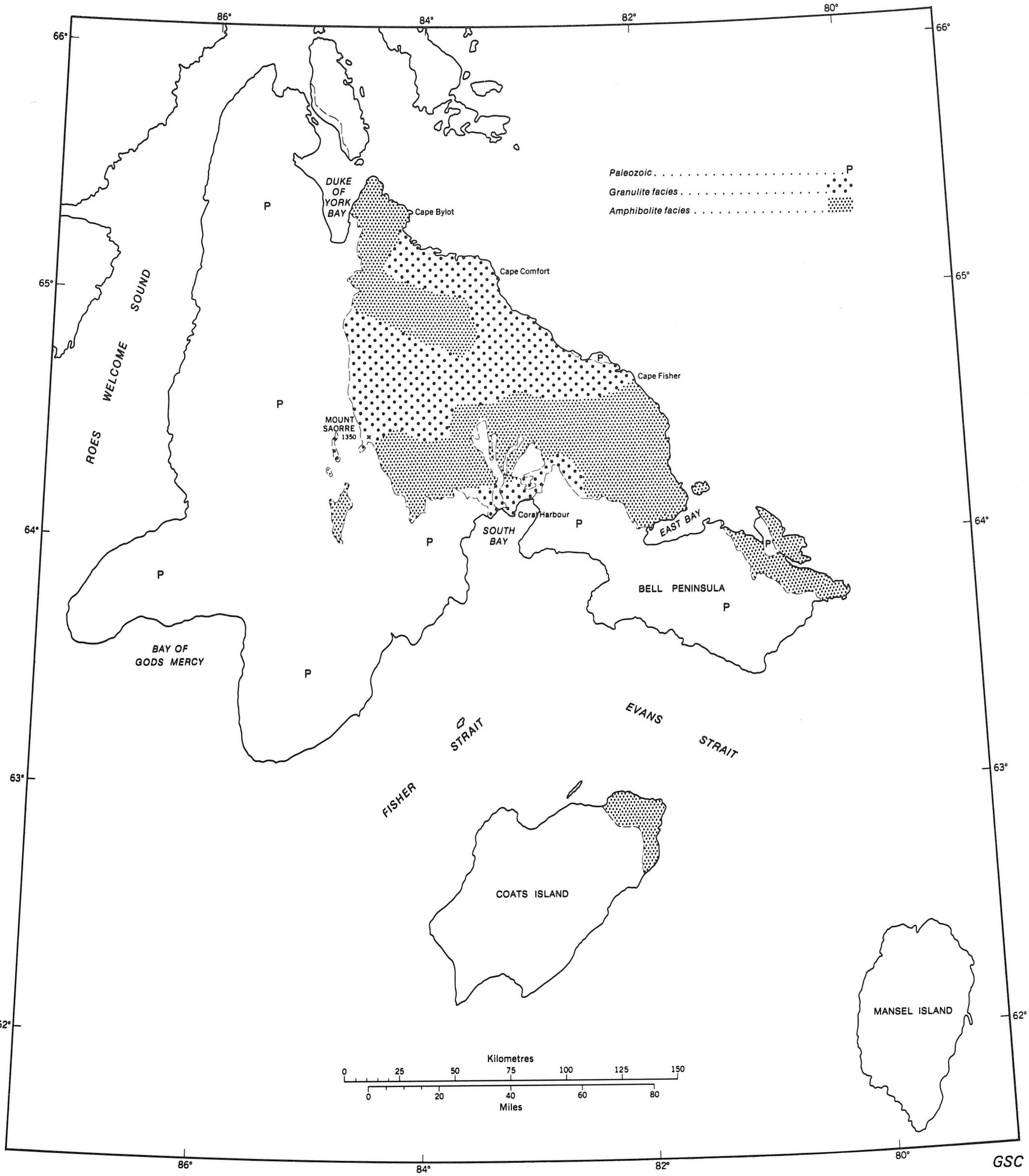


FIGURE 6. Distribution of hornblende granulite and amphibolite facies rocks on Southampton Island.

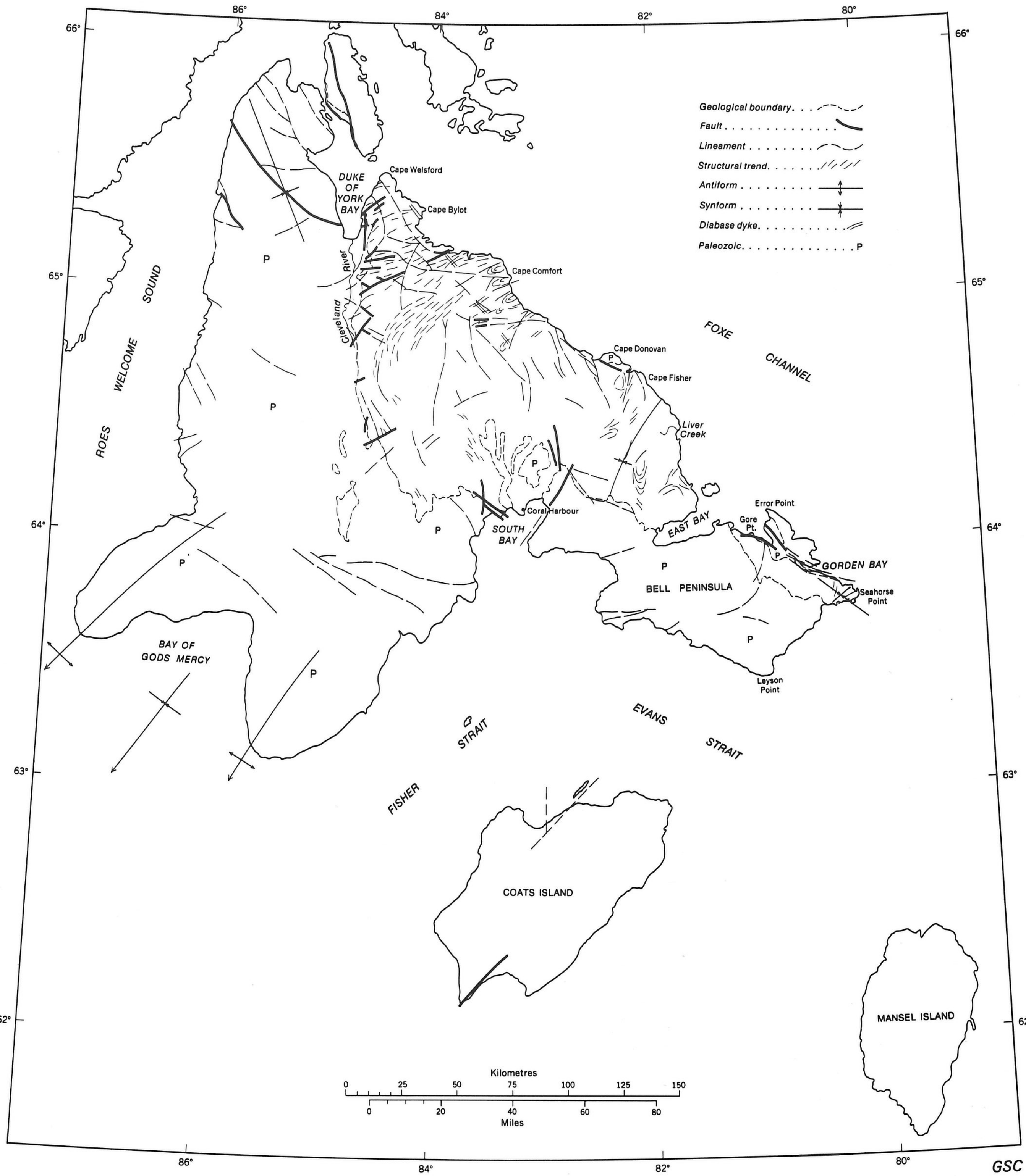


FIGURE 7. Structural elements, Southampton Island.

roughly similar to that during the Paleozoic, Southampton and Coats islands have been uplifted and slightly tilted during a post-Middle Silurian epeirogeny. Hydrographic charts of the offshore regions adjacent to these islands show lineaments that strongly suggest that they are everywhere bounded by faults.

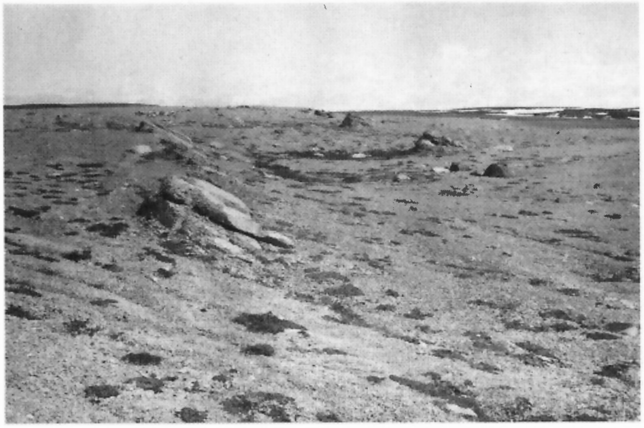
Precambrian structure, as shown on the accompanying map and figures, appears relatively simple. Strike directions are moderately uniform and steep dips are common, although as previously mentioned, there are considerable areas of low-dipping to almost horizontal gneisses. More detailed structural mapping may indicate a much more complex picture. Where exposures are good, such as along the Foxe Channel coast, and in the area between East Bay and Cape Fisher, small folds, some of which are overturned, were noted on air photographs and subsequently checked by ground observations. Broad patterns of folding are suggested from the distribution of attitudes measured on the foliation of the gneissic and migmatitic rocks. From these, major fold axes may be postulated in a broad arc extending northerly, then northeasterly, from South Bay to Foxe Channel, and southeasterly on Bell Peninsula.

With the exception of the area between Coral Harbour and The Buttocks, Paleozoic and Precambrian rocks are everywhere in fault contact. As a result of uplift of the Precambrian, numerous faults radiate outward into Paleozoic terrane, and it is not uncommon for the latter to be tilted at steep angle on random degree of azimuth (Pls. 40, 41).

The western escarpment, extending southerly from Duke of York Bay, is in part a fault scarp and in part a fault-line scarp. Wedges of Paleozoic rocks are downfaulted and thus preserved along the Precambrian side of the scarp, and remnants of Paleozoic rocks remain plastered to the side of the scarp. Sheared and crushed Precambrian gneisses are exposed as much as 600 feet west of the base of the escarpment. This suggests that, in part, the main fault system is west of the present escarpment. Vertical displacement in the Duke of York Bay area is about 1000 feet, and near the headwaters of Cleveland River it could be as much as 2000 feet.

161938

PLATE 40. Severely sheared and fractured Ordovician Bad Cache Rapids limestones at Paleozoic–Precambrian fault boundary, near Junction Bay, Bell Peninsula.



161932

PLATE 41. Ordovician Churchill River limestones dipping into Precambrian terrain, north of The Buttocks (Precambrian highland in background); tilting of strata is due to normal faulting.

A southeast-trending fault apparently lies offshore, immediately adjacent to the north coast of Southampton Island. Along this system, remnants of Paleozoic rocks are preserved in downfaulted blocks and graben structures (i.e., Cape Donovan and at Gordon Bay). Between Cape Welsford and Liver Creek, nearly vertical cliffs rise as much as 100 feet above sea level, with many lineaments parallel to subparallel to the coast. At Cape Donovon, approximately 700 feet of Paleozoic rock is in fault contact with the Precambrian, and intensely sheared Paleozoic and Precambrian rocks are exposed along many transverse faults. A graben displaying Paleozoic rocks between Gore Point and Terror Point extends southeasterly through Gordon Bay almost to Seahorse Point. The south side of the graben is marked by a linear escarpment with shearing locally exposed. A very low scarp marks part of the northeast side, with narrow, widely spaced shear zones present in the Precambrian. To the north, beneath the water of Foxe Channel, Paleozoic remnants lie adjacent to this fault.

One of the most spectacular faults is an east–west system that originates in Hudson Strait near Digges Islands, crosses Fisher Strait at the northern head of Coats Island, and possibly intersects Southampton Island near Bear Cove. This is roughly on trend with several east–west lineaments on Southampton Island that were recognized on aerial photographs and interpreted in the field as normal tension faults. Numerous northeast–southwest scissor faults subsidiary to the main fracture system extend southward into Coats Island, and northward towards Southampton Island. In the latter region they locally deform Paleozoic strata along the south coast of Bell Peninsula.

Another east–west fracture system lies off the south coast of Coats Island, with a northeast subsidiary scissor fault intersecting Cape Southampton where it has tilted Paleozoic rocks at a high angle.

Numerous southeast-trending faults extend across Roes Welcome Sound from the Keewatin mainland and intersect Paleozoic rocks at several points on the west coast of Southampton Island.

161927

PLATE 42. Silurian Severn River limestones dipping into Precambrian in graben structure, Gordon Bay, Bell Peninsula.

The azimuths of joint systems in Paleozoic strata were systematically recorded on all of the outcrops visited, but these have not yet been stereoplotted and thus their relationship to the regional tectonics is unknown. Joints are prominent features in rocks of all ages. No attempt was made to routinely map and study joints in the Precambrian. In some places they are closely spaced and continuous, whereas elsewhere they are discontinuous and irregular. One prominent set is parallel to the foliation, and another set is commonly at right angles and steeply dipping, irrespective of the orientation of the foliation joints. Angular blocks characterize areas where two sets of steeply dipping joints intersect low-dipping foliation jointing. Joints are well exposed on the sides of some of the linear valleys, and one set is generally parallel to the valley.

Most of the Precambrian rocks are foliated to some extent. This foliation ranges from thinly layered to gneissic to schistose, and it is commonly manifested by the planar or linear alignment of platy and/or acicular minerals. Although steeply dipping foliation is most common, horizontal to near-horizontal foliation is a widespread feature. Few or no structural features are noted on Figure 7 in large areas of the central part of the island. Commonly, these areas are underlain by low-dipping to horizontal rocks in which foliation is not apparent in low-level flights over the region.

The foliation of unit 3 is developed by the alternation of generally fine grained light and dark layers that tend to be thin and continuous. The foliation of unit 4 is predominantly the result of layering, but the layers are generally less continuous and the rock is generally coarser grained. The thickness of the layers ranges from $\frac{1}{8}$ inch to several tens of feet, suggesting that it is related to a primary lithology. Foliation developed within the layers appears to be dependent on an original composition that could give rise to platy or acicular minerals. The presence of quartzite and crystalline limestone in several parts of the area supports the interpretation that the foliation is a relict of original sedimentary and/or volcanic sequence.

Rock flowage features such as boudinage, intricate flow structures, and drag folds are present in the migmatitic rocks, and to a lesser extent in the gneissic rocks; they indicate movement under high temperature and intense pressure conditions. Some amphibolitic layers in the gneiss reacted as competent units under deformational stress, and are now seen to be broken and boudinaged fragments in swirly gneisses. Under more intense stress the layering of the gneiss has disappeared, and the former mafic layers appear as inclusions in foliated granitoid gneiss.

AGE DETERMINATIONS

Six potassium–argon age determinations were made from biotite contained in samples collected over a wide area of Southampton Island. All fall within a very limited Aphebian range, indicating that the last period of regional metamorphism was about 1600 m.y. ago during the Hudsonian Orogeny (1550–1850 m.y.).

TABLE VI *Potassium–argon age determinations*

Sample No.	Age (m.y.)	Unit	Location	
HF-1-68	1610±52	4	64°47′N	83°25′W
HF-3-68	1595±52	3	64°14′N	81°57′W
HF-4-68	1590±52	3	63°46′N	80°15′W
HF-21-69	1650±54	3	64°10′N	84°53′W
HF-95-69	1615±52	4	64°30′N	81°53′W
HF-202-69	1610±52	3	64°04′N	81°19′W

ECONOMIC GEOLOGY

Most of the Precambrian area is underlain by a wide variety of gneissic and granitic rocks. Although rusty zones, quartz veins, and pegmatites are not common, they were observed in all units. On the south side of Gordon Bay, rusty shear zones in gneiss contain abundant graphite and disseminated pyrite. Rusty zones are in, and associated with, the quartzite and impure quartzite of unit 2a; pyrite was the only iron-bearing mineral observed. Disseminated pyrite is present in sheared metavolcanic rocks of unit 1. Pegmatite dykes, ranging from 1 foot to 6 feet in width in the Terror Point and Cape Welsford areas, contain molybdenite scales and crystals up to 3 inches in diameter. Small barren quartz veins are widely distributed.

Although there is little likelihood of finding hydrocarbon accumulations in commercial quantities on Southampton, Coats, or Mansel Island, the rocks of these regions exhibit certain lithological and structural characteristics that point to possible occurrences of these constituents in the adjacent deeper offshore parts of the Hudson Bay Basin.

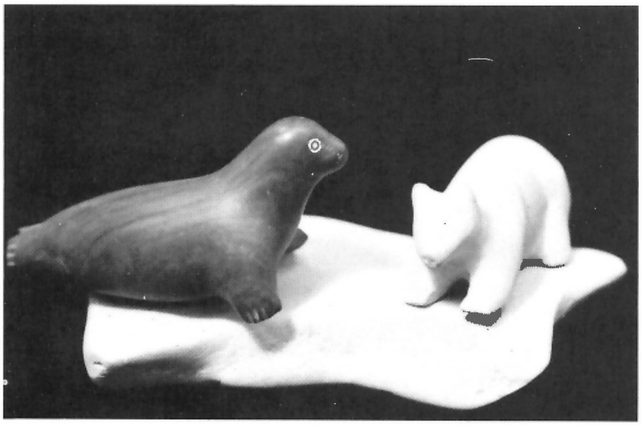
Bioherm pinnacle reefs in the Upper Ordovician Red Head Rapids Formation are potential oil and gas exploration targets that were unknown before the recent work of the Geological Survey of Canada in these areas. Similar reefs are presumably present in the immediately adjacent offshore regions of Hudson Bay, although until further offshore drilling is carried out, it is impossible to accurately predict the trend of the reef development around the margins of the Hudson Bay Basin.

The presence of Middle Silurian Attawapiskat reefs was also established on Southampton, Coats, and Mansel islands by the writers, and these reefs undoubtedly have wide distribution around the inner margins of the Hudson Bay Basin. The reefs studied are small and stunted, but this is apparently due to their proximity to the stable shelf, and it is feasible that considerably larger reefs may be present lower in the basin where subsidence during Middle Silurian time was more pronounced. If analogous lithostratigraphic and tectonic conditions prevailed in this area as in the Michigan Basin during the Middle Silurian, bioherm pinnacle reefs can probably be expected to occur offshore, completely circumscribing the Hudson Bay Basin.

A petroliferous shale unit, here referred to as the 'Boas River shale' of Late Ordovician age, contains significant petroleum per unit volume and, if found in sufficient thickness and areal extent, might be looked upon as a potential source of hydrocarbon at some future date.

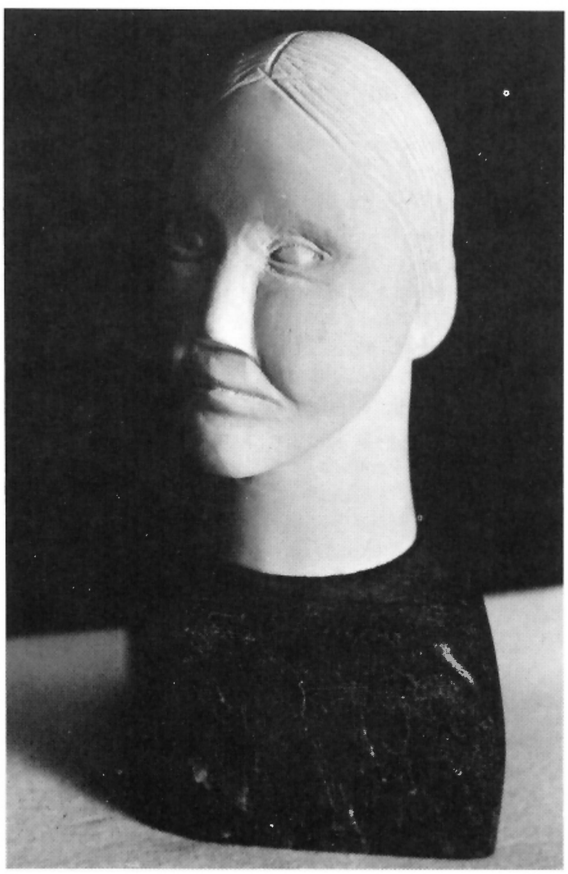
Although no evidence was found for the presence of base metal deposits on Southampton, Coats, or Mansel Island, the Ordovician Red Head Rapids and Silurian Ekwan River and Attawapiskat formations contain extensive shelf-edge deposits that could form traps for lead-zinc deposits generated in the lower parts of the Hudson Bay Basin.

The limestones and dolostones of the Red Head Rapids Formation and possibly other units of the Paleozoic on Southampton and Coats islands offer possibilities as a source of stone for Eskimo carvings (Pls. 43, 44). The micritic and light yellowish orange and tan colours of the rock are pleasing combinations that are most attractive when fashioned into artifacts by the Eskimo artist.



161930

PLATE 43. Eskimo carving from Coral Harbour (bear and base of carving composed of Paleozoic limestone).



161929

PLATE 44. Eskimo carving from Coral Harbour (head composed of Paleozoic limestone).

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