GEOLOGY AND SOME ASPECTS OF THE PALEONTOLOGY OF THE ORDOVICIAN LONG POINT FORMATION, PORT AU PORT PENINSULA, NEWFOUNDLAND

ZAFAR M. SHAIKH

GEOLOGY AND SOME ASPECTS OF THE PALEONTOLOGY OF THE ORDOVICIAN LONG POINT FORMATION, PORT AU PORT PENINSULA, NEWFOUNDLAND

BY

© ZAFAR M. SHAIKH

A THESIS

SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE

MEMORIAL UNIVERSITY OF NEWFOUNDLAND AND LABRADOR

1970

CONTENTS

Chapter 3

TRILOBITA

Chapter 4

BRYOZOA

Chapter 5

OTHER FOSSILS

Chapter 6

STRATIGRAPHY AND CORRELATION

FIGURES

TABLES

ILLUSTRATIONS

ABSTRACT

The Ordovician Long Point Formation is present in the northwest part of the Port au Port Peninsula, western Newfoundland, where it also underlies the whole of the dagger-like northeastward extension of the peninsula known as Long Point from which it derives its name. This study is concerned with the geology and some aspects of the paleontology of the Long Point Formation outcrop between Three Rock Point and the village of Black Duck Brook, an area of some thirteen square miles.

The Long Point Formation consists of fossiliferous limestones, sandstones and shales that have been divided by the writer and Weerasinghe (1970), who studied the geology of the northern part of Long Point, into seven members. Named after their type localities they are, from oldest to youngest, the Tea Cove, Shore Point, Portage, Black Duck, LeRoy, Beach Point and Misty Cove Members. The rock types present in each member and the relationship of one member to another are described.

The beds of the Long Point Formation rest unconformably on the Middle Ordovician rocks of the Humber Arm Group. They strike northeastwards and dip towards the northwest at 40 degrees in the Black Duck Brook area but as they are traced southeastwards towards Lourdes they become vertical and then overturned; since the beds always face to the northwest their structure is homoclinal. Although only minor faults of small displacement affect the formation itself, its boundaries are defined by major faults that separate it from both older and younger strata.

Fossils collected in the thesis area include brachiopods, bryozoans, cephalopods, crinoid fragments, gastropods, graptolites, ostracodes, tabulate and rugose corals and trilobites. The bryozoan and trilobite faunas are described, the former for the first time, and details are also given of some of the other fossils present.

The beds of the Long Point Formation were laid down in the shallow coastal waters of a transgressive sea. The abundance of limestones with a varied benthonic fauna and the presence of small columnar reefs built by the tabulate coral <u>Labyrinthites</u> indicate an equatorial marine environment.

The Long Point Formation is correlated, on the basis of its fossil fauna, with the Ottawa Formation of the Ottawa-St. Lawrence Lowland and its age is regarded as ranging from upper Middle Ordovician to lower Upper Ordovician (upper Wilderness to upper Barneveld Stages).

Chapter 1

INTRODUCTION

Location and Size of the Area

The regional setting of the thesis area is the northwest coast of the Port au Port Peninsula of Western Newfoundland (Fig. 1). The thesis area covers about 13 square miles. The boundaries of the area are shown in Figure 2. The distance from Black Duck Brook in the northeast to Three Rock Point in the southwest is 13 miles. Good coastal sections are present between the village of Black Duck Brook and West Bay, along the eastern side of Long Point, and at Clam Bank Cove and Three Rock Point on the northwestern side of the Port au Port Peninsula. The coast between Misty Point and the northern end of Clam Bank Cove and from the southern end of Clam Bank Cove to Three Rock Point (Fig. 2) was not included in the thesis area because it is underlain by younger strata than are present in the thesis area, and these strata are being studied by another graduate student* from Memorial University.

The map area lies between Latitude $48^{\circ}40'$ and $48^{\circ}43'$ North and Longitude $58^{\circ}58'$ and $50^{\circ}10'$ West.

Accessibility

A fairly good, all weather gravel road connects the thesis area with Stephenville via Piccadilly (Fig. 1). Stephenville is situated about 37 miles southwest of the area. Most of the roads are narrow and a network of rough tracks in the wooded areas supplements the main road system.

Coastal sections are generally accessible from the shore at low tide but where the cliffs are particularly high it is necessary to use a rope in order to study the rocks in the upper part of such

* Mrs. F.H.C. O'Brien

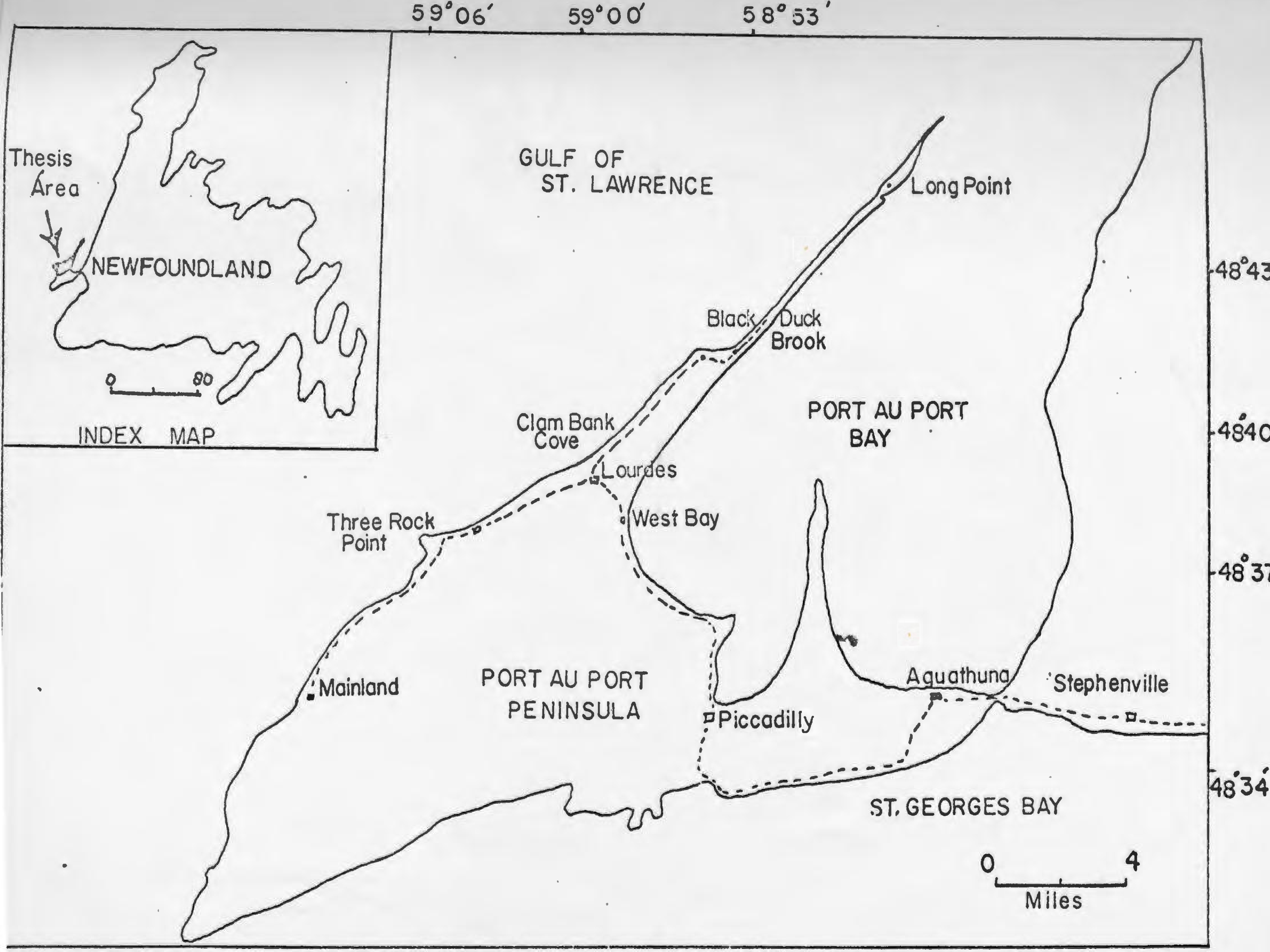


Fig. 1 MAP OF THE PORT AU PORT PENINSULA

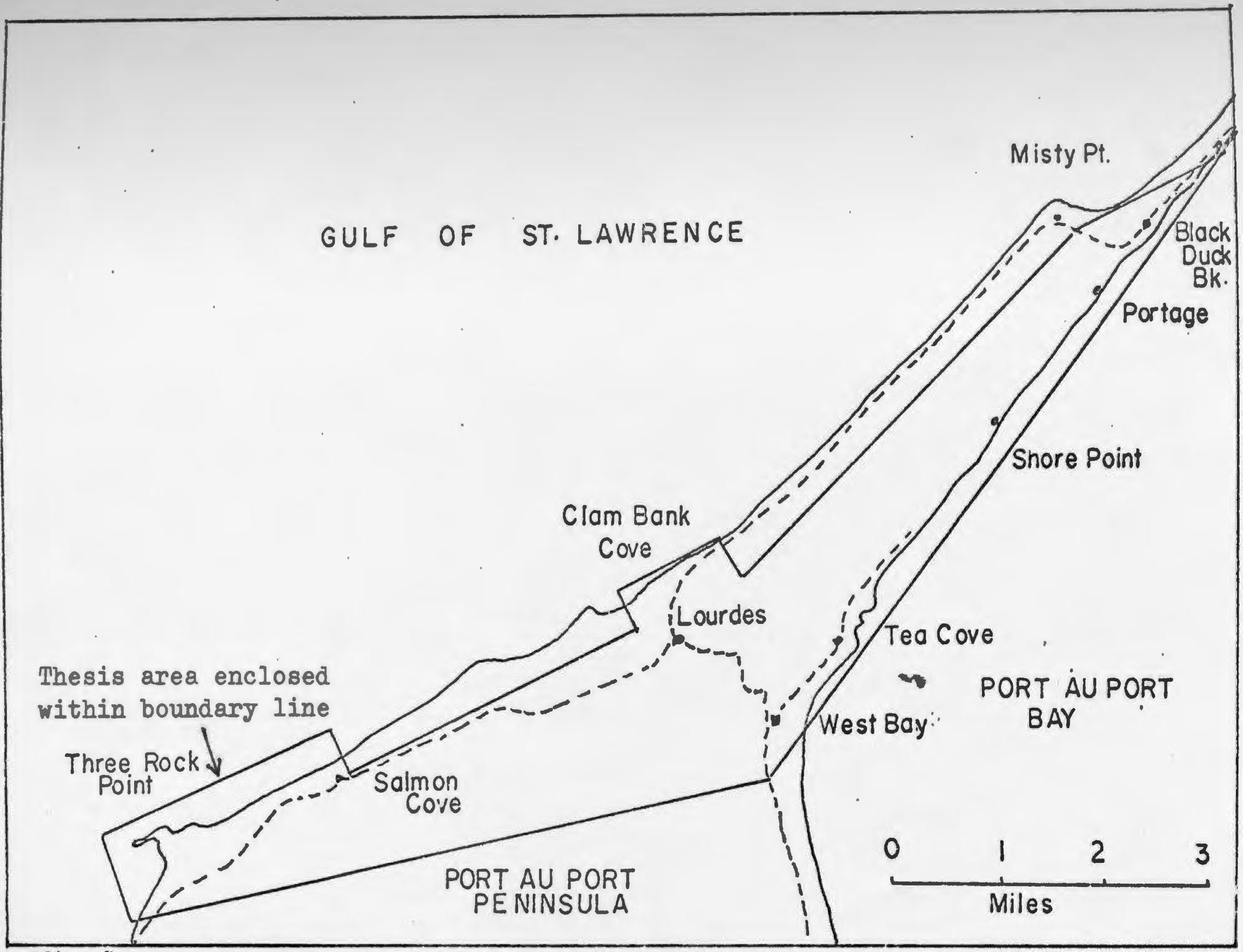


Fig.2

MAP OF THE NORTHWEST PART OF THE PORT AU PORT PENINSULA

cliffs. Away from the coast, patches of thick vegetation, swampy ground and a cover of glacial drift have resulted in a paucity of outcrops and this makes it difficult to determine the underlying geology.

Field Work

Field work was carried out between June and August of 1969 and a further week was spent in the field in July 1970. Most of the field work was accomplished by compass traverses. As no topographic map of the area is available on a suitable scale for mapping, plotting in the field was done upon aerial photographs having a scale of 1 to 10,000. Results were then transferred from the photographs to a map on a scale of four inches to a mile.

Purpose of Study

The purpose of this thesis project was twofold, firstly to study the lithology and stratigraphy of the Long Point Formation, and secondly to study some aspects of the fossil fauna in detail, notably the trilobites and the bryozoans. Prior to the present study little work had been done on the paleontology of the Long Point Formation, especially in the field of Bryozoa.

Physiography

The Port au Port Peninsula, including the thesis area, shows generally northeasterly trending hills, underlain by resistant limestones and dolomites, that rise from gently rolling lowland, which is underlain by less resistant sandstones and shales of Mississippian and Ordovician age. The nature of the underlying bedrock is thus expressed to a large extent by the topography. In the thesis area, Long Point, which is underlain by the limestones of the Long Point

Formation, is bounded on its eastern side by steep cliffs up to two hundred feet in height that face Port au Port Bay. Neighbouring areas underlain by the Green Point Formation and the Humber Arm Group show low relief as the rocks are mainly shales and sandstones which are less resistant to erosion than the limestones.

The Long Point Formation after turning inland near West Bay village forms a distinct ridge which may have originated from differential erosion along the line of a fault that separates the Green Point Formation and the Round Head breccia from the Long Point Formation.

Small streams meander through marshes between the ridges and hills of the area. Stream deposits mainly consist of silt, sand and pebbles.

Glacial Geology

Glaciation has resulted in a smooth, subdued topography and large deposits of glacial drift. Glacial deposits are very conspicuous in the north-eastern and south-western parts of the thesis area. Striations were not observed on any rock surfaces by the writer but Sullivan (1940) reported striations about 6 miles south-west of the area near Man O'War Cove and at South Head.

The area in the vicinity of Lourdes and Three Rock Point is situated on a practically horizontal terrace built of glacial outwash at an elevation of 106 feet. It seems that this terrace represents the deltaic deposits formed when the ice margin was somewhat farther east and discharging into the sea; the terrace was subsequently uplifted to its present height. Included in these deposits are many boulders of gneiss and anorthosite and neither of these rock types occurs within the area which indicates that these boulders may have been transported from the Long Range Complex, some 100 miles to the northeast which is the nearest source for these rock-types.

Geological Setting

Newfoundland forms the northernmost part of the Appalachian Mountain System. This system in Newfoundland has been divided into three distinct geologic provinces or belts, known from west to east as the Western Platform (Kay, 1966), the Central Paleozoic Mobile Belt (Williams, 1964), and the Avalon Platform (Kay and Colbert, 1965), (Fig. 3). The Central Paleozoic Mobile Belt consists of predominantly metamorphosed eugeosynclinal strata of Ordovician and Silurian age. These rocks have been folded and faulted and invaded by granitic and ultra-basic intrusions. Both the northwestern and southeastern sides of the Appalachian Central Paleozoic Mobile Belt are bounded by Precambrian rocks that are overlain by Lower Paleozoic shelf deposits thus giving a two-sided symmetry to the Appalachian Mountain system in Newfoundland (Williams, 1964). The Western Platform lies, geographically speaking on the west side of Baie-Verte-Grand Lake lineament (Fig. 3). The Precambrian crystalline rocks that constitute the basal part of the platform are physiographically expressed by the Long Range Mountains. West of this Long Range complex, Cambrian clastic rocks, locally metamorphosed, grade up into a thick series of Lower to Middle Ordovician rocks referred to as the St. George and Table Head Groups (Schuchert and Dunbar, 1934). Still further westward this carbonate sequence is apparently overlain by a thick clastic sequence called the Humber Arm Group (Schuchert and Dunbar, 1934). It includes shales, sandstones,

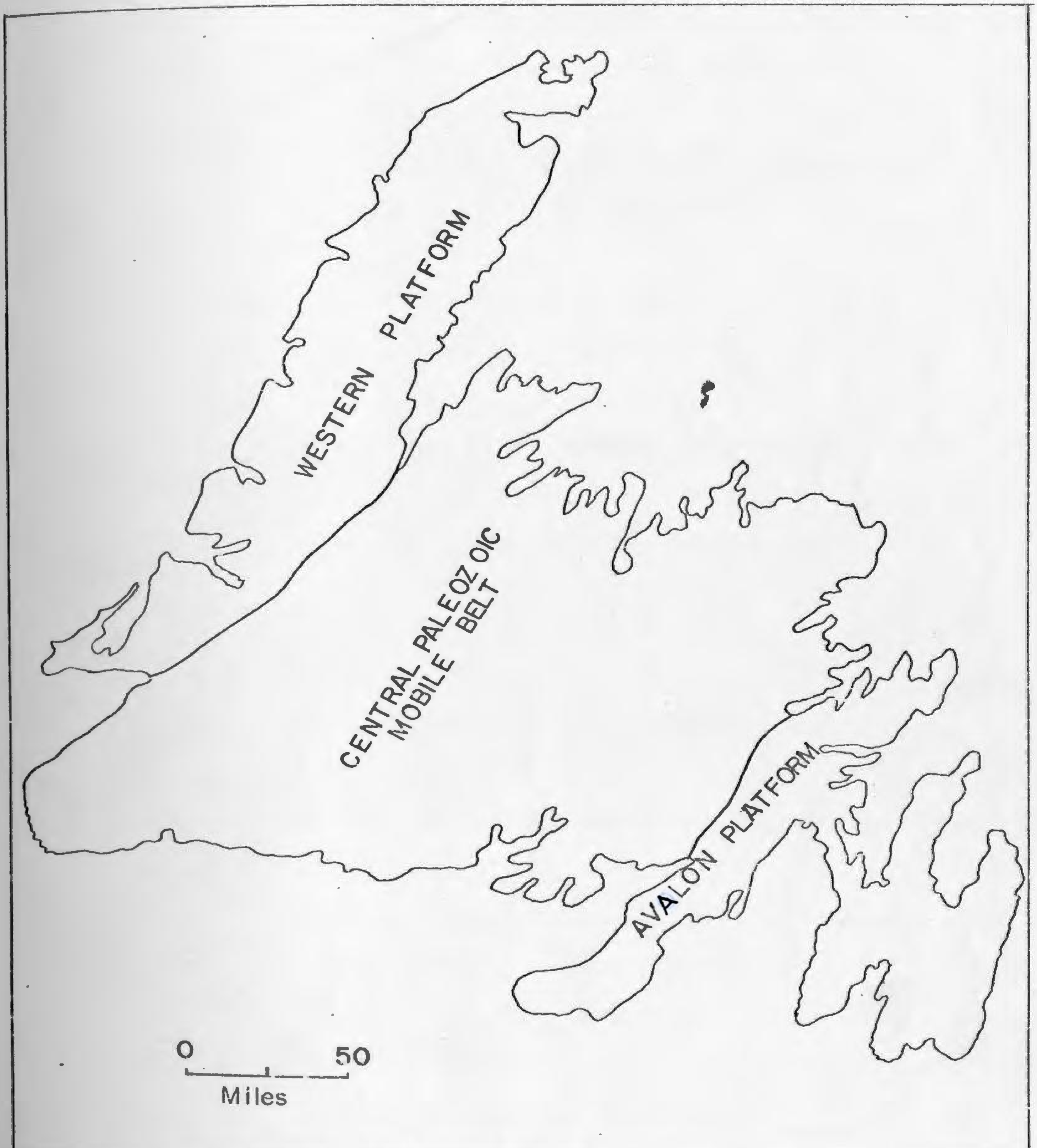


Fig.3 Major Geologic Provinces of Newfoundland Appalachians
(after Williams, 1969)

platy limestones and volcanic rocks intruded by large masses of basic and ultrabasic rocks. This clastic sequence is regarded by Rodgers and Neale (1963) as forming a klippe (Fig. 4). Upon this sequence there lies unconformably another carbonate sequence, the Long Point Formation. It is this last sequence that forms the basis for the present study.

Previous Work

The first significant geological discovery in western Newfoundland was made when coal seams were recognised at St. George's by Jukes in 1842.

Logan (1863) summarized and published Richardson's (1861) findings on the Ordovician rocks of Western Newfoundland. Logan did not give geographic names to the formations described by Richardson but numbered them in ascending order from 1 to 16. Later on he replaced these numerals by the letters A to Q. His divisions A to C = Lower Cambrian, D to I = Lower Ordovician, and K to O = Middle Ordovician while division P and Q represented the Humber Arm series as subsequently recognized by Schuchert and Dunbar (1934) (Table 1).

Murray (1873) studied the rocks of Red Island and included them in a Carboniferous series. He also described the geology of the north side of the Port au Port Peninsula where he found Carboniferous rocks dislocated and juxtaposed with Lower Silurian strata.

Howley (1874) was the first to recognize the occurrence of large faults in the vicinity of Piccadilly and also the presence of a fault at the base of the Long Point strata. He measured the Long Point strata (unnamed at that time) and found that the beds were 800 feet thick. He regarded these beds as being of Black River age on the

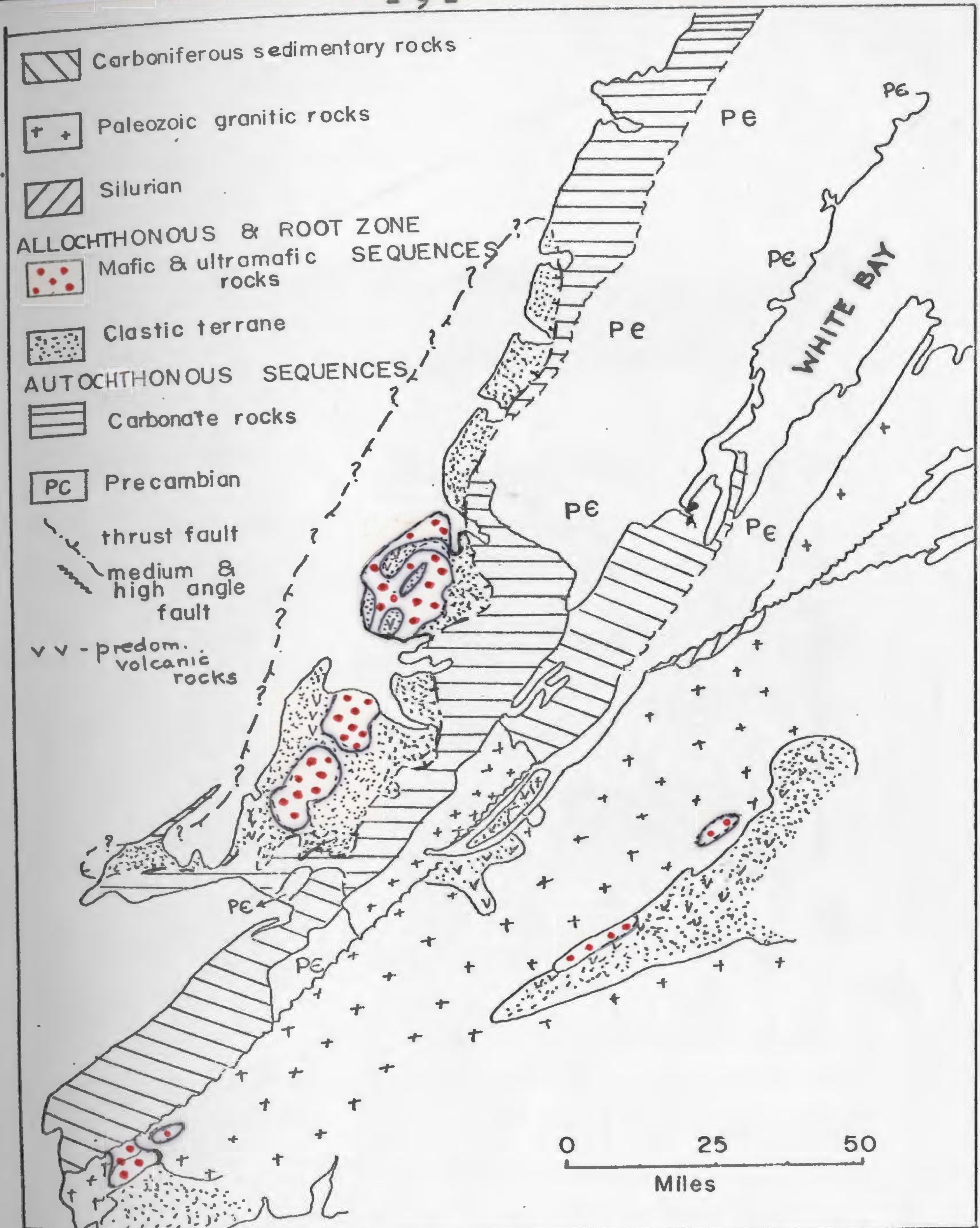


Fig. 4 Generalised Geology of Western Newfoundland, showing proposed Klippen (after Rodgers and Neale, 1963)

basis of a reef-forming bryozoan (since identified as the tabulate coral, Labyrinthitis chidlensis). Howley also discovered graptolites, including Dictyonema, in shales near the village of West Bay (now included in the Green Point Formation).

Schuchert and Dunbar (1934) determined the succession of Ordovician strata in Western Newfoundland (Table 1). They also recognized Devonian rocks in the Clam Bank Cove area and considered them to be unconformably overlying the Long Point Formation. In addition they noted the presence of thrusts and faults in western Newfoundland.

Ordovician Formations of Western Newfoundland

Standard Time Scale		Logan's Divs.	Name	Character	Thickness in Feet
?	?	Q much extended P	Humber Arm series (with basal member of Cow Head breccias)	A great clastic series, varied in texture and color. At base, locally thick deposits of very coarse limestone breccia	At least 5,000, possibly 10,000
Middle	Black River	O much extended	Long Point series	Green-gray shales and light-gray limestones	1,530
Middle	Chazyan	N to K	Table Head series	Heavy-bedded pure limestone grading upward into black shale	1,380
Lower	Canadian	I to D	St. George series	Light-colored dolomites, magnesian limestones, and fine sandstones, with Cryptozoons and intraformational conglomerates	2,080+
Lowest	Canadian	Included in Q	Green Point series	Clastic series similar to Humber Arm series	1,700+

Table 1: Ordovician Formations of Western Newfoundland.
(from Schuchert and Dunbar, 1934)

Schuchert and Dunbar (1934) established that the Green Point Formation includes the oldest Ordovician strata in western Newfoundland. Their age determination was based on the graptolite fauna in these beds, notably Staurograptus dichotomus and Dictyonema flabelliforme.

The Long Point Formation was originally called the Long Point Series by Schuchert and Dunbar (1934) who estimated its thickness to be 1500 feet (Table 2). They recognized a fault separating the

Long Point Formation from the younger beds of the Cow Head Breccia and the Humber Arm Group.

5. (Highest known strata, exposed along Black Duck Cove, west side of Long Point peninsula.)
Greenish thin-bedded rippled calcareous sandstones, with some blue limestone and zones of greenish shale, containing, in the upper part, *Dinorthis* aff. *D. iphigenia*, *Hesperorthis* aff. *H. tricenaria*, *Plectorthis* sp., *Valcourea* sp., *Dalmanella rogata*, *Sowerbyella sericea* ? (large), *Rafinesquina* aff. *R. minnesotensis*, and, in the lower part, in brick-red sandstone, *Rafinesquina* near *R. deltoidea*. (Dip 25°N.45°W.) Thickness, about..... 536
4. Unstudied strata from Black Duck Cove to near the lighthouse, 7 miles north along the west shore, estimated............... 667
3. (Exposed at the lighthouse and on both coasts.)
Greenish-gray, somewhat rippled, calcareous shales interbedded with three layers of fine-grained limy sandstone and some sandy limestone, the harder beds in the upper part replete with three species of *Buthotrephis*. In the shales occur "*Protaræa*," *Streptelasma* aff. *S. profundum*, an anomalocystid, *Valcourea* 2 spp., *Dalmanella* near *D. rogata*, *Rafinesquina* aff. *R. minnesotensis*, *R. alternata*, *Sowerbyella* (small tumid form), *S.* aff. *S. undulata* Salter, *Maclurites* n. sp., *Subulites* n. sp., *Endoceras proteiforme*, *Gonioceras* n. sp., *Ceraurinus* aff. *C. scofieldi*, *Illænus victor* (entire specimens), *Leperditia*. (Dip. 20°N.54°W.) 150
2. (Exposed for 12 miles south of the lighthouse along the greater part of the eastern shore.)
Light-gray to dove-colored sandy limestone series in thin and thick beds, some rippled, and with oölitic zones having *Strephochetus* and thin beds of intraformational conglomerate. *Monotrypa* of a single species occurs throughout, locally making small hemispheric reefs. On and about the reefs occur *Echinosphærites* sp., *Graptodictya* aff. *G. proava*, *Hesperorthis* aff. *H. tricenaria*, *Glyptorthis* aff. *G. bellarugosa*, *Rafinesquina* aff. *R. minnesotensis*, *Valcourea* sp., *Camerella* aff. *C. volborthi*, *Gonioceras* n. sp., *Pterygometopus* aff. *P. callicephalus*. In these beds, at Three Rocks Point, were collected in addition to the above *Streptelasma* aff. *S. profundum*, *Rafinesquina alternata*, *Sowerbyella sericea*? (large), *Triplesia extans*, *Maclurina* n. sp., *Bucania* near *punctifrons*. (Dip 20°-25°)...... 50
1. Lower limestone and shaly limestone of east shore. Exposed for 1½ miles north of Rocky Point........................ 125
The basal 50 feet, exposed in the high cliff 1½ miles north of Rocky Point, are thick-bedded arenaceous rippled light-gray limestone, weathering yellowish, and becoming thin-bedded above. The upper 75 feet are knobbly, sparingly fossiliferous limestone with three zones of greenish shale and knobbly limestone, with *Glyptorthis* nearest to *G. crispata*, *Valcourea* 2 spp., *Rafinesquina* aff. *R. minnesotensis*, *Maclurites* n. sp., *Gonioceras* n. sp. (Dip 43°N.30°W.)

Table 2: Generalized section of the Long Point Formation (from Schuchert and Dunbar, 1934)

Sullivan (1940) mapped the Port au Port Peninsula and described a remeasured section of the Long Point Formation (Table 3). He established that the Long Point Formation contains the youngest

Ordovician fauna in the region. Sullivan also noticed that the Long Point Formation is overturned at Three Rock Point and he concluded from this that the Long Point beds had been affected by thrusting from the Table Head and St. George Groups. He estimated the thickness of the Long Point Formation as 1432 feet.

	Lithology and fauna of the beds	Thickness in feet
7	Thin bedded, knobbly limestone with occasional sandstone layers. Greenish gray color. Very fossiliferous, containing *Dinorthis* cf. *D. iphigenia* (Billings), *Hesperorthis tricenaria* (Conrad), *Dalmanella rogata* (Sardenson), *Sowerbyella sericea* (Sowerby) and *Rafinesquina* cf. *R. minnesotensis* Winchell.	300'
6	Slabby, greenish gray, sandy limestone beds, sparsely fossiliferous. Exposed near the inner part of the cove at Black Duck Brook.	90
5	Thin bedded knobbly limestone, of light grey color, interbedded with shaly layers of greenish gray color. Occasional sandstone layers. Almost entirely unfossiliferous. Exposed along the west shore of Long Point between Black Duck Brook and the Light House.	443
4	Limestone conglomerate with boulders up to 2 feet in diameter. Exposed ½ mile south of the light house on the west shore of Long Point.	4
3	Shaly, sandy limestone and interbedded shaly beds. Found near the light house on both sides of the point. Sparsely fossiliferous, with *Leperditia fabulites* Conrad, the most abundant form.	170
2	Thin bedded, knobbly, coarse grained, brownish and light gray limestones. Contains reefs of *Monotrypa magna* Ulrich, and is very fossiliferous, the writer having collected the following: *Ceraurus pleurexanthemus* (Green), *Cryptolithus* sp., *Encrinurus cybeleformis* (Raymond), *Illaenus* sp., *Leperditia fabulites* Conrad, *Gonioceras* cf. *G. anceps* (Hall), *Maclurites bigsby* (Hall), opercula for *Maclurites*, *Glyptorthis* cf. *G. bellarugosa*, *Hesperorthis tricenaria* (Conrad), *Rafinesquina deltoidea* Conrad, *Rafinesquina alternata* (Emmons), *Rafinesquina* cf. *R. minnesotensis* Winchell, *Strophomena incurvata* (Shepard),	

	Valcourea sp., Graptodictya sp., and other bryozoans. Bed 2 is exposed along most of the eastern shore of Long Point to a point 2 miles northeast of West Bay Village. It is also exposed at the northeast salient of Three Rocks Cove.	240
1	Thick bedded, massive, cliff forming gray limestone, grading upward into Bed 2. Occasional greenish gray shaly layers. Contains Monotrypa magna Ulrich, Maclurites bigsbyi (Hall), Gonioceras cf. G. anceps Hall, Rafinesquina alternata (Emmons), Rafinesquina cf. R. minnesotensis Winchell, Leperditia fabulites Conrad, Illaenus sp. Bed 1 is found on the east side of Long Point lying between the base of Bed 2, 2 miles northeast of the village of West Bay, and the Green Point shales and limestones, which lie to the southeast of the large fault cutting across the base of Long Point.	185
	Total	1432 feet

Table 3: Section of the Long Point Formation. (from Sullivan, 1940).

Riley (1962) mapped the Stephenville area and studied the rocks ranging in age from Precambrian to Pleistocene. His work was published in a memoir of the Geological Survey of Canada. Table 4 shows the succession of rocks from lower Ordovician to lower Devonian.

Era	Period or Epoch	Formation (thickness in feet)	Lithology
Palaeozoic	Lower Devonian	Clam Bank Group 1,879+	Red sandstone, shale, conglomerate, minor limestone
	Fault contact with Long Point Group		
	Fault contact with St. George Group		
	Middle Ordovician	Long Point Group 1,432+	Limestone, sandy shale, possibly equivalent to upper part of Humber Arm.
		Humber Arm Group 5,000+	Red, green and black pyritiferous shales, limestone, greywacke, limestone conglomerate, sandstone; basalt tuff, agglomerate
			"Cow Head Breccia"

Palaeozoic		Table Head Group 807-813	Black and grey, knobbly weathering limestone, black carbonaceous shales, black shaly limestone.
	Erosional Disconformity		
	Lower Ordovician	St. Georges Group 2,400 +	Massive grey, buff and pink dolomite; shaly dolomite, black limestone.
		Green Point Group 1,270 +	Shale, limestone, sandstone (probably in part equivalent to lower part of St. George Group; may be in part Upper Cambrian).

Table 4: Succession of Ordovician and Lower Devonian Formations (from Riley, 1962).

The presence of two largely contemporaneous Lower Paleozoic sequences in Western Newfoundland, one carbonate (miogeosynclinal) and the other clastic (eugeosynclinal), has attracted the attention of many geologists. Rodgers and Neale (1963) proposed a klippe hypothesis to explain the field relationships between these two sequences. According to them the carbonate sequence includes the St. George and Table Head Groups that belong to the miogeosynclinal facies. The other, clastic sequence, represented by the Humber Arm Group, forms the eugeosynclinal facies and is associated with ultramafic rocks. Each sequence appears to range from early Cambrian to Middle Ordovician but, structurally, the clastic terrane is surrounded on three sides by, and generally seems to lie above, the carbonate sequence. The latter rests unconformably on Precambrian rocks and is autochthonous. Rodgers and Neale (1963) stated that if the clastic terrane is also autochthonous, then either invisible unconformities or rapid facies changes must separate the two. Since there is no evidence for these possibilities they suggested that the clastic terrane is allochthonous and forms two large klippen (Fig. 4), one extending along the west coast from Port au Port to Daniel's Harbour, and the other at the tip of the Great Northern Peninsula between Canada and Pistolet Bays. These allochthonous masses are thought to have originated east of the carbonate sequence in an area where large bodies of Lower Paleozoic clastic and volcanic rocks now occur as remnants in a dominantly granitic terrane. This area is, broadly speaking, the shallow northwest trending trough east of the Annieopsquotch Mountains. From this area, their place of origin, they are thought to have been first squeezed up and then to have slid, under gravity, westward into a basin where shales were being deposited upon the autochthonous carbonate sequence. If such a movement did occur, then it was probably during the Taconic Orogeny, whose effects are so marked in the Maritime Provinces.

Rodgers (1965) considered, from the evidence available to him, that an unconformity is present between the Long Point Formation and the underlying Humber Arm Group. Earlier workers regarded this contact as being due to the presence of a major fault. Brueckner and Utting (see Rodgers, 1965) dug out the base of the Long Point Formation and provided further evidence of the unconformable nature of the contact.

Bolton (1965) identified the reef-forming coral of the Long Point Formation as Labyrinthites chidlensis, which is identical to colonies from the rocks of the Manicouagan area (Quebec Province) of

Middle Ordovician age (Wilderness stage). Previously this coral was thought to be the bryozoan Monotrypa magna (Schuchert and Dunbar, 1934, Sullivan in Riley, 1962) and before that it was thought to be a coral of the Tetradium type by Billings (1881).

Kay (1969) gave the thickness of the basal limestone of Long Point Formation as 75 metres. He stated that the basal limestone lies unconformably on the Humber Arm thrust sheet, and that it is succeeded by shales containing Lower Llanvirnian (Zone 6) graptolites of about early Chazyan age. He divided the Long Point Formation into 4 units (Table 5).

4 Units:

First Unit (lowest) ---	sandstone and mud-cracked calcilutite 20 meters thick.
Second Unit -----------	sandy and silty beds overlain by bedded limestone, 25 meters thick, containing reefs of coral Labyrinthites and brachiopod fauna, Bilobia, Chaulistomella, Camerella, Glyptorthis, Hesperorthis, Leptellina, Macrocoelia, Mimella, Opeikina, Sowerbyella, Sowerbyites, and Strophomena, associated with the corals Billingsaria, Labyrinthites and Streptelasma, and with Gonioceras. Brachiopods in this unit characterize Valcourian-Ashbyan and Portfieldian stages of the Chazyan and Balorian series of the Appalachian region.
Third Unit ------------	sandy and shaly beds succeeded by well bedded limestones, 30 meters thick.
Fourth Unit -----------	poorly exposed shaly and sandy unit.

Table 5: Division of the Long Point Formation according to Kay (1969)

ACKNOWLEDGEMENTS

Special thanks are due to Professor M.M. Anderson of the Geology Department, Memorial University of Newfoundland, who suggested the subject of the thesis and supervised all stages of its preparation. His interest, both in the field and during the writing up of the thesis, greatly encouraged the writer.

The writer is also indebted to the other members of the Geology Department who made helpful suggestions, and in particular to Dr. W.D. Brueckner for providing details of the relationship between the Long Point Formation and underlying strata.

Thanks are also due to Mr. F. Thornhill for making thin sections, to Mr. W.S. Marsh for printing the photographs and to Mr. P. Browne for typing the manuscript.

Finally, the author wishes to gratefully acknowledge the many valuable discussions held with a fellow graduate, Asoka Weerasinghe, who was also studying the geology of the Long Point Formation.

The writer was supported during his studies by a University Fellowship from Memorial University and by a $250.00 scholarship received from the British Newfoundland Exploration Company. Field work was supported by Professor M.M. Anderson's N.R.C. grant # A-5100.

Chapter 2

GEOLOGY AND STRUCTURE

General Statement

The Long Point Formation rests unconformably on the rocks of the Humber Arm Group. The formation consists of fossiliferous limestones, sandstones and shales and it underlies the whole of the dagger-like northeastward extension of the Port au Port peninsula known as Long Point. The Port au Port peninsula is the only area in western Newfoundland where the formation is known to occur and it outcrops from the tip of the Long Point in the north to Three Rock Point in the south except for the coastal strips between Misty Cove and the northern end of Clam Bank Cove and between the southern end of Clam Bank Cove and Salmon Cove which are underlain by younger, probably Upper Silurian or Lower Devonian strata (Map 1.). The distance from the tip of Long Point to Three Rock Point is twenty miles.

The base of the Long Point Formation is present about two miles northeast of West Bay village on the eastern side of Long Point. At this locality the lowermost beds of the Long Point Formation, consisting of sandstone and calcareous mudstone, lie unconformably on the strata of the Humber Arm Group. The underlying Humber Arm rocks are red and green shales and friable claystones that are crumpled and disturbed (chaotic zone, Brueckner, 1966). About 500 feet northward from this locality, beneath the unconformity at the base of the cliffs, greywackes and greenish shales of the Humber Arm Group are intruded by gabbro.

The strike of the beds of the Long Point Formation remains constant at 40 degrees east of north from where they are first seen at the coast northeast of West Bay village to Black Duck Brook. The dip, however, which is to the north-west, decreases along the same stretch of coast from 40° to 12°.

About one and a half miles northeast of West Bay village, the beds of the Long Point Formation turn inland towards Lourdes so that the strata change their strike from 40 degrees to 70 degrees east of north. Between this locality and West Bay village the rocks exposed in the coastal cliffs are green shales, sandstones and limestones containing dolomite fragments that belong to the Green Point Formation.

Inland, the Long Point Formation is rarely exposed and only the limestones that are resistant to erosion form conspicuous outcrops. At the northern end of Lourdes where the village begins there is a roadside exposure of sandstone of greywacke character that belongs to the Humber Arm Group. Southwestward from Lourdes, the contact between the Long Point Formation and strata underlying Round Head mountain is totally obscured beneath superficial deposits. Thus, Round Head, which is composed of lime-breccia, is separated from the nearest exposures of limestone belonging to the Long Point Formation by a strip of marshland developed on glacial and scree deposits.

At Three Rock Point, the Long Point Formation outcrops along the shore for about one mile and it then strikes beneath the sea into the Gulf of St. Lawrence. The beds along this part of the coast are overturned.

The highest beds of the Long Point Formation present in the thesis area are encountered in a brook that flows into the northern end of Clam Bank Cove over a waterfall. Maroon coloured sandstones and shales are well exposed below the waterfall. The sandstone beds are between 6 to 9 inches thick and are interbedded with shales. A gradual change in the colour of the beds from greenish grey to deep maroon is apparent in this section. The Long Point Formation is overlain at the northern end of Clam Bank Cove by reddish-brown, poorly sorted, cross-bedded sandstones of the Clam Bank Formation which is regarded as Upper Silurian or Lower Devonian in age. The change in colour in this part of the Long Point Formation may be interpreted in either of two ways: firstly, as due to deposition of iron leached from the overlying Clam Bank Formation, or secondly, as resulting from a gradual change in environmental conditions from marine to terrestrial.

However, since no break was observed at the northern end of Clam Bank Cove between the Long Point Formation and the Clam Bank Formation, the latter interpretation is regarded as the correct one.

The stratigraphy of the Green Point and the Long Point Formations is discussed in greater detail in the pages that follow.

The Rocks

Green Point Formation

Stratigraphically, the Green Point Formation is the oldest Ordovician sequence in the area under study. It is named after the type locality of Green Point in the Bonne Bay area (Schuchert and

Dunbar, 1934). The formation consists of olive-green shales, light-grey sandstones, and thin-bedded buff-grey limestones. The total area underlain by the Green Point Formation is about one and a half square miles. This area lies to the north of the village of West Bay (Fig. 1; Map I) where the formation outcrops for half a mile along the shore and underlies a wedge shaped area inland between strata of the Long Point Formation to the north and rocks of the Humber Arm Group to the south. The Green Point Formation is bounded to north and south by faults.

The sequence of beds exposed along the coast between the southern and northern boundary faults is given below in Table 6.

	Lithology	Thickness
8	Very much crumpled grey to green shale with thin limy-sandstone beds (Pl. 1, Fig. 1) ----------------	200'
7	Greenish shale with buff-colored sandy-limestone ---	200'
6	Light bluish shale inter-bedded with sandy-limestone beds; the shale contains graptolites (Pl. 1, Fig. 2)	70'
5	Greenish-grey, fissile shale ------------------------	50'
4	Covered interval --	500'
3	Greenish shale --	100'
2	Olive-green shale with bands of grey sandstone -------	20'
1	Massive thick-bedded buff to grey limy sandstone with very few shaly beds; these beds contain fragments of dolomite measuring 5" across (Pl. 1, Fig. 3). ------------------------------------	60'

Table 6: Section of the Green Point Formation exposed along the coast northeast of West Bay Village.

These units are unfossiliferous with the exception of unit 6 which contains the graptolites mentioned in the preceding chapter.

Long Point Formation and its Members

The Long Point Formation consists of generally fossiliferous brown and grey limestones, sandstones and shales. Schuchert and Dunbar (1934) referred to these beds as the Long Point Series. Later, Sullivan (1940) regarded them as a Group, which he divided into 7 units. Rodgers (1965) subsequently replaced the term Group by Formation. He divided it into two members, a basal and an upper, at the same time distinguishing 7 units in the basal member but assigning no names to them. More recently Kay (1969) has divided the Long Point Formation into 4 units, again without naming them. In the present detailed study of the western part of the Long Point Formation it was felt necessary for ease of reference and recognition of particular strata within the succession to divide the formation into members on the basis of lithology. Since another postgraduate student, Asoka Weerasinghe, was studying the remainder of the Long Point Formation outcrop to the north of the present thesis area, joint discussions were held to determine the number of members present in the Formation as a whole and the names that should be assigned to them. The seven members of the Long Point Formation have been agreed upon and their names are given below in Table 7, which also gives details of the lithology and thickness of each member.

Unit No.	Member	Lithology	Thickness
7	Misty Cove	Maroon sandstone and greyish green shale containing graptolites------------	1450'+
6	Beach Point	Well bedded nodular limestone interbedded with bluish shale----------	85'
5	LeRoy	Grey nodular limestone interbedded with blue shale-----------------------	25'

4	Black Duck	Brown nodular limestone, with coral reefs, interbedded with shale -----	65'
3	Portage	Grey nodular limestone with bluish grey shales------------------------	18'
2	Shore Point	Brown to dark brown calcareous sandstone interbedded with massive fossiliferous limestone, some shaly partings --------------------------	50'
1	Tea Cove	Yellow sandstone interbedded with calcareous mudstone ---------------	12'

Table 7: Members of the Long Point Formation.

Tea Cove Member * (1)

This is the lowest member of the Long Point Formation and it outcrops at the base of the cliffs along the eastern shore of Long Point, about two miles northeast of Tea Cove. The member is very friable and consists of yellow sandstone interbedded with mudstone. Exposures are poor because the beds weather readily and the base of the cliffs at this locality is largely hidden beneath scree. Furthermore, the outcrop is discontinuous as a result of small-scale faulting. The Tea Cove Member lies unconformably on the green and maroon shales of the Humber Arm Group and it is overlain conformably by the calcareous sandstones and thick limestones of the Shore Point Member (Pl. 2 Figs. 1,2,3.).

Lithologically it differs from the remainder of the formation in lacking limestones. The beds of calcareous sandstone range from 6 to 8 inches in thickness while the subordinate, interbedded, very friable calcareous mudstones are 4 to 6 inches thick. The member lacks fossils and has a thickness of 12 feet.

Shore Point Member (2)

This member is well exposed at its type locality, Shore Point, two

*Map I does not show the outcrops of the three lower members of the Long Point Formation because they are only exposed in the cliffs along the east side of Long Point. Their distribution is, however, indicated in the stratigraphic sections accompanying the map.

miles southwest of Black Duck Brook village along the eastern shore of Long Point, where its outcrop extends from two miles northeast of Tea Cove to Black Duck Brook village. The Shore Point Member consists of thick bedded, brown to dark brown, ferruginous sandstones and light yellow calcareous sandstones interbedded with thick buff-colored fossiliferous limestone. Shaly partings are occasionally present. Details of the succession at Shore Point are given below in Table 8.

9	Light brown calcareous sandstone interbedded with grey limestones	6'
8	Greyish blue shale	6"
7	Light brown fossiliferous limestone	8'
6	Evenly bedded, grey sandy limestone	6'
5	Greyish-blue shale	6"
4	Thick bedded fossiliferous limestone	8'
3	Light brown sandy limestone	5'
2	Greyish-blue shale	1'
1	Brown to dark brown ferruginous sandstone	10'
	Total	56'

Table 8: Succession within the Shore Point Member at Shore Point.

The uppermost beds of the Shore Point Member are light brown calcareous sandstones and light grey limestones. Mud-cracks are present on some of the limestone surfaces and these exhibit a polygonal pattern (Pl. 5, Fig. 3). The mud-cracks are filled with fine sandy material which appears to be more resistant to erosion than the surrounding limestone as on exposed surfaces the filling is found elevated a few millimeters above the surrounding limestone surface. The presence of mud-cracks indicates that during the deposition of these beds they were temporarily exposed to the atmosphere and this resulted in the desiccation and shrinkage of the sediments so that cracks developed which were subsequently filled by fine sand when the sea readvanced over the exposed area.

Cross bedding is a common feature of some of the sandstone beds of the Shore Point Member and it is particularly apparent in the brown to dark brown ferruginous sandstones that form the lower part of the sequence. The cross-laminations are generally inclined in the same direction i.e. towards the northeast indicating a southwesterly source for the sediment. Jointing is a conspicuous feature of this member (Pl. 3, Fig. 1).

The Shore Point Member is overlain conformably by the more shaly Portage Member. The thickness of the Shore Point Member at the type locality is 56 feet.

Portage Member (3)

This member is exposed in the cliffs on the eastern side of Long Point from southwest of Black Duck Brook to Portage, a distance of about three miles. The best exposure is present at Portage where the top and bottom of the member are exposed (Pl. 3, Fig. 2). Its thickness at this locality is 18 feet. This member is composed of greenish-grey, thinly bedded, nodular limestones interbedded with light blue shales. The limestone beds are about five to six inches thick. About mid-way up the sequence, or a little higher, limestones with conspicuous shaly partings temporarily dominate the sequence. Thus a conspicuous 'band' of limestones separates the typical nodular limestones and interbedded shale succession of the Portage Member into a lower and an upper part.

The Portage Member is succeeded by the fossiliferous limestones of the Black Duck Member, the boundary being drawn where the shaly interbeds become inconspicuous. The limestones of this member are fossiliferous and contain the brachiopods Öpikina and Sowerbyites, the gastropod Maclurites and the nautiloid Gonioceras.

Black Duck Member (4)

This member is continuously exposed in the cliffs from Beach Point, one and a half miles southwest of the tip of Long Point, to Portage, about two miles southwest of Black Duck Brook. South of this point the Black Duck Member forms the top of the cliffs until the whole of the formation turns inland where it becomes a conspicuous ridge that continues to Round Head Mountain (see Map 1). It reappears at Three Rock Point where the whole formation is overturned. This member is broken up by several small normal faults in front of Lourdes (See Map 1) and ends up at a fault contact with Round Head Mountain.

The lower half of the sequence is composed of grey, thin bedded limestones that are interbedded with shales (Pl. 3, Fig. 3) whereas the upper half of the sequence consists of light brown, thick bedded, sometime 6 to 8 feet thick, limestones with occasional shaly layers.

The limestone of the Black Duck Member contains numerous colonies of the tabulate coral, Labyrinthites chidlensis. These coral bodies are dome-shaped with a flat undersurface and although they are scattered throughout the member they locally grew in close association and gave rise to small reefs. The reefs formed are wave-resistant structures that now appear as irregular, columnar bodies five to seven feet across and six to thirty feet in height (Pl. 4, Fig. 3). The columnar form of coral reefs indicates that sea level was rising at the time of their formation because corals grow upwards in order to maintain their position within the most agitated waters.

The Black Duck Member conformably overlies the Portage Member and it is succeeded, with slight disconformity, by the LeRoy Member in which shales predominate. This disconformity is shown by an erosional surface between them.

The Black Duck Member is very fossiliferous and in addition to tabulate corals the fossil fauna includes stromatoporoids, brachiopods, gastropods, cephalopods, ostracods, crinoids, trilobites and bryozoans. In some of the coral reefs the stromatoporoids are an important element. The bryozoan fauna in particular is very rich in the lower half of the sequence but the fauna decreases in number of individuals as the sequence is ascended. The writer has collected species of the following bryozoa: Pachidictya, Calopora, Monotrypella, Atactotoechus, Hemiphragma, Goldfussitrypa, Stictopora, Amplexopora, Batostoma, and Diplotrypa.

LeRoy Member (5)

This member is exposed in the cliffs on the east side of the Long Point Formation from north of Tea Cove to a mile south of the tip of Long Point where the beds strike beneath the sea. The beds gradually descend, as they are traced northeastwards in the thesis area, from the upper inaccessible part of the cliff to near beach level where they can be studied. The LeRoy Member has a thickness of 25 feet in a cliff section one mile northeast of Black Duck Brook village. It consists of brown limestone interbedded with buff to grey shales and the sequence has a shaly aspect; the limestone beds are from 4 to 6 inches in thickness. It is overlain conformably by the Beach Point Member.

Brachiopods and trilobites are the most abundant fossils in the LeRoy Member and whereas brachiopods are common at nearly all levels in the Long Point Formation, trilobites are rare in the other members so that the trilobites collected from the LeRoy Member constitute nearly the whole of the known trilobite fauna of the Long Point Formation. Representatives of the following genera were found by the writer: Illaenus, Encrinurus, Sphaerocoryphae, Uromystrum, Calyptaulax and Isotelus.

Beach Point Member (6)

The Beach Point Member first appears in the cliffs on the east side of Long Point about half-way between Shore Point and Portage. Southwestward from this locality only discontinuous exposures of the Beach Point Member are present above the cliffs. Northeastward along the strike, the beds of the Beach Point Member descend gradually towards beach level until the cliffs are largely in this member. However, this does not occur within the thesis area where they form only the upper part of the cliffs. The boundary between the Beach Point Member and the overlying Misty Cove Member is not exposed, since it lies landward of the cliffs beneath superficial deposits, and consequently no direct measurement of the thickness of the member could be made; its estimated thickness is 85 feet. The Beach Point Member consists of grey nodular limestones interbedded with bluish shales. The limestone beds are five to six inches thick. Few fossils were collected from this member but the solitary coral Lambeophyllum is worthy of mention because it is one of the earliest known rugose corals.

Misty Cove Member (7)

The Misty Cove Member is the uppermost member of the Long Point Formation. It underlies the greater part of the Long Point (Map. 1) and coastal outcrops are almost continuous on its western side from near its tip to Black Duck Brook where the beds disappear beneath the sandy beach of Misty Cove (Weerasinghe, 1970). Within the thesis area, the Misty Cove Member outcrops in the cliffs of Clam Bank Cove, near Lourdes, and there are also several small, weathered exposures in the ditches beside the road leading from Winterhouse to Portage and thence along the eastern side of Long Point to Beach Point. At the northern end of Clam Bank Cove, the uppermost beds of the member are well exposed in a stream section. These beds can be divided into a lower sequence (650 feet thick) of thinly bedded, greenish-grey sandstones and limestones interbedded with shales of a similar color, and an upper sequence (45 feet thick) of red to brown sandstones that are separated from one another by a few feet of transitional beds in which the color of the beds changes from greenish-grey to maroon. Brachiopods and graptolites are present in the greenish-grey beds whereas the red beds are apparently unfossiliferous; brachiopods are, however, common in the transitional beds. The change in the lithology and color of the uppermost beds of the Misty Cove Member probably indicates a change from marine to terrestrial or fluvial conditions. At the eastern end of Clam Bank Cove no break was observed between the red beds of the Misty Cove Member and the red beds of the Clam Bank Formation nor is there any evidence for the fault contact generally postulated (Rodgers, 1965). However, at the western end of Clam Bank Cove, the red beds of the Long Point Formation are succeeded after a short covered interval by fossiliferous grey limestones of the Clam Bank Formation and the suddenness of this change is regarded as due to faulting. This fault is considered to run from Clam Bank Cove to Round Head Mountain.

Structural Geology

An unconformity separates the upper Middle Ordovician rocks of the Long Point Formation from the underlying lower Middle Ordovician rocks of the Humber Arm Group. This unconformable contact is poorly exposed in a cliff section about two miles northeast of Tea Cove. There, the Tea Cove Member of the Long Point Formation, consisting of calcareous sandstones and mudstones, lies, apparently with angular discordance, on the green and maroon shales of the Humber Arm Group (Pl.2, Figs. 2,3).

From the locality where the contact is exposed northeastward as far as the tip of Long Point, the strike of the Long Point Formation is practically constant at 40 degrees east of north, but the dip of the beds, which is towards the north-west, gradually decreases from 40 degrees to 12 degrees. Southeastwards from the same locality there is a marked change in the strike and the dip resulting from the whole formation turning inland (see Map 1). The beds now strike 78 degrees east of north and within a short distance they stand vertically. In the vicinity of Lourdes the beds are overturned and dip towards the south-east at moderately high angles; overturning is also seen in the uppermost beds of the Long Point Formation where they are exposed in the cliffs of Clam Bank Cove, and again at Three Rock Point where the limestones of the lower part of the succession reappear as a result of faulting.

Overturning of the limestones is not easy to detect in the isolated outcrops but where the Black Duck Member is concerned, the domed coralla of *Labyrinthites* with their flat bases provide an excellent criterion for establishing the top and bottom of beds because the great majority of the coralla are found undisturbed in their original growth position with the domed surface uppermost.

Along the whole length of the outcrop of the Long Point Formation the beds face or young to the northwest, irrespective of their dip, and they therefore form a single homocline as was noted by Rodgers (1965).

Faults in the thesis area fall into two categories: (1) those that appear restricted to the Long Point Formation, and (2) those that separate beds belonging to formations or groups of different ages. The former are all relatively minor faults in which the amount of displacement ranges from only a few inches to a few feet whereas the latter are apparently major faults involving considerable displacement.

Only some of the minor faults can actually be observed in the field and these are found in the cliffs on the east side of Long Point where, with the exception of one reverse fault (Pl. 5, Fig. 2), they are normal transverse or oblique faults of small throw. Most of these normal faults are present along the stretch of coast just northeast of the locality where the Long Point Formation turns inland and thus appear to be related to this structural feature. In the vicinity of Lourdes a series of parallel faults has resulted in small lateral displacements of the outcrops of limestone belonging to the Black Duck and Beach Point Members (Map 1). These limestones underlie narrow ridges and the arrangement of the ridges enabled the fault pattern to be determined.

Four major faults are present in the area. The most important of these is a east-northeasterly trending fault that extends from Salmon Cove to West Bay, here named the Lourdes fault. The Lourdes fault separates the Long Point and Clam Bank Formations on its northern side from rocks of the St. George-Table Head Group, Humber Arm Group and Green Point Formation in its southern side. North of the Lourdes fault, the Clam Bank Formation is separated from the Long Point Formation to east and west by two other major faults, probably high angle normal faults. The area underlain by the Clam Bank Formation thus represents a down-faulted block. The fault to the west of this block trends west-northwest through Salmon Cove (which probably owes its existence to the presence of the fault) while the fault to the east of it has a north-easterly course from the northern end of Round Head Mountain to the western end of Clam Bank Cove; both faults are apparently cut-off by the Lourdes fault. The fourth major fault is the east trending fault that forms the southern boundary of the wedge-shaped area underlain by the Green Point Formation (Map 1). It runs from just north of Tea Cove to meet the Lourdes fault east of the village and separates the rocks of the Green Point Formation from those of the Humber Arm Group to the south. Sullivan (1940) regarded this fault, and not the fault to the north of the Green Point Formation, as being the eastern part of the Lourdes fault because he considered the Lourdes fault to be a thrust during whose movement Table Head limestones were forced over the beds of the Long Point Formation, brecciating and mixing both types of limestones at the nose of the thrust sheet and along the thrust zone. Sullivan (1940) believed the Lourdes fault to be a thrust because the Round Head limestones contain fragmented material which is lithologically very similar to the Long Point beds. However, it has not been established with certainty that this fragmented material came from the Long Point Formation and, since the Lourdes fault is not exposed anywhere along its course, its nature remains uncertain.

Joints are common in the beds of the Long Point Formation but they are less obvious in the shaly parts of the succession. They are well displayed in the Shore Point Member where three sets are present. The most conspicuous strikes 2 degrees west of north and the other two sets run at approximately 54 degrees east of north and 26 degrees east of north respectively. These joints give rise to rhombohedral blocks in the Shore Point Member (Pl. 2, Fig. 1).

Plate 1

Figs. 1-3	Rock types of the Green Point Formation.
Fig. 1	Grey to green shales interbedded with thin limy sandstones, two miles northeast of Tea Cove on the eastern side of Long Point, Port au Port Peninsula.
Fig. 2	Fossiliferous sandy limestones associated with bluish shales from about one and a half miles northeast of Tea Cove on the eastern side of Long Point, Port au Port Peninsula.
Fig. 3	Thick-bedded buff to grey limy sandstone containing fragments of dolomite 5 inches across, one mile northeast of Tea Cove on the eastern side of Long Point, Port au Port Peninsula.

PLATE I

Fig. 1

Fig. 2

Fig. 3

Plate 2

Figs. 1-3 Unconformity between Long Point Formation and underlying Humber Arm Group.

Fig. 1 Calcareous sandstone and mudstones of the Tea Cove Member of the Long Point Formation about 2½ miles northeast of Tea Cove on the eastern side of Long Point, Port au Port Peninsula. Minor cross faults and weathering largely obscure the contact with shales of the Humber Arm Group which are exposed in the centre of the figure.

Fig. 2 In the upper right-hand corner of the figure, the lowermost beds of the Tea Cove Member unconformably overlie green and maroon shales of the Humber Arm Group about 2½ miles northeast of Tea Cove. In the foreground are disturbed beds (chaotic zone, Brueckner, 1966) of the Humber Arm Group.

Fig. 3 A general view of the unconformity between the Long Point Formation and the underlying Humber Arm Group.

PLATE 2

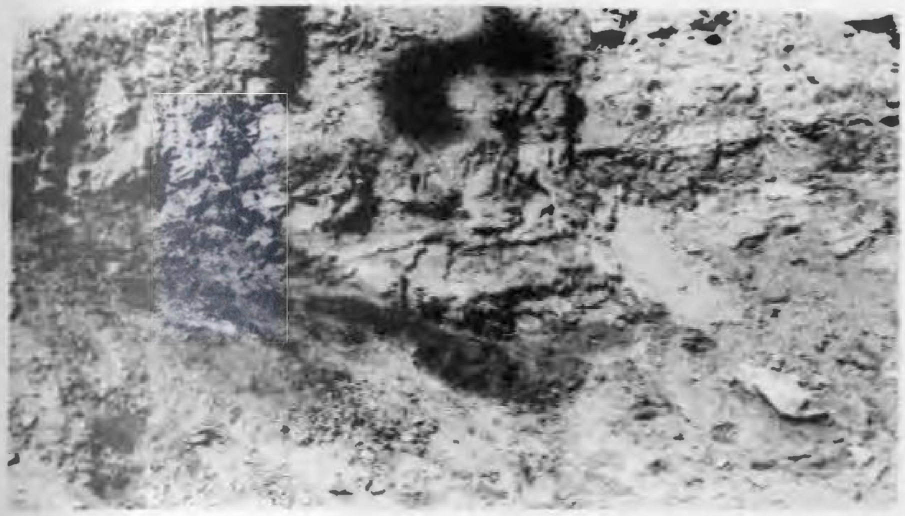


Fig.1

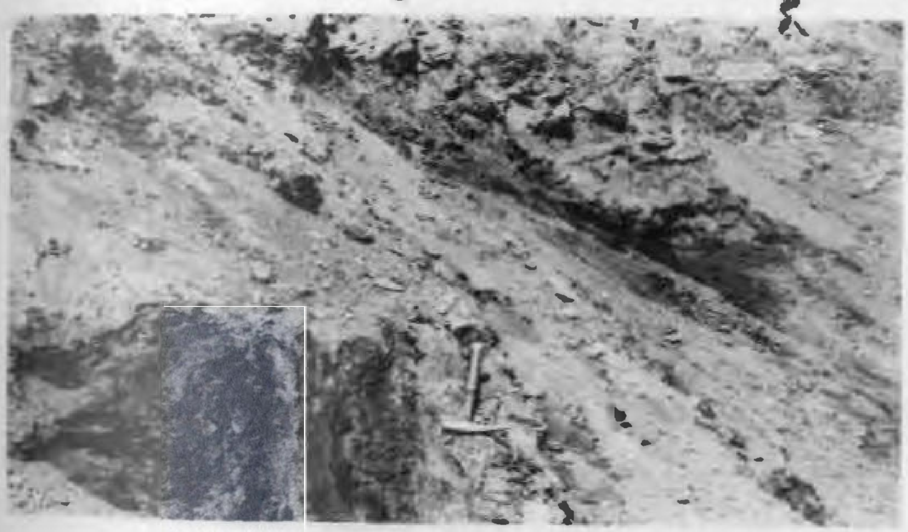


Fig. 2

Fig.3

Plate 3

Figs. 1-3	Rock types and bedding features of the Shore Point, Portage and Black Duck Members.
Fig. 1	Dark brown ferruginous sandstones and fossiliferous limestones (at the bottom left of the figure) of the Shore Point Member of the Long Point Formation, one mile southwest of Portage. Jointing is a conspicuous feature of these beds and in places it divides them up into rhombohedral blocks.
Fig. 2	Grey nodular limestones interbedded with bluish grey shales of the Portage Member of the Long Point Formation, at Portage. A conspicuous band of limestones separates the typical nodular limestone/shale succession into a lower and an upper part.
Fig. 3	Brown nodular, thinly bedded limestones and interbedded shales of the Black Duck Member of the Long Point Formation at the level of Black Duck Brook post office. The limestones contain large coralla of the tabulate coral Labyrinthites, several of which can be recognized in the photograph.

PLATE 3

Fig. 1

Fig. 2

Fig. 3

Plate 4

Fig. 1 Disconformable contact between the LeRoy Member and the underlying Black Duck Member of the Long Point Formation one mile northeast of Black Duck Brook village, on the eastern side of Long Point, Port au Port Peninsula.

Fig. 2 Thin bedded limestones and Sandstones associated with shales of the Misty Cove Member of the Long Point Formation at the northern end of Clam Bank Cove, where they are exposed in the banks of a brook opening into the Cove.

Fig. 3 Large number of dome-shaped colonies of Labyrinthites, forming a columnar coral reef.

PLATE 4

Plate 5

Figs. 1-3 Structural features in the Lomg Point Formation.

Fig. 1 Slumping ? or possibly slight tectonic disturbance of the beds of the Black Duck Member two miles southwest of Portage on the eastern side of Long Point, Port au Port Peninsula.

Fig. 2 Reverse fault affecting the Shore Point and Portage Members of the Long Point Formation. The hade of the fault is 15 degrees with a displacement of 12 feet. Beds of the left hand side of the photograph have been downthrown.

Fig. 3 Polygonal mud-cracks present in the uppermost limestones of the Shore Point Member. These mud-cracks are filled by fine sandy material.

Fig. 4 Intrusive body of gabbro in the shales of the Humber Arm Group.

PLATE 5

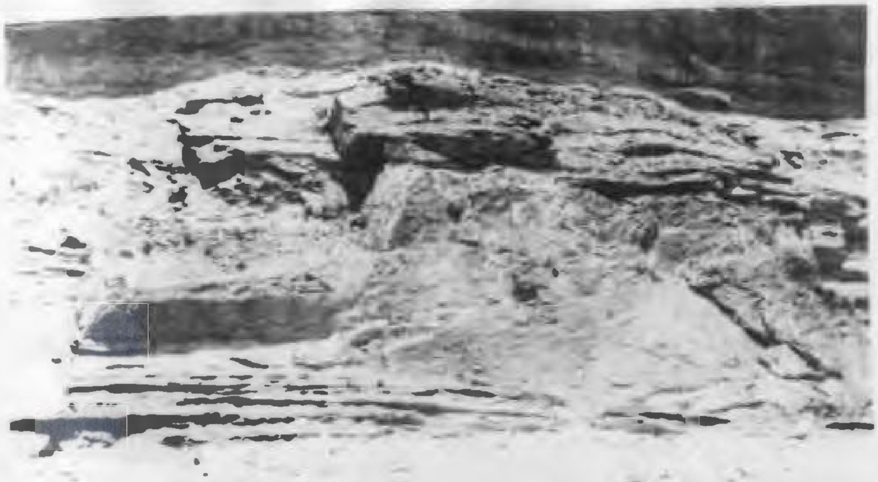


Fig. 1

Fig. 2

Fig. 3

Fig. 4

CHAPTER 3

TRILOBITA

Apart from one specimen of Illaenid collected from the Black Duck Member of the Long Point Formation, the trilobites described in this chapter came from the succeeding LeRoy Member. The trilobite fauna includes representatives of the following families: Asaphidae, Bathyuridae, Cheiruridae, Encrinuridae, Illaenidae and Pterygometopidae. The trilobites described here, and the bryozoans and other fossils considered in chapters 4 and 5 respectively, are classified to family level. All the specimens studied have been placed in the collection of the Department of Geology of the Memorial University of Newfoundland.

The morphological terms used in this study are defined in Volume (O), Arthropoda 1, of the Treatise on Invertebrate Paleontology (Moore, 1959).

Family	ILLAENIDAE	Hawle and Corda, 1847
Subfamily	ILLAENINAE	Hawle and Corda, 1847
Genus	ILLAENUS	Dalman, 1827

<u>Illaenus lacertus</u> Whittington, 1954

Plate 6, Figs. 1,2,3.
Plate 7, Figs. 1,2,3.

<u>Locality and Horizon</u>

Specimen ZMS 001: complete enrolled individual with exoskeleton preserved, from the top of the LeRoy Member, half a mile southwest of Black Duck Brook village on the eastern side of Long Point.

Description

The cephalon is subsemicircular in outline and convex longitudinally; it is only gently convex transversely between the eyes. The dimensions of the cephalon are as follows:

Length:	31mm.	saggital
Width:	53mm.	transverse
Length:	29mm.	exsaggital

Outside the eyes the cheeks descend steeply and are almost vertical. The axial furrows are broad and shallow; at the posterior margin of the cephalon the distance between them is half the cephalic width. They extend forward and slightly inward and die out at about half the cephalic length. The glabella has little independent convexity between the axial furrows. Areas of muscle insertion on the glabella are indicated in specimen ZMS 001 by patches of a darker color on the exoskeleton (Pl.6, Fig. 1). Four pairs of markings are present (Pl.6). The first pair (from the posterior margin of the glabella) are irregularly ovate, with elongation parallel to the axial furrows, and they are situated between the axial furrows and the saggital line. The second pair, separated from the first by a short distance, are elongated and expanded and almost diamond shaped. The third and fourth pairs are smaller and less obvious. They are transversely ovate in outline with the fourth slightly wider than the third. The eye lobe is 2mm. away from the posterior margin of the cephalon and it is nearer to the lateral margin than it is to the axial furrow. The palpebral lobe shows gentle longitudinal convexity that dies out transversely. The eyes are traversed by numerous eye facets. The anterior branch of the facial suture runs forward and outwards and then curves in to meet the anterolateral margin. The anterior surface of the cephalon is marked by fine pits and terrace lines (Pl. 7, Fig. 2).

The thorax is composed of 9 segments which are wider than long. The gently convex axis narrows posteriorly to two-thirds of its width anteriorly. The inner part of each pleura is flat and horizontal and the outer part is bent down steeply (Pl. 7, Fig. 3). The dimensions of the thorax are as follows:

Length: 22mm. saggital

Width: 40mm. transverse

The pygidium is smaller than the cephalon and has a greater width than length (Pl. 7, Fig. 3). The convex axis of the pygidium dies out posteriorly. The margin of the pygidium forms a smooth curve. The dimensions of the pygidium are as follows:

Length: 18mm. saggital

Width: 30mm. transverse

Discussion

This specimen closely resembles Illaenus lacertus, Whittington (1954) in the gentle convexity of the axial part of its cephalon, both transversely and longitudinally, and also in the smooth outward slope of the fixed cheeks and the palpebral lobes. The presence of four muscle markings on the glabella is another notable similarity. The external surface of the cephalon is also finely pitted and shows terrace lines anteriorly. This specimen differs from I.groenlandicus Troedsson (1928) in all the features mentioned above. I.americanus Billings (1859) collected by Teichert (1937) from the Melville Peninsula (Baffin Island), may well be placed within I. lacertus on the basis of the cephalon having a similar outline in anterior view and the presence of grooves on the external surface of the pygidium. It seems likely that the specimen from the Long Point Formation of the Port au Port Peninsula is closely related to illaenids found in northern Greenland, Silliman's Fossil Mount (Baffin Island) and the Melville Peninsula (Baffin Island). I. groenlandicus, I. americanus and I. lacertus have this character in common: the outer parts of the thoracic pleurae are steeply bent down so that the anterolateral margin of the pygidium has a sharp angle. The species mentioned above are regarded as Black River-Trenton in age.

Family	ENCRINURIDAE	Angelin, 1854
Subfamily	ENCRINURINAE	Angelin, 1854
Genus	ENCRINURUS	Emmrich, 1844

Encrinurus aff. E. trentonensis Walcott, 1880

Plate 8, Figs. 1,2.

Locality and Horizon

Specimen ZMS 002: a weathered pygidium collected from the LeRoy Member of the Long Point Formation at the level of Black Duck Brook post office on the eastern side of Long Point.

Description of the pygidium

The pygidium is strongly convex and its outline is that of an equilateral triangle that is a little wider than long (Pl. 8, Fig. 1). It is composed of numerous axial rings and 6 pairs of pleurae; 11 axial rings are clear but more were originally present as the posterior end of the pygidium is worn so that the remaining segments cannot be distinguished. All the ring furrows are continuous but become fainter mesially at the posterior end. The axial furrows are straight, strongly convergent and become faint posteriorly. The pleurae are narrow and curve gently outwards with weak convexity. Successive pleural ribs are directed increasingly backward. The interpleural furrows are broad and moderately deep (Pl.8, Fig 2). Surface ornamentation obscured. The dimensions of the pygidium are as follows:

Length:	2mm. saggital
Width:	2mm. transverse

__Discussion__

It is not possible on this weathered specimen to distinguish the number of segments present and this pygidium is, therefore, only tentatively likened to that of __Encrinurus trentonensis__, Walcott (1880). It differs from __E.cybeleformis__ (see page 48) in having an outline which is more nearly that of an equilateral triangle, in being broader anteriorly and in having a more strongly developed convex central axis with uninterrupted annulations. __E.trentonensis__ has been collected by Wilson (1947) from the Ottawa Formation of the Ottawa-St.Lawrence Lowland which is regarded as Black River - Trenton in age.

Family	ENCRINURIDAE	Angelin, 1854
Subfamily	ENCRINURINAE	Angelin, 1854
Genus	ENCRINURUS	Emmrich, 1844

__Encrinurus__ aff __E.cybeleformis__ Raymond

Plate 8, Figs. 3,4.

__Locality and Horizon__

Specimen ZMS 003: a weathered pygidium from the LeRoy Member of the Long Point Formation, three miles southwest of Black Duck Brook village on the eastern side of Long Point.

Description of the pygidium

The pygidium is narrowly triangular in outline and therefore longer than broad (Pl. 8 , Fig. 3). The axis is narrow and strongly convex; convexity decreases towards the posterior end. The axial segments are distinctly outlined from the anterior to the posterior end. There are 7 pleural segments that are curved sharply downward; the 6 anterior pleural segments are distinctly seen and clearly separated from one another whereas the last pleural lobe is fused with the axis to form a solid posterior tip to the pygidium. Of the 15 axial segments present the last 11 are interrupted by a smooth band that extends to the posterior end where the whole axis becomes smooth (Pl. 8, Fig. 4). A pair of tubercles is present on each tergum and a single tubercle on each pleura. The dimensions of the pygidium are as follows:

Length: 12mm. saggital

Width: 9mm. transverse

Discussion

This specimen shows a very close similarity to the pygidium of Encrinurus cybeleformis Raymond; in having (1) tubercles arranged in a similar pattern (2) the same number of pleurae (3) the first, second and third posterior segments coalesced to form a solid border and (4) a solid central pygidial axis posteriorly that is uninterrupted by annulations. E. cybeleformis has been collected by Wilson (1947) from the Ottawa Formation of the Ottawa St. Lawrence Lowland which is regarded as Black River to Trenton in age.

Family	CHEIRURIDAE	Salter, 1864
Subfamily	DEIPHONINAE	Raymond, 1913
Genus	SPHAEROCORYPHE	Angelin, 1854

<u>Sphaerocoryphe robusta</u> Walcott, 1875

Plate 9, Figs. 1,2.

<u>Locality and Horizon</u>

Specimen ZMS 004: incomplete cephalon showing only the left genal spine. Collected from the top of the LeRoy Member of the Long Point Formation, two miles southwest of Black Duck Brook village on the eastern side of Long Point.

<u>Description</u>

The cephalon is strongly convex so that the axial furrows are very distinct. The neck furrow is broad and shallow axially but becomes deeper laterally. The neck ring is narrow and elevated. The dimensions of the cephalon and of the glabella are as follows:

Length of the cephalon:	10mm. saggital
Length of the glabella:	4mm. saggital
Width of the cephalon:	8mm. transverse
Width of the glabella:	5mm. transverse
Height of the glabella:	3mm.

The glabella is almost circular in outline and is strongly inflated. It consists of two parts, anteriorly a bulbous portion, that constitutes the main part of the glabella, and posteriorly a pair of small glabellar lobes (Pl. 9, Fig. 1). These are separated anteriorly from the main part of the glabella by preoccipital furrows that curve back almost to the neck furrow. The eyes are missing but the palpebral lobes are present and these show that the eyes are set far out from the glabella. Free cheeks are also missing. The fixed cheeks are triangular and convex. Genal spines are long and curved downward. The facial suture cuts the lateral and frontal margins (Pl. 9, Figs. 1,2). The surface of the cephalon is granular with the granules coarser on the globose anterior lobe of the glabella.

Discussion

This fragmentary specimen appears identical to *Sphaerocoryphae robusta* Walcott (1875) in having a very inflated and bulbous glabella that has two rudimentary glabellar lobes posteriorly. Wilson (1947) found *S.robusta* in the Ottawa Formation of the Ottawa St. Lawrence Lowland which is regarded as Black River-Trenton in age.

Family	ILLAENIDAE	Hawle and Corda, 1847
Subfamily	ILLAENINAE	Hawle and Corda, 1847
Genus	ILLAENUS	Dalman, 1827

Illaenus aff. *I. alveatus* Raymond, 1925

Plate 9, Fig. 3

Locality and Horizon

Specimen ZMS 005: six thoracic segments and associated pygidium from the Black Duck Member of the Long Point Formation, one mile northeast of Black Duck Brook village.

Description

The six thoracic segments show the terga to be wider than the pleurae. The outer part of each pleura is bent down steeply and the anterior part of the pygidium is angulate to conform with their shape (Pl. 9, Fig. 3). The large, rounded pygidium, relatively wider (tr.) than long, is broadest anteriorly and decreases in width postero-medially. The smooth axial field is convex anteriorly. The dimensions of the pygidium are as follows:

Length of the pygidium: 23mm. saggital

Width of the pygidium: 26mm. transverse

<u>Discussion</u>

This species resembles <u>Illaenus alveatus</u> Raymond (1925). Its thoracic segments are like those of <u>I.alveatus</u>, with the pleurae bent steeply downwards and the anterior margin of the pygidium similarly angulate. <u>I.alveatus</u> has been collected by Whittington (1965) from the lower part of the Table Head Formation which is regarded as Middle Ordovician in age.

Superfamily	BATHYURACEA	Walcott, 1886
Family	BATHYURIDAE	Walcott, 1886
Genus	UROMYSTRUM	Whittington, 1953

<u>Uromystrum validum</u> (Billings), 1865

Plate 9, Figs. 4,5.

<u>Locality and Horizon</u>

Specimen ZMS 006: incomplete cranidium. Collected from the LeRoy Member of the Long Point Formation, about one mile southwest of Black Duck Brook village on the eastern side of Long Point.

<u>Description of cranidium</u>

The glabella is almost twice as long as wide and shows a slight expansion anteriorly which gives the glabella the appearance of having a slight constriction at about its mid-length. It is gently convex and without glabellar furrows (Pl. 9, Fig. 4). The crescentric eyes are large and almost equal in length to the posterior half of the glabella; they are situated laterally behind the mid-length of the glabella. Facial sutures are widely divergent and although not present on this specimen, the angle at which they diverge is indicated by the furrow running from the posterior part of the glabella forwards and outwards to the anterior end of the eye (Pl. 9, Fig. 4). The occipital ring is very well defined and the same width as the glabella. Ornamentation indistinct. The dimensions of the glabella are as follows:

Length:	8mm. saggital
Width:	5mm. transverse
Length of the eye:	4mm. sagittal

Discussion

The cranidium of this specimen is very similar to the cranidium of Uromystrum validum (Billings) in its general shape, absence of glabellar furrows and in having widely divergent facial sutures. U. validum has been collected by Whittington (1953) from Lower to Middle Ordovician rocks in Newfoundland.

Family	ASAPHIDAE	Burmeister, 1843
Subfamily	ISOTELINAE	Angelin, 1854
Genus	ISOTELUS	DeKay, 1824

Isotelus aff. I. gigas DeKay, 1824

Plate 10, Figs. 1,2,3.

Locality and Horizon

Specimen ZMS 007: incomplete cephalon together with 8 thoracic segments from the LeRoy Member of the Long Point Formation, about half a mile southwest of Black Duck Brook village on the eastern side of Long Point.

Description

The cephalon is sub-triangular in outline and only gently convex. The dimensions of the cephalon are as follows:

Length: 10mm. saggital

Width: 25mm. transverse

The cephalon has indistinct axial furrows. These taper forwards and die out at about the level of the palpebral lobes so that the glabella is little differentiated, and there are no glabellar furrows (Pl.10, Figs. 1,3). The eyes are large and prominent and situated somewhat behind the transverse mid-line of the cranidium on conspicuous, elevated palpebral lobes (see reconstruction - Pl.10, Fig. 2). The genal angles are almost pointed. There are eight thoracic segments. The axis of the thorax is less than half and more than one-third of its whole width.

Discussion

The incompleteness of this specimen makes a specific identification difficult but its general appearance and, in particular, the rather angular cephalon and absence of genal spines, place it close to I.gigas DeKay (1824) which has been reported by Wilson (1947) from the Ottawa Formation of the Ottawa-St.Lawrence Lowland which is regarded as Black River - Trenton in age.

Family	PTERYGOMETOPIDAE	Reed, 1905
Subfamily	PTERYGOMETOPINAE	Reed. 1905
Genus	CALYPTAULAX	Cooper, 1903

Calyptaulax incepta Whittington, 1965

Plate 10, Figs. 4,5,6.

Locality and Horizon

Specimen ZMS 008: complete cranidium with four thoracic segments. Collected from the LeRoy Member of the Long Point Formation at the level of Black Duck Brook post office on the eastern side of Long Point.

Description

The cephalon is semicircular in outline. It is convex and the highest point is shown by the large eye lobe (Pl. 10, Figs. 4,5). The dimensions of the cephalon are as follows:

Length: 8mm. saggital

Width: 12mm. transverse

Length: 6mm. exsaggital

The glabella expands forward from the occipital ring to reach its maximum width across the frontal lobe (which is twice as wide as the occipital ring). The length of the glabella (saggital) is shorter than the maximum width (transverse). Axial furrows are sinuous. The occipital ring is convex and the highest point on the posterior margin of the glabella. Occipital furrow shallow medially, becoming deep distally between the outer part of the occipital ring and lateral lobe 1p. Lateral glabellar furrow 1p starts at the axial furrow, one shallow branch running directly back and not quite reaching the occipital furrow, so that its outlines are slightly inflated. The anterior branch of lateral furrow 1p runs inward and forward for a short distance and dies out, outlining the curved posterior margin of lateral lobe 2p. Lateral lobe 2p is quadrangular in outline. Lateral lobe 3p is subtriangular in outline due to lateral furrow 3p which commences at the axial furrow. Inner ends of the lateral furrows 2p and 3p and the anterior branch of the 1p furrow, lie on the exsaggital line (Pl. 10, Fig. 5). The convex triangular cheek is dominated by the prominent eye lobe, which extends from a point adjacent to the outer end of lateral glabellar furrow 3p to the posterior border furrow. The palpebral lobe is formed by a prominent gently convex band that is curved in a semicircular outline. The palpebral furrow is deep and broad. The eye surface slopes steeply to the furrow which marks the outer margin of the eye lobe (Pl. 10, Fig. 6). The genal angle is rounded and the cheek outside the eye slopes steeply. The lateral border is relatively broad and gently convex. Posterior branch of the facial suture curves around the eye lobe and runs forward and outward from cheek to the margin. Closely spaced tubercles are present on the glabella and fixed cheek.

Discussion

This specimen appears to be identical to Calyptaulax incepta Whittington (1965), especially in the following features that appear to be characteristic of this species: (1) the uniquely quadrangular shape of the lobate portion of the glabella, (2) the conspicuous double curve of the first lateral furrows, (3) the approximately equal width of the first and second lateral lobes and (4) the presence of coarse tuberculations on the frontal lobe and axial portion of the glabella and only faint tuberculations laterally and on the glabella palpebral lobes.

Whittington (1965) found C. incepta in the Table Head Formation which is regarded as being Lower to Middle Ordovician.

Plate 6

Figs. 1-3 — Illaenus aff. I.lacertus Whittington, 1954

Collected from the top of the LeRoy Member of the Long Point Formation about half a mile southwest of Black Duck village on the eastern side of Long Point, Port au Port Peninsula.

Fig. 1 — Dorsal view of the posterior part of the cephalon, showing the first and second pairs of muscle markings. Note that the darker areas on the cephalon indicate the muscle markings.
ZMS 001; X 2.

Fig. 2 — Drawing,based on Fig. 1, to show more distinctly the broad, shallow axial furrows and the first two pairs of muscle markings on the cephalon.
ZMS 001; X 2.

Fig. 3 — Drawing of the anterior part of the cephalon showing the third and fourth pairs of muscle markings.
ZMS 001; X 2.

PLATE 6

Fig. 1

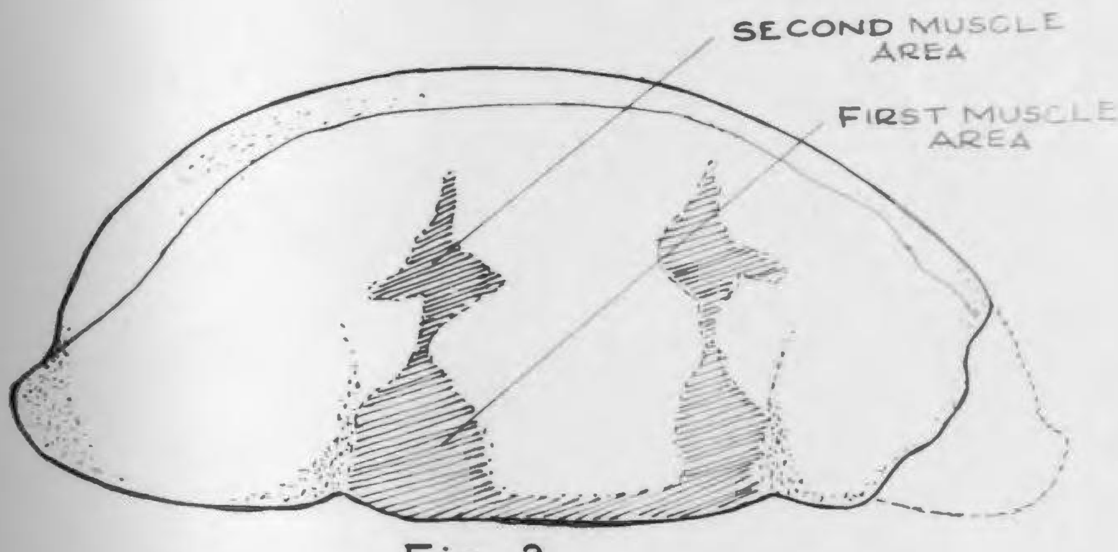


Fig. 2

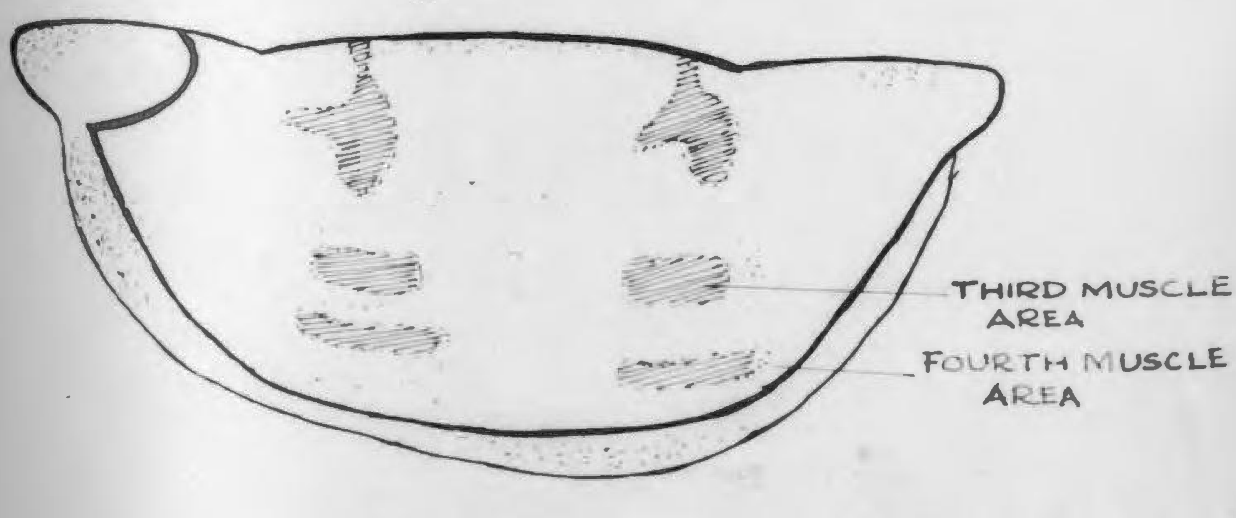


Fig. 3

Plate 7

Figs. 1-3 Illaenus aff. I. lacertus Whittington, 1954

Collected from the top of the LeRoy Member of the Long Point Formation about half a mile southwest of Black Duck Brook village on the eastern side of Long Point, Port au Port Peninsula.

Fig. 1 Lateral view of the enrolled specimen showing thoracic segments and part of cephalon. ZMS 001; X 2.

Fig. 2 Dorsal view of the cephalon and the pygidium. Note anteriorly on the cephalon the left palpebral lobe and terrace lines. ZMS 001; X 2.

Fig. 3 Dorsal view of the thorax and pygidium, showing the steep outward curvature of the other part of each pleura and smooth curve of the pygidial border sides. ZMS 001; X 2.

PLATE 7

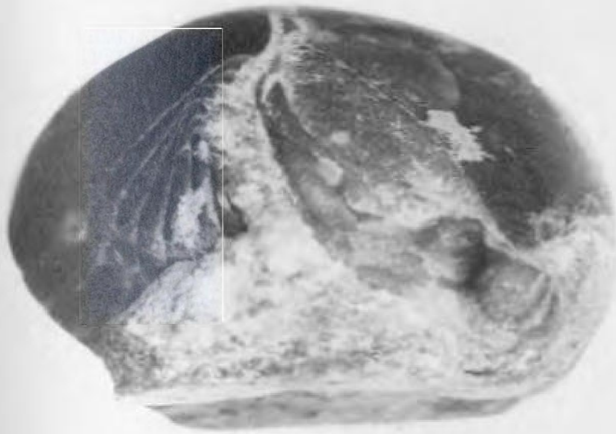


Fig. 1

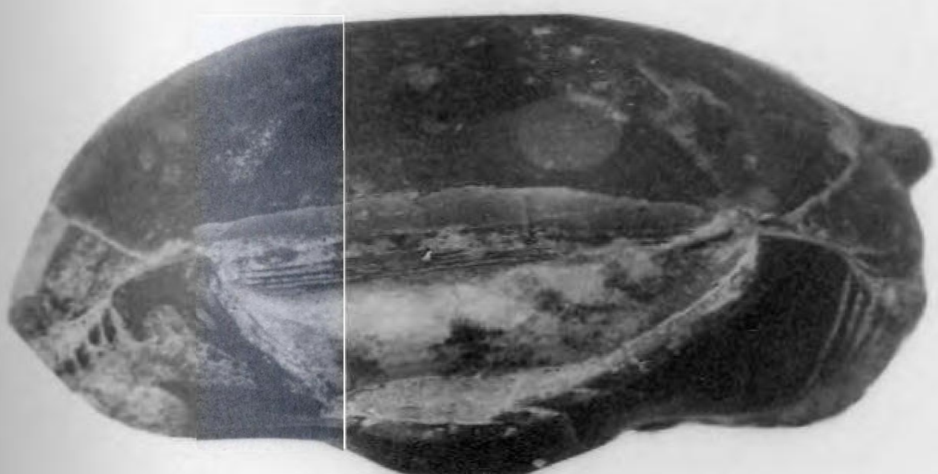


Fig. 2

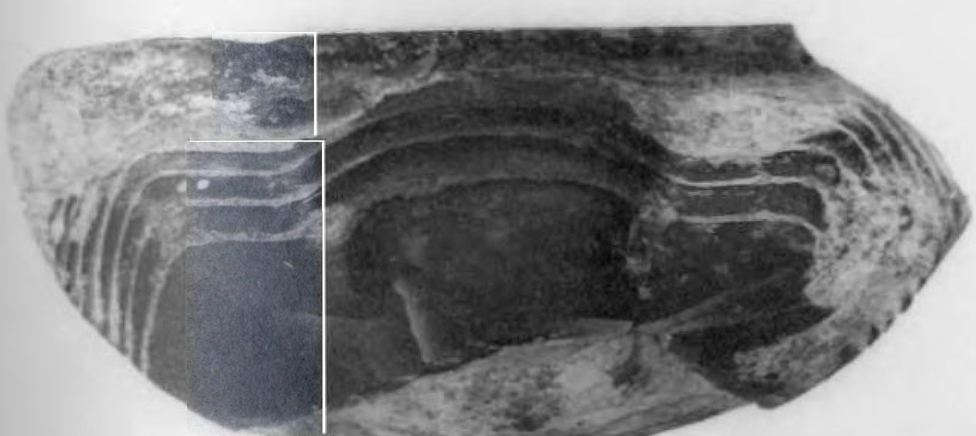


Fig. 3

Plate 8

Figs. 1-2	Encrinurus aff. E. trentonensis Walcott, 1880
	Collected from the LeRoy Member of the Long Point Formation, at the level of Black Duck Brook post office on the eastern side of Long Point.
Fig. 1	Dorsal view of the pygidium. ZMS 002; X 50.
Fig. 2	Reconstruction based on the same specimen as Fig. 1, showing complete segmentation in greater detail. ZMS 002; X 70.
Figs. 3-4	Encrinurus aff. E. cybeleformis Raymond.
Fig. 3	Dorsal view of the pygidium, showing the unsegmented portion of the axis and the paired tubercles on each segment. ZMS 003; X 50.
Fig. 4	Drawing based on Fig. 3, to show more distinctly solid axis of the pygidium and the paired tubercles on each segment. ZMS 003; X 50.

PLATE 8

Fig. 1

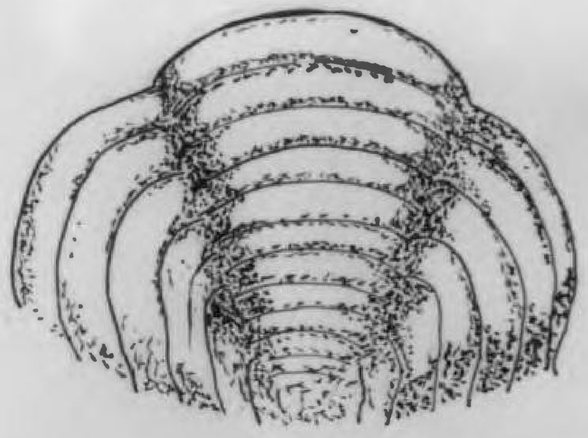


Fig. 2

Fig. 3

Fig. 4

Plate 9

Figs. 1-2	Sphaerocoryphe robusta Walcott, 1875
	Collected from the top of the LeRoy Member of the Long Point Formation, two miles southwest of Black Duck Brook village, Port au Port Peninsula.
Fig. 1	Dorsal view of the cephalon showing the bulbous anterior portion of the glabella with two rudimentary glabellar lobes. Note the distinct neck ring and genal spine. ZMS 004; X 15.
Fig. 2	The reconstruction based on Fig. 1, showing the bulbous anterior portion of the glabella with the left palpebral lobe and genal spine. ZMS 004; X 15.
Fig. 3	Illaenus aff. I. alveatus Raymond, 1925
	Collected from the Black Duck Member of the Long Point Formation, one mile northeast of Black Duck Brook village on the eastern side of Long Point.
	Dorsal view of the pygidium and incomplete thorax. Note that the pleurae are steeply bent down and that the anterior margin of the pygidium is angulate to conform with their shape. ZMS 005; X 4.
Figs. 4-5	Uromystrum aff. U. validum (Billings)
	Collected from the LeRoy Member of the Long Point Formation, about a mile, southwest of Black Duck Brook village on the eastern side of Long Point, Port au Port Peninsula.
Fig. 4	Dorsal view of the glabella showing slightly expanded anterior half of glabella, the large crescentic eyes and the conspicuous occipital ring. ZMS 006; X 15.
Fig. 5	Drawing of complete cephalon showing the widely divergent facial sutures. ZMS 006; X 15.

PLATE 9

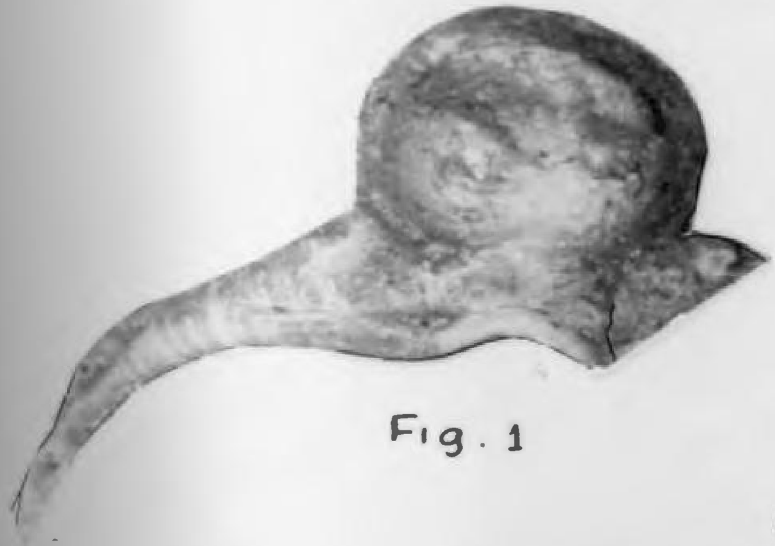


Fig. 1

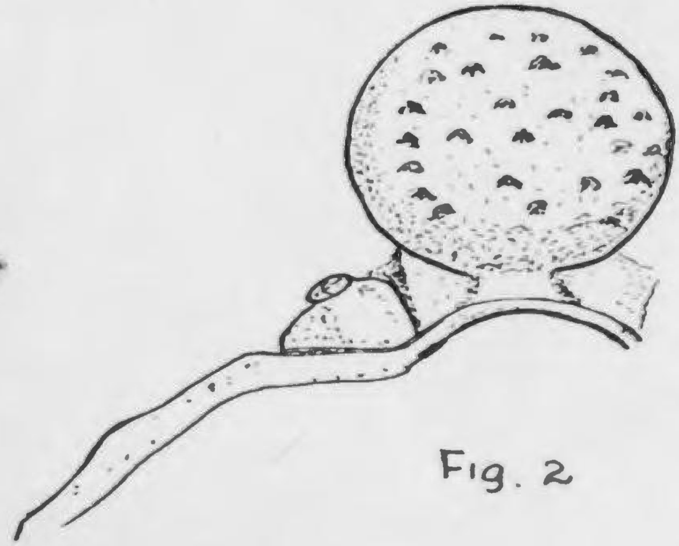


Fig. 2

Fig. 3

Fig. 4

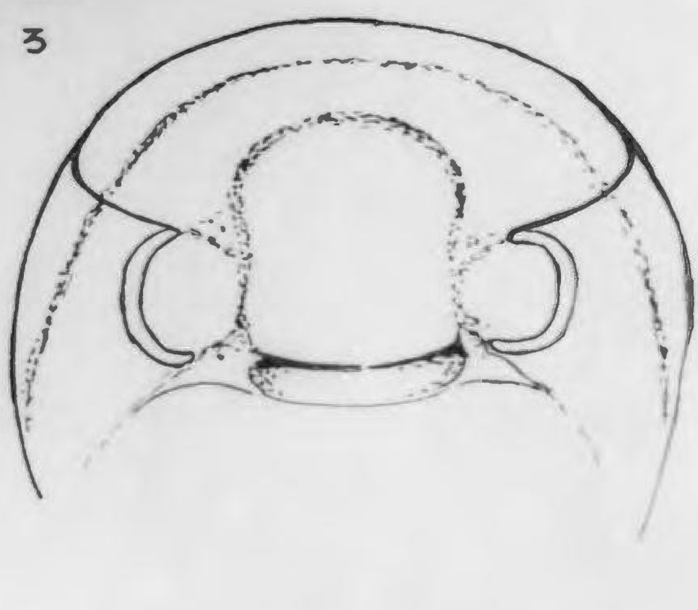


Fig 5

Plate 10

Figs 1-3 *Isotelus* aff. *I. gigas* DeKay, 1824

Collected from the Black Duck Member of the Long Point Formation, half a mile southwest of Black Duck Brook village on the eastern side of Long Point, Port au Port Peninsula.

Fig. 1 Dorsal view of the specimen, showing the position of the prominent eyes and, posteriorly, eight thoracic segments. ZMS 007; X 2.

Fig. 2 Cast of the palpebral lobe and visual surface. ZMS 007; X 2.

Fig. 3 Reconstruction based on Fig. 1, showing subtriangular cephalon with indistinct axial furrows and feebly differentiated glabella without furrows; genal angles almost pointed. ZMS 007; X 2.

Figs. 4-5 *Calyptaulax* aff. *C. incepta* Whittington (1965)

Collected from the LeRoy Member of the Long Point Formation at the level of Black Duck Brook post office on the eastern side of Long Point, Port au Port Peninsula.

Fig. 4 Dorsal view of the cephalon and thorax, showing glabella with glabellar furrows and prominent palpebral lobes. ZMS 008; X4.

Fig. 5 Dorsal view of cephalon showing distinct glabella, glabellar furrows, palpebral lobes and occipital ring. ZMS 008; X 6.

Fig. 6 Drawing based on Fig. 5, showing faceted eye surface, palpebral lobes and coarse granular surface of the glabella. ZMS 008; X 4.

PLATE 10

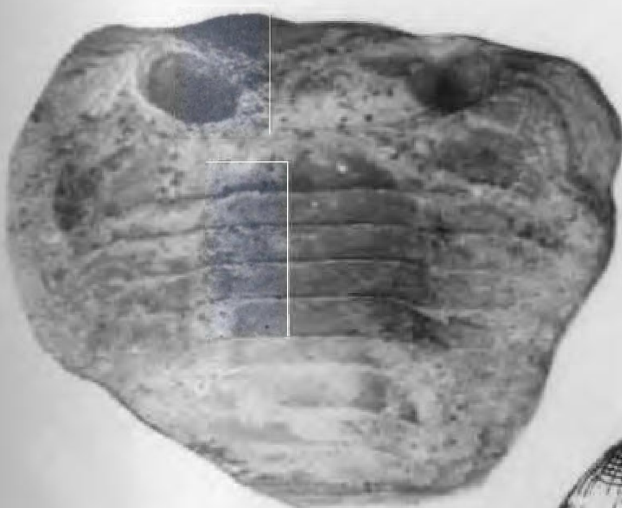


Fig. 1

Fig. 2

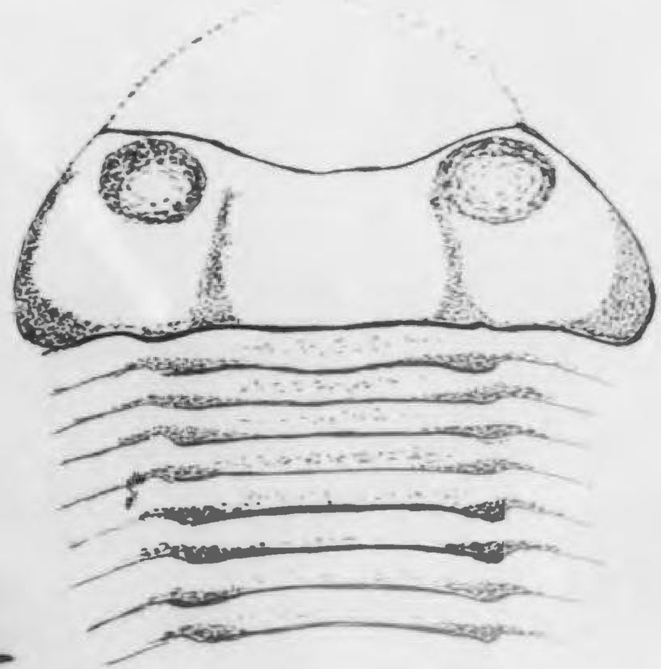


Fig. 3

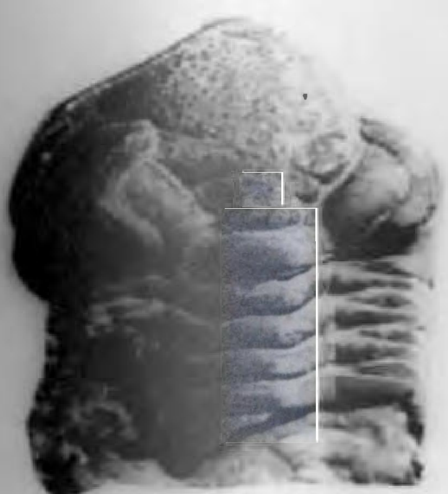


Fig. 4

Fig. 5

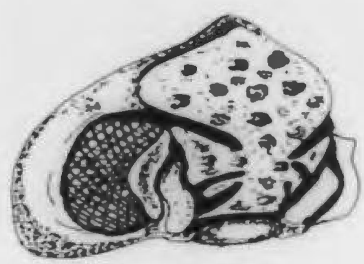


Fig. 6

Chapter 4

BRYOZOA

This chapter describes the bryozoans found in the Long Point Formation where they are an important element of the fauna. They are most abundant in the Black Duck Member and all the specimens described below were collected from that member. Little systematic work has been done on the bryozoans of the Long Point Formation and this is the first account of the forms present.

The morphological terms used in the descriptions that follow are defined in Volume (G), Bryozoa, of the Treatise on Invertebrate Paleontology (Moore, 1953).

Order	CRYPTOSTOMATA	Vine, 1883
Family	RHINIDICTYIDAE	Ulrich, 1895
Genus	PACHIDICTYA	Ulrich, 1882

Pachidictya aff. *P. ambigua* Ross, 1961

Plate 11, Figs. 1,2,3.

LOCALITY AND HORIZON

Specimen ZMS 009: collected from the Black Duck Member of the Long Point Formation, one mile northeast of Black Duck Brook on the eastern side of Long Point.

DESCRIPTION

The zoarium consists of slender, bifoliate ribbon-shaped branches with numerous bifurcations. The zooecia are arranged in longitudinal rows. In shallow tangential section the zooecia are oval in cross section and the zooecial walls contain abundant well developed acanthopores (Pl. 11, Fig. 1). In deep oblique tangential section where the acanthopores are cut obliquely they appear as median bands in the zooecial walls (Pl. 11, Fig. 2). The zooecia grow from the mesothecal plane at a high angle. Farther out from the mesothecal plane, the zooecial walls thicken without marked change in the direction of growth. Transverse sections reveal a band of median tubuli in the mesothecal plane (Pl. 11, Fig. 3). Narrow tabulate interspaces are poorly developed between the zooecial walls. Diaphragms are not seen and hemisepta are absent.

DISCUSSION

This specimen is characterized by narrow tabular interspaces and thick zooecial walls with a fine granulous microstructure which is crowded with acanthopores. These features place this form close to Pachidictya ambigua Ross (1961a). P.ambigua has been reported by Ross (1961) from the Ellis Bay Formation of Anticosti Island which is regarded as Ordovician in age.

Order	CRYPTOSTOMATA	Vine, 1883
Suborder	STICTOPORELLIDAE	Nickles & Bassler, 1900
Group	STICTOPORID	Phillips, 1960
Genus	STICTOPORA (Rhinidictya	Nicholsoni Ulrich, 1882 Nicholsoni Ulrich, 1882)

Stictopora nicholsoni Ulrich, 1882

Plate 12, Figs. 1,2,3,4.
Plate 13, Figs. 1,2.
Plate 14, Figs. 1,2.

LOCALITY AND HORIZON

Specimen ZMS 010: very common throughout the Black Duck Member of the Long Point Formation from near the tip of Long

Point to Three Rock Point.

DESCRIPTION

The zoarium has narrow ribbon-shaped branches that run parallel to one another except where they bifurcate.

Zooecia are arranged in median longitudinal ranges, parallel to the direction of growth of the zooarial branch (Pl. 12, Fig. 1). In longitudinal section the thin zooecial walls arise from the mesotheca at a high angle, extend only a short distance and then change their direction, curving outward away from the mesothecal plane (Pl. 12, Fig. 2). This change in the direction of growth also marks the transition from the immature to the mature region in which the walls thicken greatly. The inner zooecial walls lining the zooecial tubes have laminae steeply inclined distally toward adjacent zooecia (Plate 14). Toward the outer wall these steep laminae curve abruptly toward adjacent zooecia and become broad distally convex laminae. The zooecial apertures in the mature region are restricted due to the heavy development of the laminae (Pl. 12, Fig. 3). Hook-shaped superior hemisepta extend across the zooecial tube (Pl. 12, Fig. 3). In a few of the zooecia inferior hemisepta arise from the mesotheca and extend transversely into the zooecial tube (Pl. 12, Fig. 4); diaphragms occasionally present. In transverse section the mesotheca is pierced by median tubuli (Pl. 13, Fig. 1). These tubuli extend outward as acanthopores to the periphery of the zoarium, approximately parallel to the direction of zooecial growth. Acanthopores are abundant and present in distinct longitudinal bands (Pl. 13, Fig. 2).

DISCUSSION

The presence of median tubuli, acanthopores and regularly arranged elongate zooecial apertures show this form to be similar to Stictopora nicholsoni Ulrich(1882). S. nicholsoni has been collected from the Tyrone Formation, New York, which is regarded as Trenton in age.

Order	CRYPTOSTOMATA	Vine, 1883
Family	RHABDOMESIDAE	Vine, 1883
Genus	Goldfussitrypa	Bassler, 1952

Goldfussitrypa aff. *G. esthonia* (Bassler) 1911

Plate 15, Figs. 1,2.

LOCALITY AND HORIZON

Specimen ZMS 011: collected from the Black Duck Member of the Long Point Formation, about two miles northeast of Tea Cove on the eastern side of Long Point.

DESCRIPTION

The zoarium is ramose, slender with a diameter of 2.5mm. In transverse section the axial region displays irregular zooecia with no particular outline (Pl. 15, Fig. 1). The peripheral region is distinguished by the thickening of the zooecial walls (Pl. 15, Fig. 2). The zooecial tubes are short and without diaphragms; they curve abruptly towards the surface in the mature region. Acanthopores are abundant.

DISCUSSION

Due to the poor state of preservation of this specimen the sections do not show the internal features clearly and consequently it is only tentatively related to *G. esthonia* (Bassler, 1911) which has a thick cortex-like mature region and a thin walled immature region. However this specimen appears to differ in the absence of diaphragms in the axial region.

Order	TREPOSTOMATA	Ulrich, 1882
Suborder	INTEGRATA	Ulrich & Bassler, 1904
Family	AMPLEXOPORIDAE	Miller, 1889
Genus	AMPLEXOPORA	Ulrich, 1882

Amplexopora aff. *A. evensis* Phillips, 1965

Plate 16, Figs. 1,2,3.
Plate 17, Figs. 1,2,3.

LOCALITY AND HORIZON

Specimen ZMS 012: collected from the Black Duck Member of the Long Point Formation about three miles northeast of West Bay on the eastern side of Long Point.

DESCRIPTION

The zoarium has cylindrical branches with the main stem up to 18mm. and smaller up to 5mm. in diameter. The surface is smooth. In transverse section the thin-walled zooecia are polygonal in outline and average 6 zooecia in 2 mm. (Pl. 16, Fig. 1). Mesozooecia, similarly polygonal in outline but smaller, are present between the zooecial tubes. Longitudinal sections show long zooecial tubes with broad crenulations axially and closer crenulation in the peripheral region (Pl. 16, Fig. 2, and Pl. 16, Fig. 3). Zooecial tubes approach the surface with a gentle curve (Pl. 17, Figs. 1,3) in the narrow peripheral region. Diaphragms are sparse in the axial region (Pl. 17, Fig. 1) but are concentrated in the sub-peripheral region; they may be flat, curved or cystoidal in the subspherical region. Acanthopores are not seen. The thin walls of the axial region thicken slightly towards the outer region. In longitudinal section there are three or four levels at which the zooecial tubes bifurcate to give a marked increase in the diameter of the zoarium (Pl. 17, Fig. 2). Associated with this bifurcation of the tubes, is a curved band of diaphragms which extends across the colony (Pl. 17, Fig. 3).

DISCUSSION

This specimen is characterised by slender, crenulate zooecial walls, infrequent acanthopores, some of which extend into the subperipheral region. All these features place this form close to Amplexopora evensis Phillips (1965). It differs from A. glengaria Fritz (1957) in having less diaphragms in both the axial and the peripheral regions. A. evensis has been reported by Phillips (1965) from the Caradoc Series, which is Upper Ordovician in age, and A. glengaria has been reported by Fritz (1957) from the Ottawa Formation, which is regarded as Black-River to Trenton in age.

Order:	TREPOSTOMATA	Ulrich, 1882
Suborder	INTEGRATA	Ulrich & Bassler, 1904
Family	CALOPORIDAE (emendation of Calloporidae, Ulrich, 1890)	Ulrich, 1890
Genus	CALOPORA	Hall, 1851

Calopora aff. C. dumalis Ross, 1969

Plate 18, Figs. 1,2,3,4.
Plate 19, Figs. 1,2.

LOCALITY AND HORIZON

Specimen ZMS 013: collected from the Black Duck Member of the Long Point Formation about two miles northeast of Tea Cove on the eastern side of Long Point.

DESCRIPTION

The zoarium is ramose with cylindrical branches ranging from 4 to 5mm. in diameter. In oblique tangential section the zooecia are partly in contact and partly isolated by numerous polygonal and sub-polygonal mesozooecia (Pl. 18, Fig. 1). Peripherally the zooecial walls show integrate structure with their boundaries clearly defined (Pl. 18, Fig. 2). In longitudinal section the axial region is thin walled and distinctly separable from the thick walled peripheral region (Pl. 18, Fig. 4). This distinction is also clear in transverse section (Pl. 19, Fig. 1). Diaphragms are present in the axial region and they are either flat or very slightly curved. They are numerous in the subperipheral and peripheral regions (Pl. 18, Fig. 4, Pl. 19, Fig. 2). The mesozooecia both in the peripheral and subperipheral regions, also have closely spaced diaphragms. Peripherally the zooecial tubes curve outwards and their walls become thicker (Pl. 18, Fig. 4). The microstructure of the zooecial wall is clear in the peripheral region where it consists of steeply inclined parallel laminae (Pl. 18, Fig. 3). The laminae of adjacent zooecial walls are curved where they abut and the laminae of the diaphragms and the zooecial walls interfinger with one another (Pl. 18, Fig. 5).

DISCUSSION

In internal structure this specimen shows close resemblance to Calopora dumalis Ross (1969) which has been reported from the Trentonian in New York State. It has the same slender zooecial branches and numerous mesozooecia but it differs in having more numerous diaphragms in the sub-peripheral and peripheral regions of the zooecial tubes as well as in the mesozooecia.

Order	TREPOSTOMATA	Ulrich, 1882
Suborder	INTEGRATA	Ulrich & Bassler, 1904
Family	AMPLEXOPORIDAE	Miller, 1882
Genus	MONOTRYPELLA	Ulrich, 1882

Monotrypella aff. M. aequalis Ulrich, 1882

Plate 19, Figs. 3,4.

LOCALITY AND HORIZON

Specimen ZMS 014: collected from the Black Duck Member of the Long Point Formation one mile southwest of Three Rock Point on the western side of Port au Port Peninsula.

DESCRIPTION

The zoarium is ramose, consisting of cylindrical somewhat flattened branches 7 to 14 mm. in diameter. The surface of the zoarium exhibits low, rounded monticules generally consisting of zooecia larger than the average but in some instances the zooecia are of normal size. In tangential section, the zooecia are polygonal in outline, thin walled, numbering from 7 to 8 in 2mm.; those in the monticules are larger and 5 to 6 occupy the same space (Pl. 19, Fig. 3). Mesopores are absent and there are no acanthopores. In longitudinal section the zooecial tubes in the axial region are thin walled and they are crossed by straight diaphragms about one and a half tube-diameters apart. Toward the periphery the tubes gradually bend outwards and their walls become very slightly thickened (Pl. 19, Fig. 4). In this region the diaphragms become more numerous, averaging about two in the space of one tube diameter. In the mature region mesopores are occasionally found with closely spaced straight diaphragms (Pl. 19, Fig. 4).

DISCUSSION

This specimen resembles Monotrypella aequalis Ulrich in its general external and internal structure, but differs in having straight zooecial walls, a much shorter mature region and straight diaphragms.

Order	TREPOSTOMATA	Ulrich, 1882
Suborder	INTEGRATA	Ulrich & Bassler, 1904
Family	TREMATOPORIDAE	Miller, 1889
Genus	Batostoma	Ulrich, 1882

Batostoma aff. B. winchelli Ulrich, 1893

Plate 20, Figs. 1,2.

LOCALITY AND HORIZON

Specimen ZMS 015: collected from the Black Duck Member of the Long Point Formation, one mile southwest of Black Duck Brook village on the eastern side of Long Point.

DESCRIPTION

The zoarium is large and ramose, consisting of cylindrical branches from 6 to 8 mm. in diameter and about 20 mm. in length. In transverse section the zooecia are sub-polygonal to rounded in outline, variable in size and from 8 to 9 occur in the space of 2mm. The moderately thick zooecial walls are studded with acanthopores (Pl. 20, Fig. 1). Mesopores practically non-existant. The integrate character of the wall is distinct, a dark line separating each zooecium. In longitudinal section the zooecial tubes in the axial region are thin walled and crossed by diaphragms varying from two to four tube diameters apart (Pl. 20, Fig. 2). As the zooecial tubes approach the mature region they curve abruptly outward and their walls thicken. Diaphragms are generally straight but occasionally they are oblique. Acanthopores are prominent (Pl. 20, Fig. 2).

DISCUSSION

In tangential and longitudinal section this form closely resembles *Batostoma winchelli* Ulrich, (1893) in having numerous acanthopores and a moderately elongated mature region that curves abruptly outwards and contains closely spaced diaphragms. *B. winchelli* had been reported by Fritz (1957) from the lower part of the Ottawa Formation, Black River to Trenton in age.

Order	TREPOSTOMATA	Ulrich, 1882
Suborder	INTEGRATA	Ulrich & Bassler, 1904
Family	TREMATOPORIDAE	Miller, 1889
Genus	HEMIPHRAGMA	Ulrich, 1893

Hemiphragma aff. *H. crassicrenulatum* Fritz, 1957

Plate 21, Figs. 1,2,3.

LOCALITY AND HORIZON

Specimen ZMS 016: collected from the Black Duck Member of the Long Point Formation, three miles northeast of Tea Cove on the eastern side of Long Point.

DESCRIPTION

The zoarium is ramose and the branches have a smooth surface and range from 5 to 14 mm. in diameter. Transverse sections show polygonal zooecia, apparently in contact, and 5 are present in 2mm. distance; mesopores few, sometime wanting (Pl. 21, Fig. 1). Acanthopores appear to be absent. The zooecial walls are thin in longitudinal section, showing here and there coarse crenulations or waviness (Pl. 21, Fig. 2). Diaphragms are well developed but hemiphragms are also sparingly present within the zooecia (Pl. 21, Fig. 3). Diaphragms are commonly grouped closely at the surface and they may be straight, oblique, concave or convex; hemiphragms have similar attitudes (Pl. 21, Fig. 3).

DISCUSSION

This specimen is similar to Hemiphragma crenulatum Fritz (1957) in having these features in common: (1) the zooecial walls are wavy and crenulated, (2) in the presence of hemiphragms and 3) in having beaded mesopores that reach the surface. H. crenulatum has been reported by Fritz (1957) from the Ottawa Formation which is regarded as Black-River to Trenton in age.

Order	TREPOSTOMATA	Ulrich, 1882
Suborder	INTEGRATA	Ulrich & Bassler, 1904
Family	TREMATOPORIDAE	Miller, 1889
Genus	DIPLOTRYPA	Nicholson, 1879

Diplotrypa schucherti Fritz, (1966)

Plate 22, Figs. 1,2,3.

LOCALITY AND HORIZON

Specimen ZMS 017: one of a number of small mound shaped colonies collected from many localities all along the length of Black Duck Member of the Long Point Formation.

DESCRIPTION

The colonies are little mound-shaped structures, measuring one to two inches in width and half an inch in height. In transverse section the zooecia are polygonal in outline or rounded where interrupted by mesopores (Pl. 22, Fig. 1). The walls are thin and integrate. Mesopores are small and few in number, generally quadrangular in outline and sometimes they occur in pairs (Pl. 22, Fig. 2). Acanthopores apparently absent. Longitudinal section reveals thin walls of uniform thickness throughout their length (Pl. 22, Figs. 2,3). The walls are crenulate where mesopores intervene; diaphragms are horizontal and closely spaced in mesopores. Sometimes the mesopores have a beaded appearance.

DISCUSSION

Horizontal diaphragms, integrate walls, absence of acanthopores and beaded appearance of the mesopores clearly indicate its relationship to Diplotrypa schucherti, Fritz (1966). D. schucherti was first described by Fritz (1966) from the Long Point Formation of the Port au Port Peninsula.

Order	TREPOSTOMATA	Ulrich, 1882
Suborder	AMALGAMATA	Ulrich & Bassler, 1904
Family	ATACTOTOECHIDAE	Duncan, 1939
Genus	ATACTOTOECHUS	Duncan, 1939

Atactotoechus aff. A. kayi Phillips,1962

Plate 23, Figs. 1,2,3.
Plate 24, Figs. 1,2.

LOCALITY AND HORIZON

Specimen ZMS 018: collected from the Black Duck Member of the Long Point Formation;two miles southwest of Black Duck Brook on the eastern side of Long Point.

DESCRIPTION

Ramose zoarium consisting of cylindrical branches 6 to 7 in 2mm. diameter. Mesopores are present but few in number. In shallow tangential section the zooecia appear rounded and they are surrounded by mesopores. Numerous acanthopores present in the zooecial wall (Pl. 23, Fig. 1). In longitudinal section the axial region is narrow and the zooecial walls are longitudinally laminated and undulate slightly (Pl. 23, Fig. 2). Diaphragms are absent in the axial region. The subperipheral region shows the zooecial tubes, containing few diaphragms curving gently outwards (Pl. 23, Fig. 2). Zooecial walls are thickened and display atactotoechid wall structure (Pl. 23, Fig. 3) in which the zooecial laminae in longitudinal section remain relatively straight as they approach the zooecial boundaries and intersect the boundaries at low angles (Plate 24). Irregularly arranged diaphragms are numerous in the peripheral region; they are curved and some are compound in nature (Pl. 23, Fig. 2).

DISCUSSION

This specimen resembles Atactotoechus kayi Phillips (1962) in (1) possessing thick walls towards the peripheral region (2) an absence of diaphragms from the axial region (a few may be present in peripheral region), and (3) exhibiting a typical atactotoechid wall structure. A. kayi has been reported by Phillips (1962) from the Chazyan (Ordovician) of New York State and Vermont.

Plate 11

Figs. 1-3 <u>Pachidictya</u> aff. <u>P. ambigua</u> Ross, 1961

Collected from the Black Duck Member of the Long Point Formation one mile northeast of Black Duck Brook on the eastern side of Long Point.

Fig. 1 Shallow tangential section showing longitudinal arrangement of zooecia with acanthopores between them. ZMS 009; X 25.

Fig. 2 Deep oblique tangential section cutting across the acanthopores which appear as a median band in the zooecial walls. ZMS 009; X 25.

Fig. 3 Transverse section through the mesotheca reaching the median tubuli. Note also the acanthopores in the zooecial walls. ZMS 009; X 25.

PLATE II

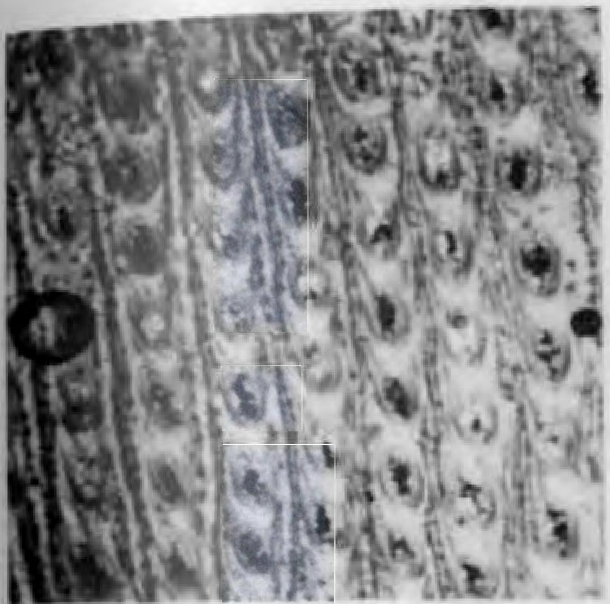


Fig.1

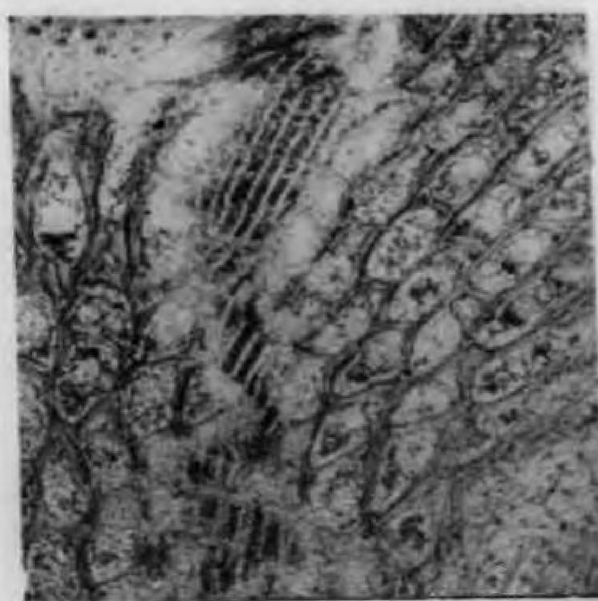


Fig.2

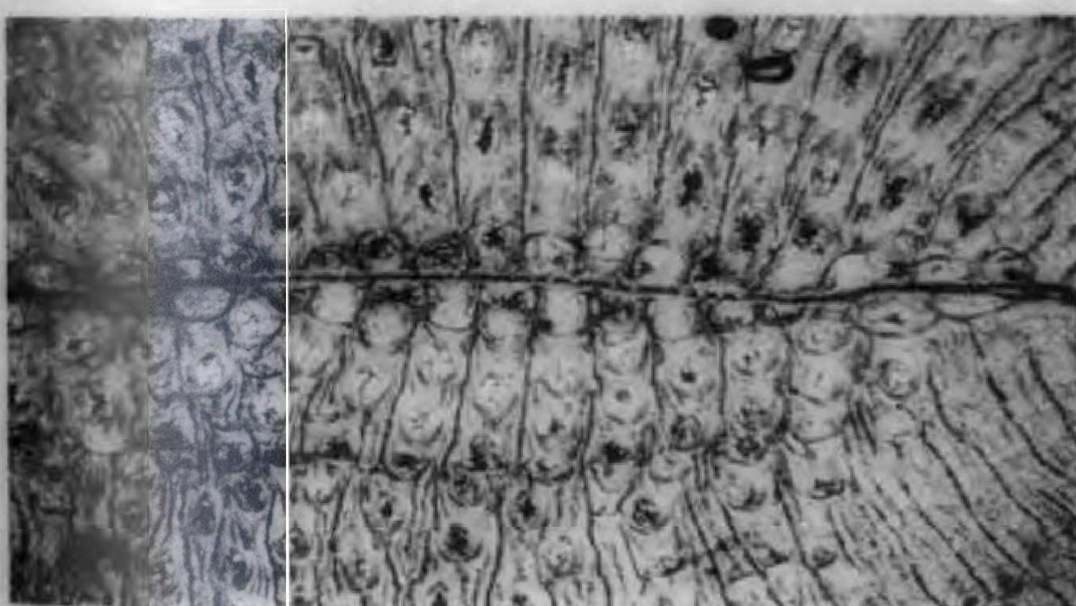


Fig.3

Plate 12

Figs. 1-4 Stictopora nicholsoni Ulrich, 1882

Collected from the Black Duck Member of the Long Point Formation from near the tip of Long Point to Three Rock Point.

Fig. 1 Shallow tangential section showing zooecia in median longitudinal ranges. Numerous acanthopores present around zooecial walls. ZMS 010; X 25.

Fig. 2 Longitudinal section through mesotheca and early part of zooecium. ZMS 010; X 50.

Fig. 3 Longitudinal section showing superior hemisepta. ZMS 010; X 25.

Fig. 4 Longitudinal section showing inferior hemisepta. ZMS 010; X 25.

PLATE 12

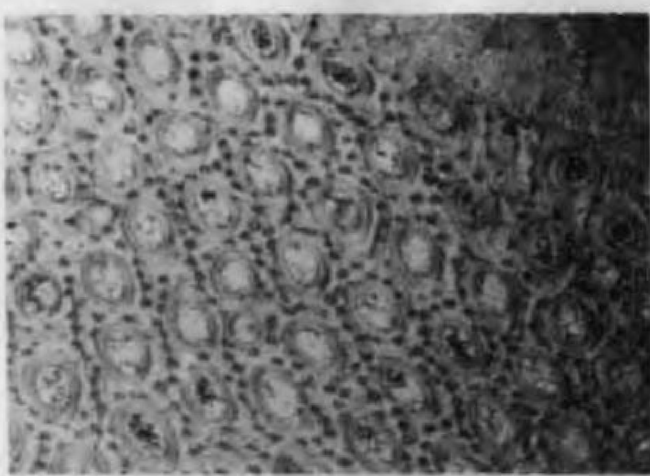


Fig.1

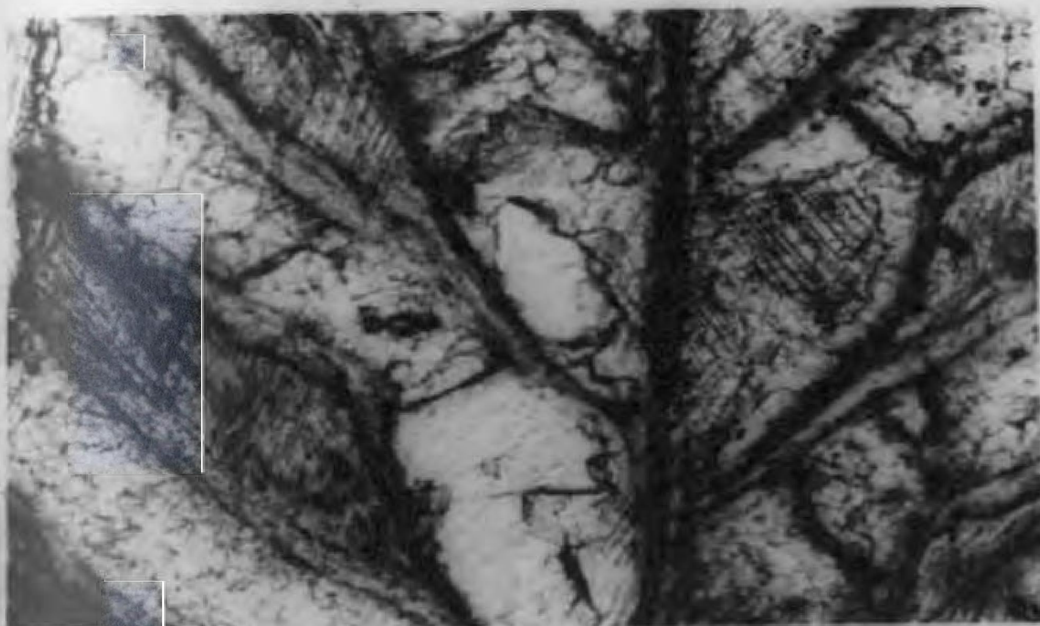


Fig. 2

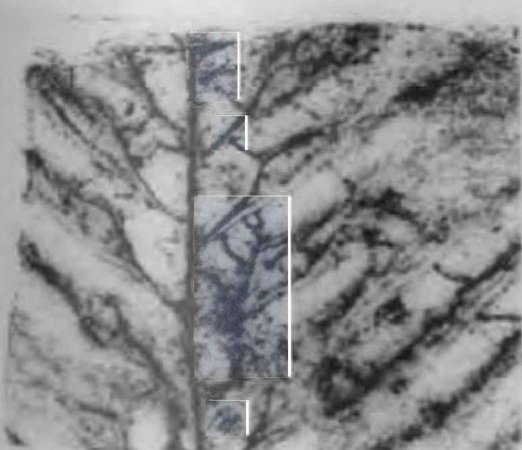


Fig. 3

Fig. 4

Plate 13

Figs. 1-2 <u>Stictopora nicholsoni</u> Ulrich, 1882

Fig. 1 Transverse section through mesotheca showing median tubuli. ZHS 010; X 50.

Fig. 2 Shallow tangential section showing acanthopores in the lamellate zooecial walls. ZHS 010; X 50.

PLATE 13

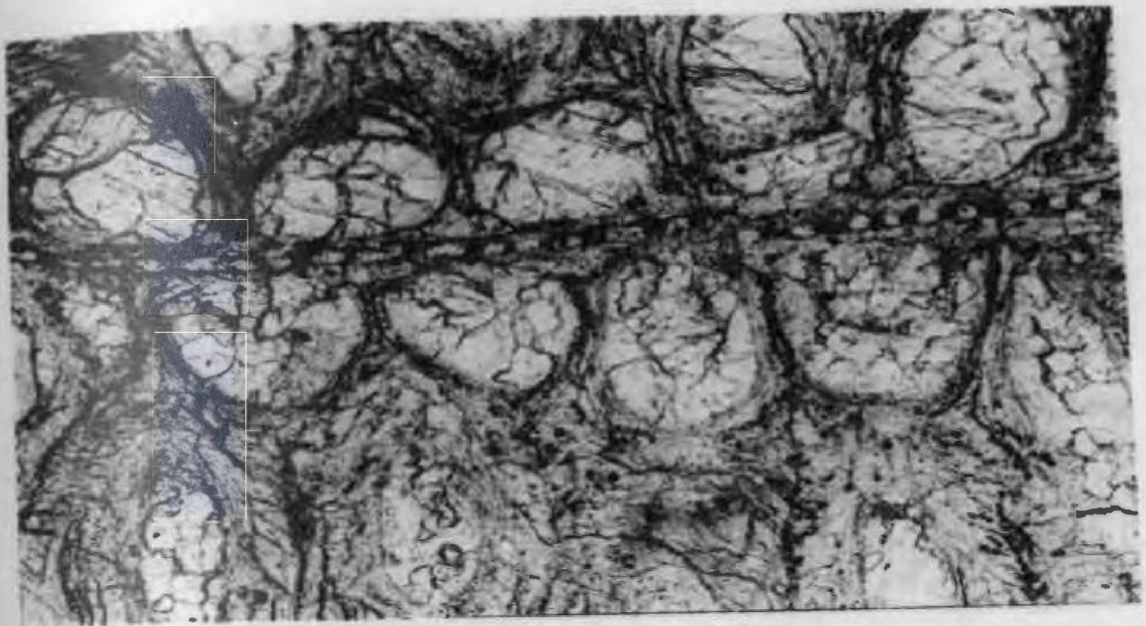


Fig.1

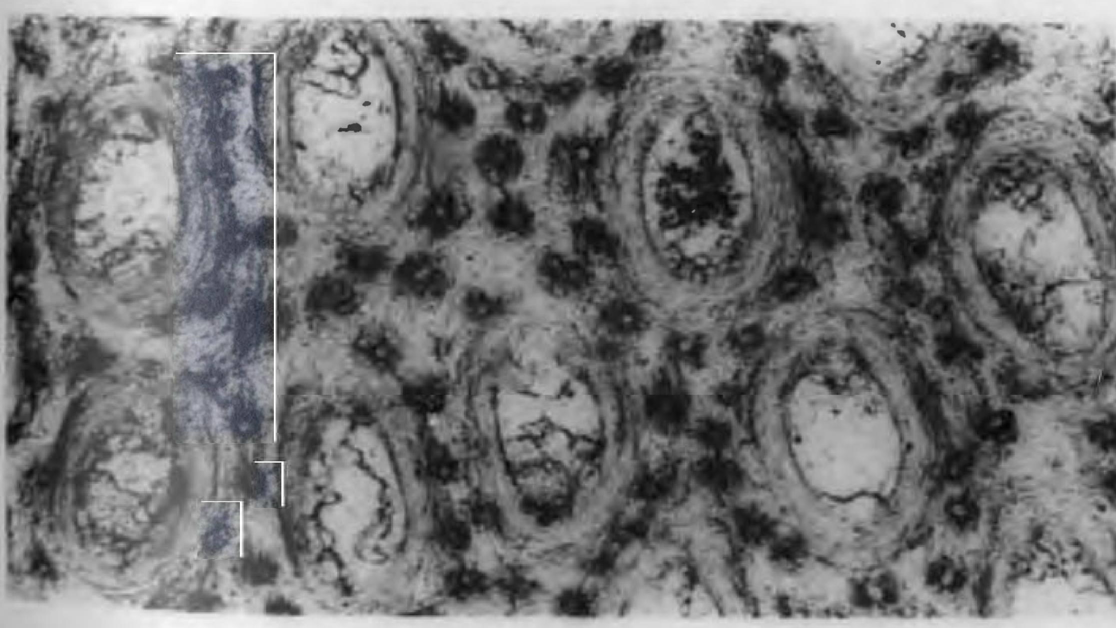


Fig.2

Plate 14

Figs. 1-2 _Stictopora nicholsoni_ Ulrich, 1882

Fig. 1 Oblique longitudinal section through the mesothecal plane. Note distinct superior hemisepta and acanthopores. X 150, (_from_ Phillips, 1960).

Fig. 2 Longitudinal section through the mesothecal plane. Note distinct inferior hemisepta, inner immature and outer mature regions of zooecia. X 75, (_from_ Phillips, 1960).

PLATE 14

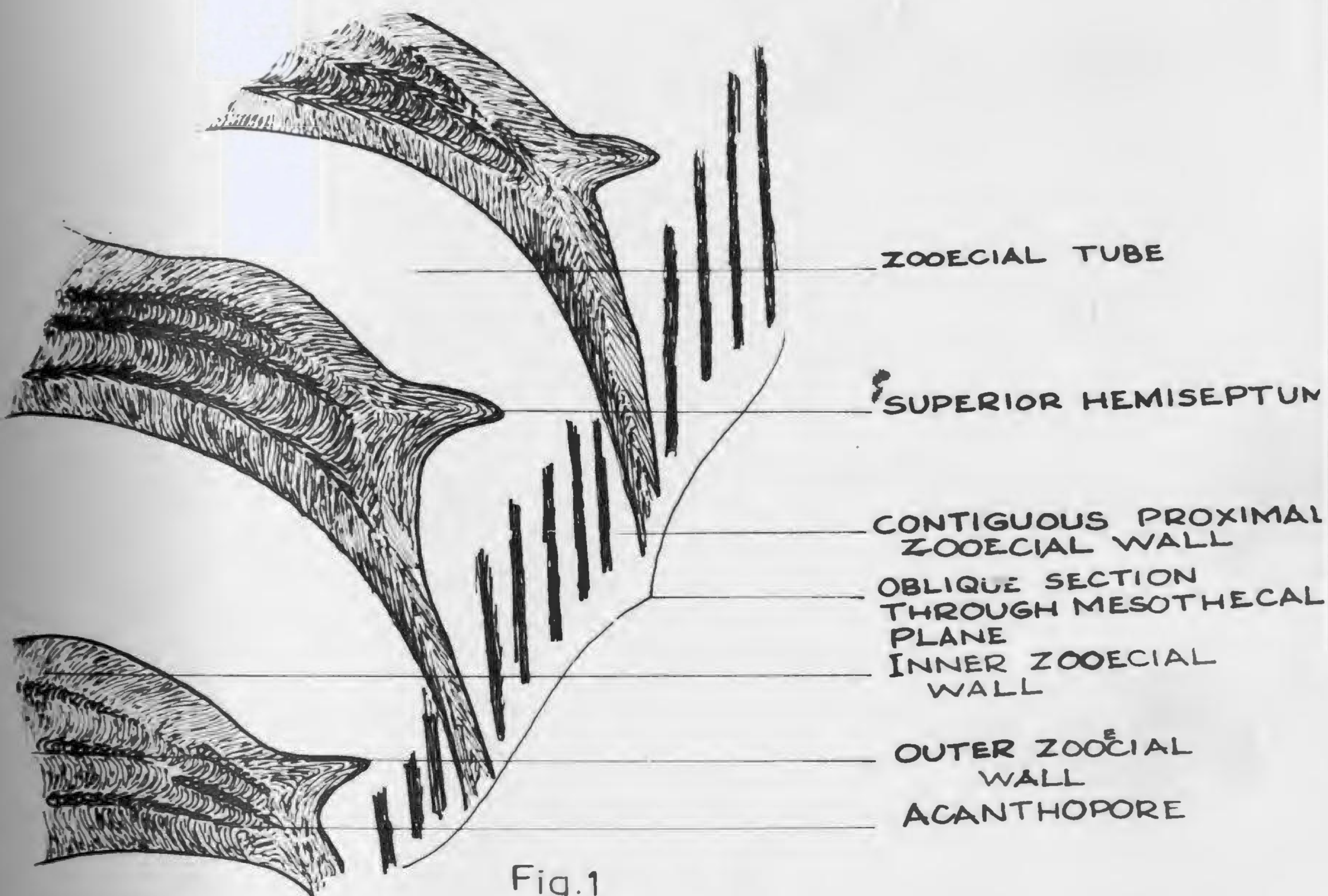


Fig.1

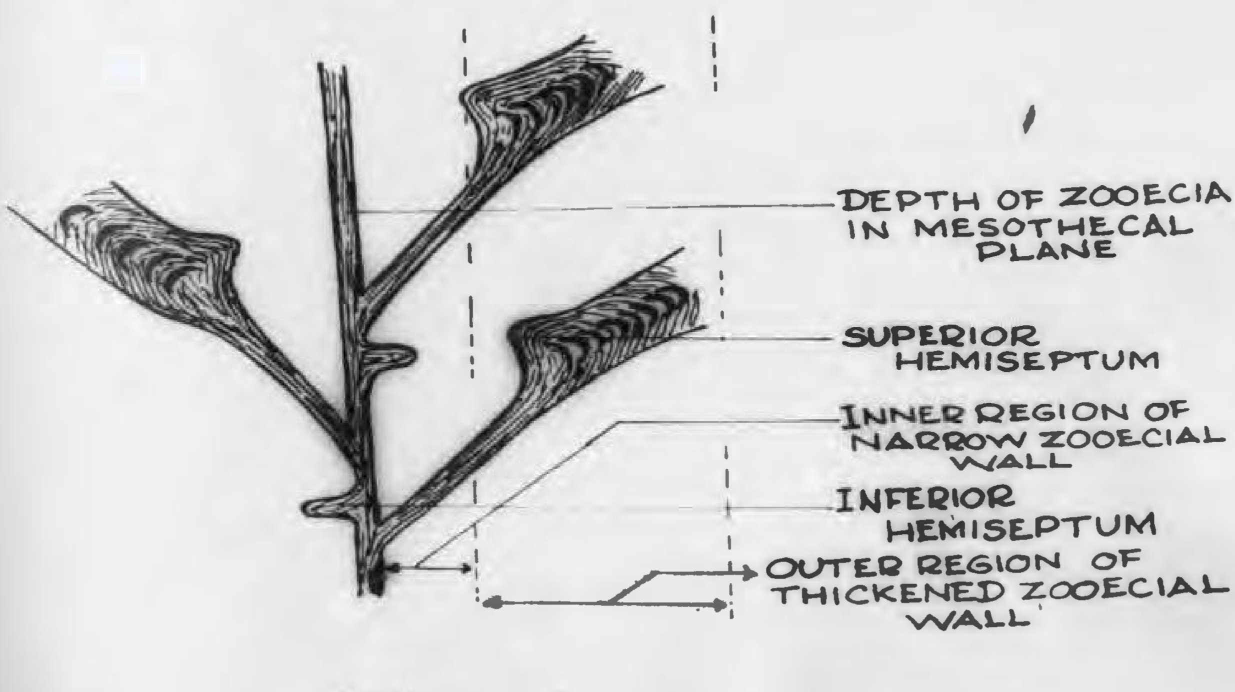


Fig.2

Plate 15

Figs. 1-2 <u>Goldfussitrypa</u> aff. <u>G. esthonia</u> (Bassler) 1911

Collected from the Black Duck Member of the Long Point Formation about two miles northeast of Tea Cove.

Fig. 1 Transverse section showing axial region with zooecia of irregular outline. ZMS 011; X 25.

Fig. 2 Longitudinal section showing short zooecial tubes without diaphragms. ZMS 011; X 25.

PLATE 15

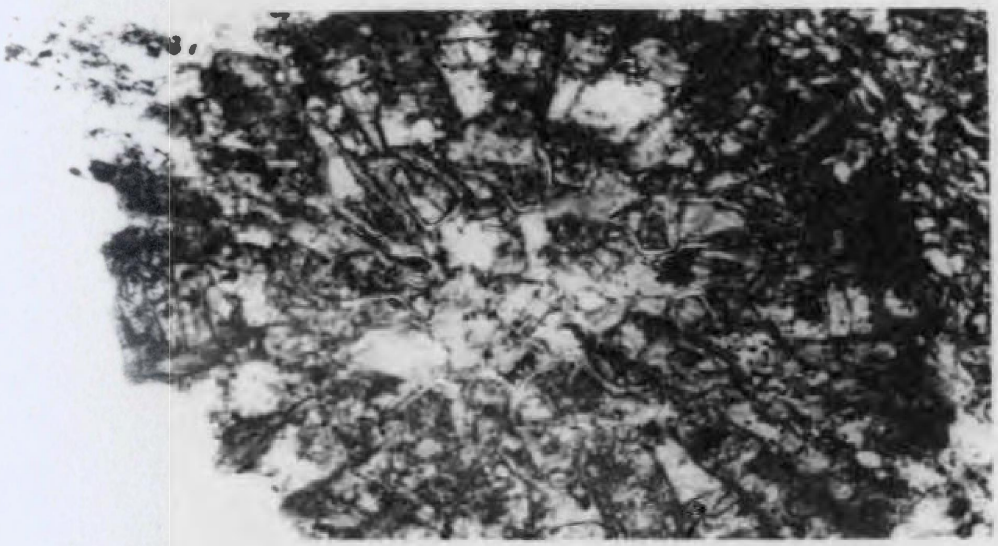


Fig.1

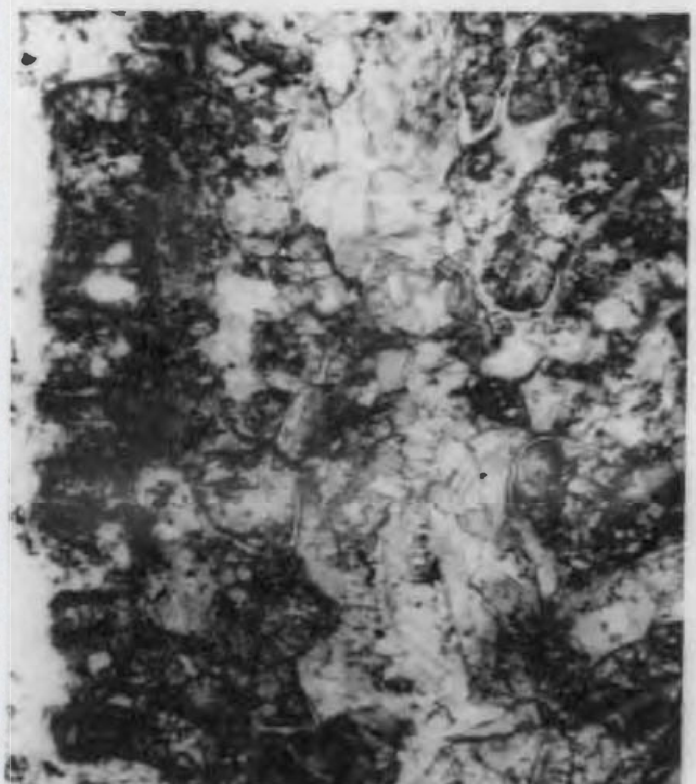


Fig 2

Plate 16

Figs. 1-3 — *Amplexopora* aff. *A. evensis* Ross, 1965

Collected from the Black Duck Member of the Long Point Formation three miles northeast of Tea Cove on the eastern side of Long Point.

Fig. 1 — Transverse section showing polygonal zooecia with smaller mesozooecia. ZMS 012; X 50.

Fig. 2 — Longitudinal section through axial region showing zooecial tubes with broad crenulations. ZMS 012; X 50.

Fig. 3 — Longitudinal section through peripheral region showing close crenulations of curved zooecial walls and the straight and curved diaphragms of the sub-peripheral region. ZMS 012; X 50.

PLATE 16

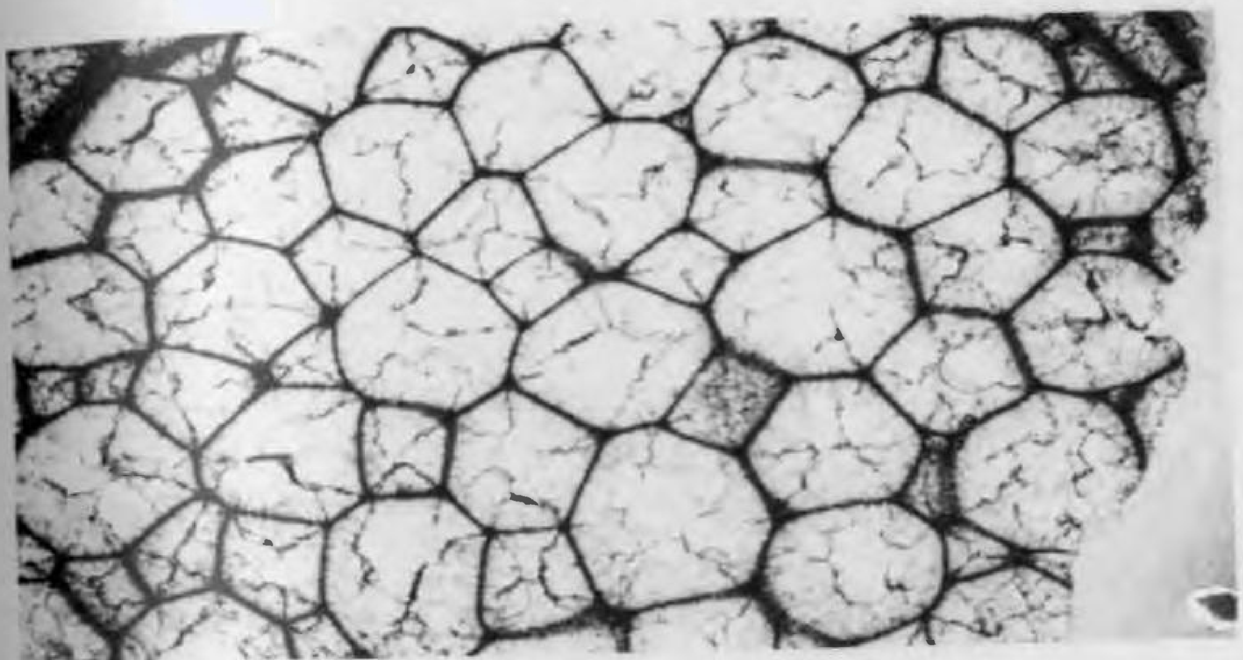


Fig.1

Fig.2

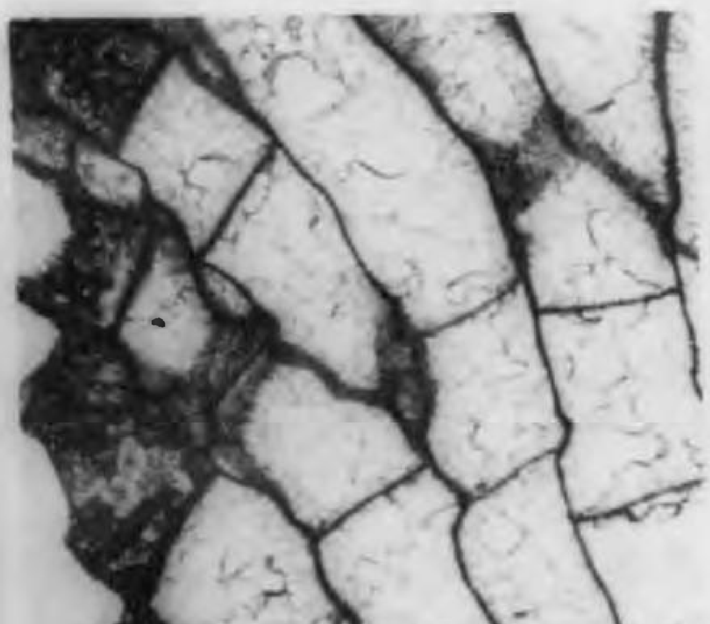


Fig.3

Plate 17

Figs. 1-3 <u>Amplexopora</u> aff. <u>A. evensis</u> Ross, 1965

Collected from the Black Duck Member of the Long Point Formation three miles northeast of Tea Cove on the eastern side of Long Point.

Fig. 1 Longitudinal section showing axial region with no diaphragms. ZMS 012; X 50.

Fig. 2 Longitudinal section showing bifurcation of the zooecial tubes. ZMS 012; X 50.

Fig. 3 Oblique longitudinal section showing two levels at which zooecial tube bifurcate and the associated curved bands of diaphragms extending across the zoarium. ZMS 012; X 25.

PLATE 17

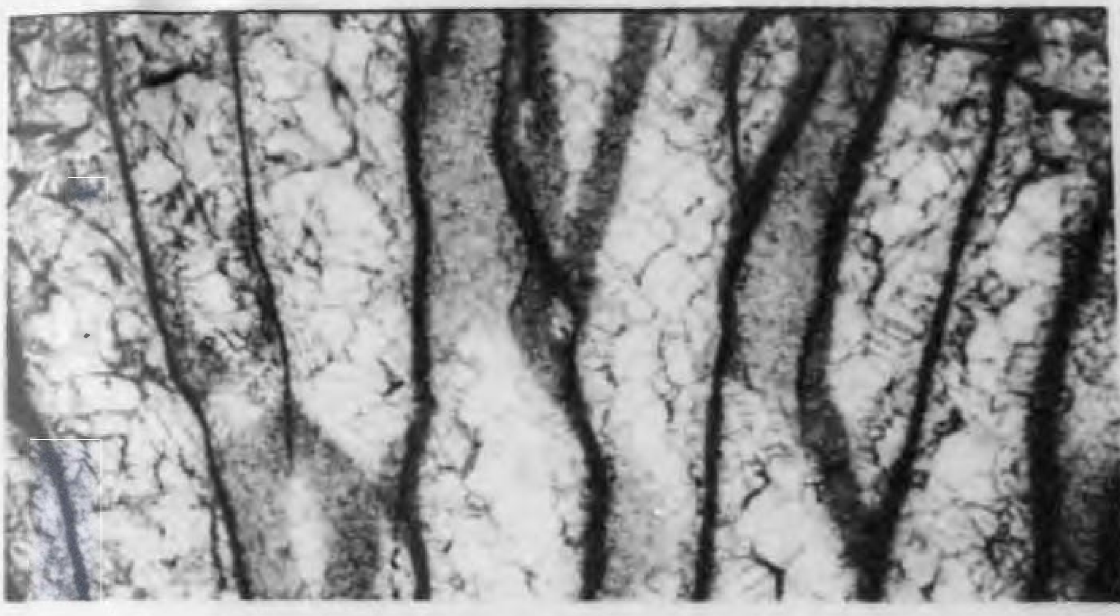


Fig.1

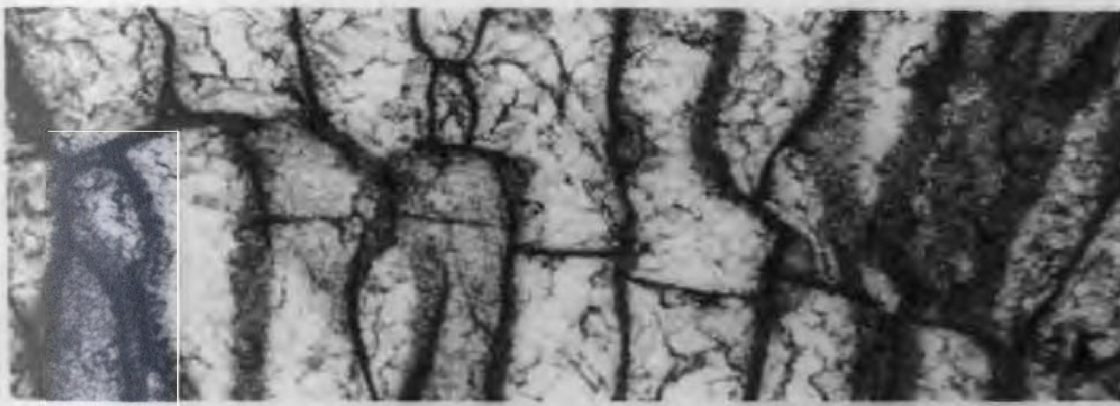


Fig.2

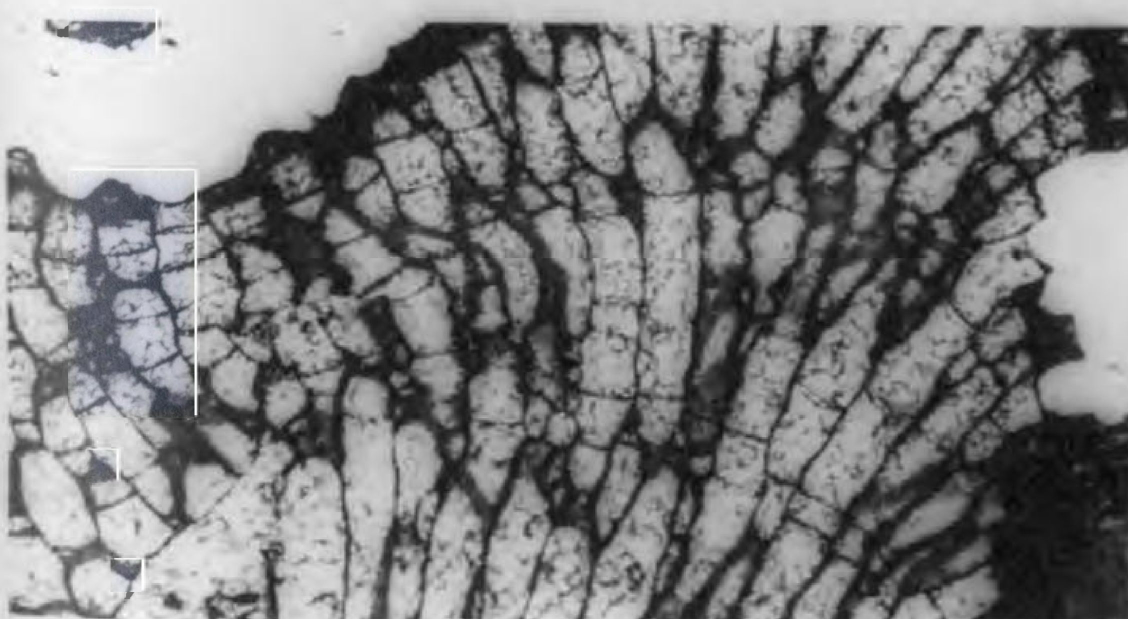


Fig.3

Plate 18

Figs. 1-4 Calopora aff. C.dumalis Ross, 1969

Collected from the Black Duck Member of the Long Point Formation two miles northeast of Tea Cove on the eastern side of Long Point.

Fig. 1 Oblique tangemtial section across zoarial stem showing, in the lower part of the figure, zooecia surrounded by smaller mesozooecia. ZMS 013; X 25.

Fig. 2 Shallow tangential section showing rounded to polygonal zooecia with well defined walls. ZMS 013; X 25.

Fig. 3 Longitudinal section showing flat, curved and compound diaphragms and the microstructure of zooecial walls and diaphragms. The former consist of steeply inclined laminae and the latter of parallel laminae that extend into and interfinger distally with the laminae of the zooecial walls. ZMS 013; X 50.

Fig. 4 Longitudinal section showing numerous diaphragms in the zooecia and meso-zooecia of the sub-peripheral region. ZMS 013; X 25.

PLATE 18

Fig 1

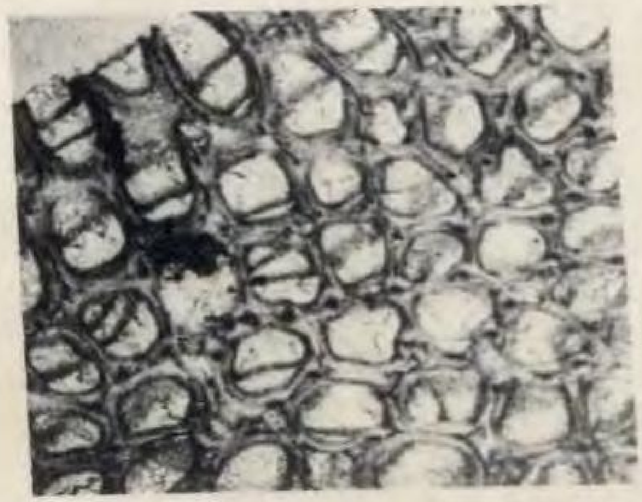


Fig 1

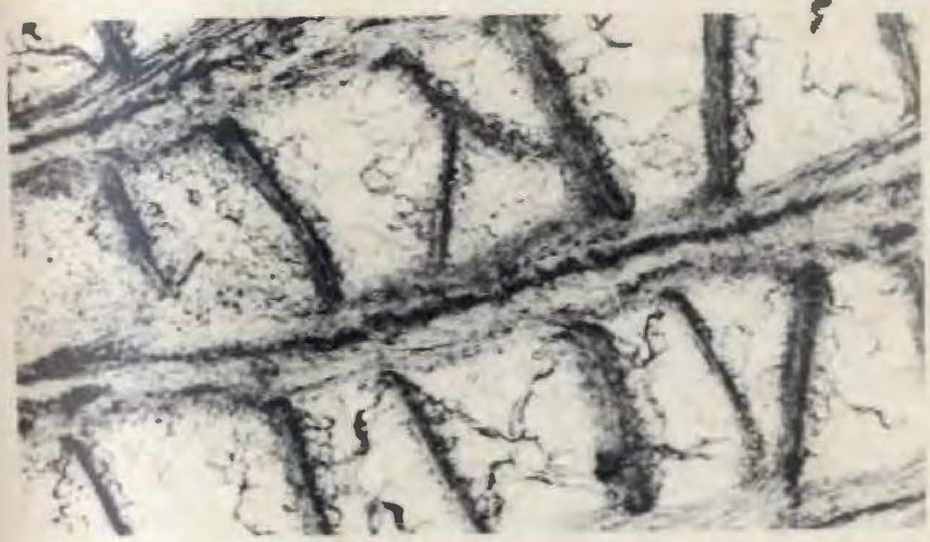


Fig 3

Fig 4

Plate 19

Figs. 1-2 — Calopora aff. C. dumalis Ross, 1969

Collected from the Black Duck Member of the Long Point Formation two miles northeast of Tea Cove on the eastern side of Long Point.

Fig. 1 — Transverse section showing well defined axial and peripheral regions. ZMS 013; X 25.

Fig. 2 — Longitudinal section showing fewer diaphragms in the axial region than in the peripheral region. ZMS 013; X 25.

Figs. 3-4 — Monotrypella aff. M. aequalis Ulrich, 1882

Collected from the Black Duck Member of the Long Point Formation one mile southwest of Three Rock Point.

Fig. 3 — Transverse section showing axial region with polygonal zooecia. ZMS 014; X 25.

Fig. 4 — Longitudinal section showing straight diaphragms in the peripheral region. ZMS 014; X 25.

PLATE 19

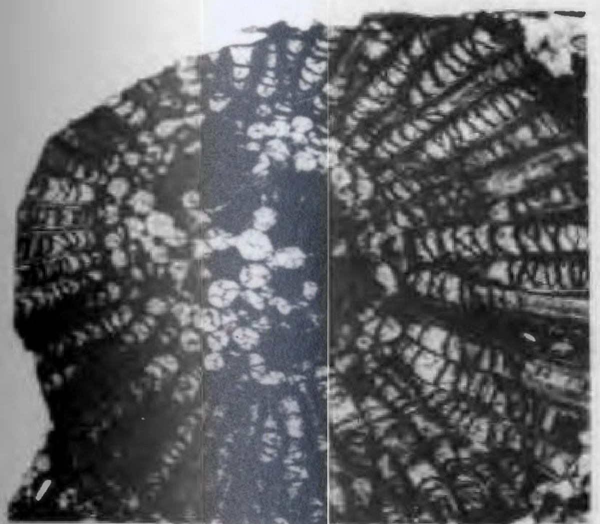


Fig.1

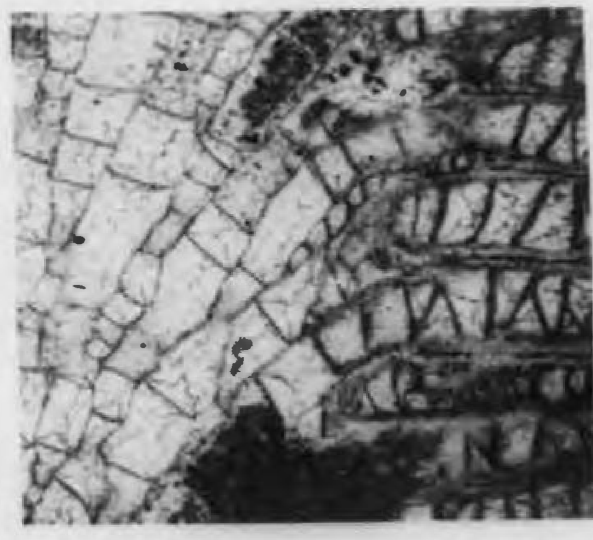


Fig.2

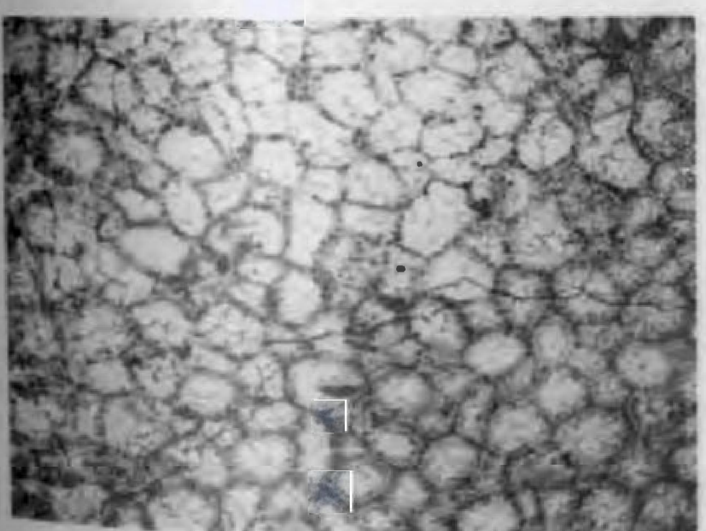


Fig.3

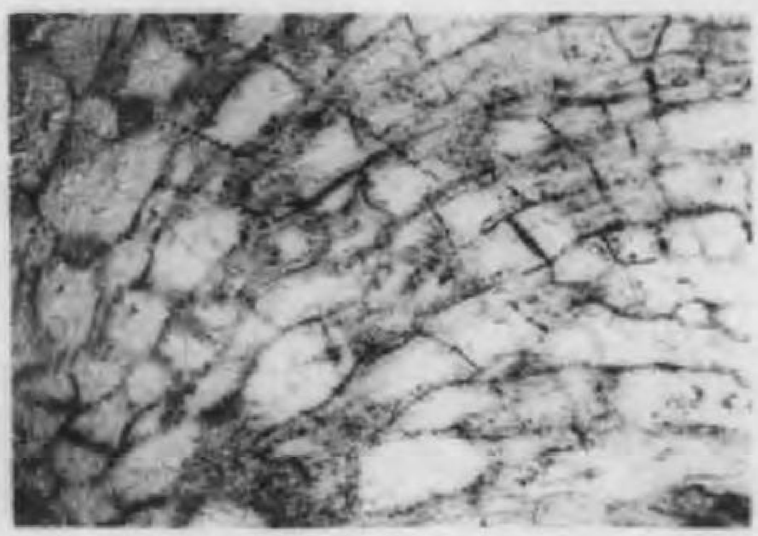


Fig.4

Plate 20

Figs. 1-2 Batostoma aff. B. winchelli Ulrich, 1893

Collected from the Black Duck Member of the Long Point Formation one mile northeast of Black Duck Brook on the eastern side of Long Point.

Fig. 1 Transverse section showing sub-polygonal to rounded zooecia. Note the integrate character of the wall. ZMS 015; X 25.

Fig. 2 Longitudinal section showing thin walled axial region crossed by diaphrams. ZMS 015; X 25.

PLATE 20

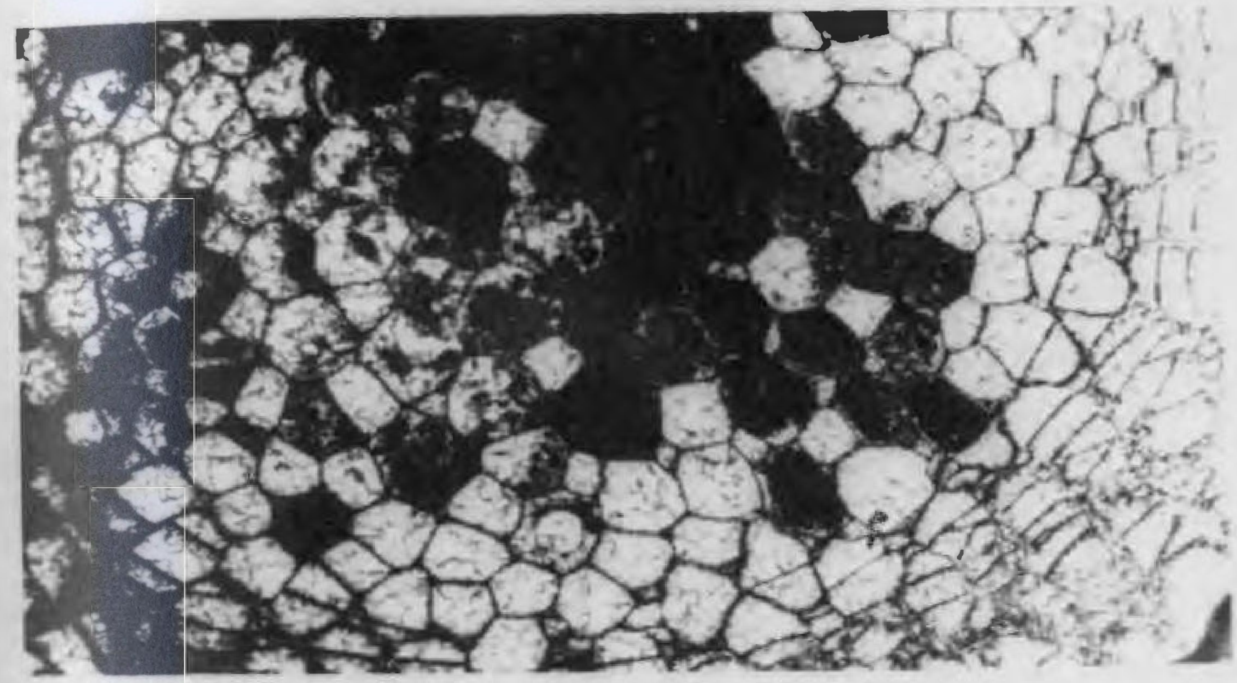


Fig. 1

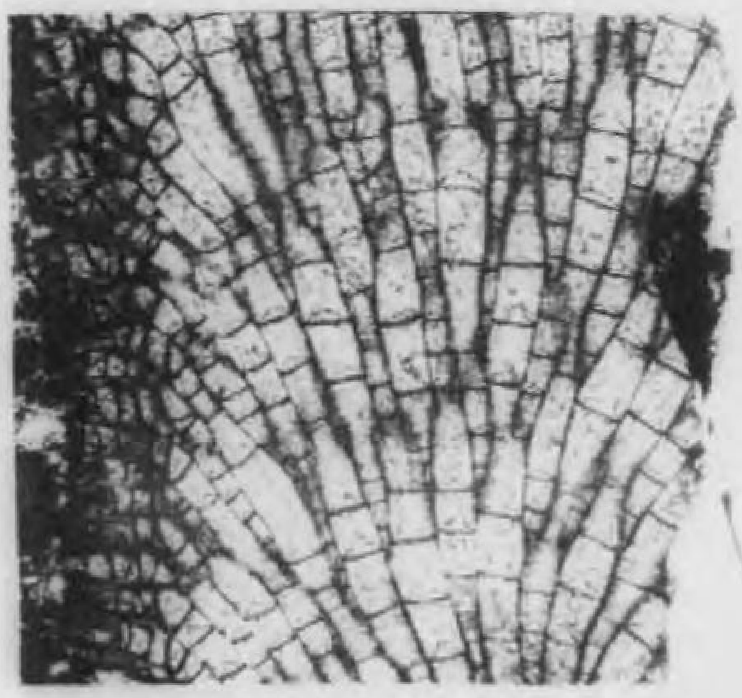


Fig. 2

Plate 21

Figs. 1-3 — <u>Hemiphragma</u> aff. <u>H. crassicrenulatum</u> Fritz, 1957

Collected from the Black Duck Member of the Long Point Formation three miles northeast of Tea Cove on the eastern side of Long Point.

Fig. 1 — Transverse section showing polygonal zooecia with few mesopores. ZMS 016; X 40.

Fig. 2 — Longitudinal section showing straight diaphragms in zooecia with crenulate walls. ZMS 016; X 40.

Fig. 3 — Longitudinal section showing straight diaphragms, hemiphragms and crenulated walls. ZMS 016; X 25.

PLATE 21

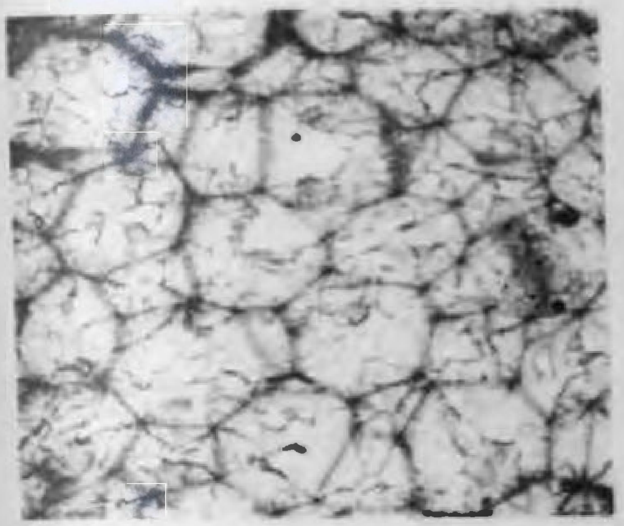


Fig.1

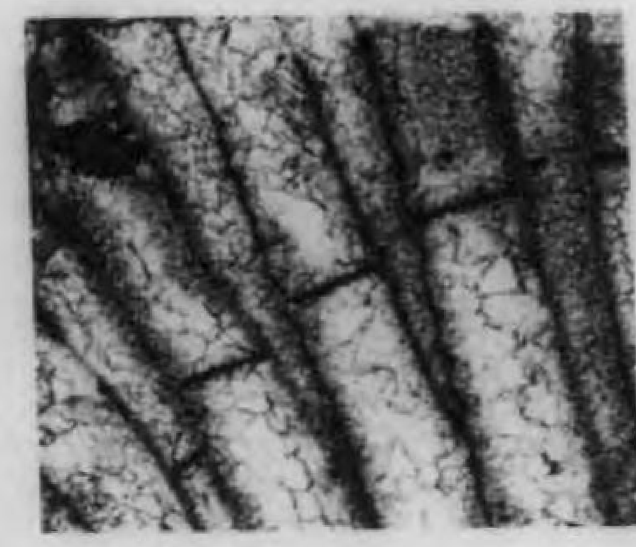


Fig.2

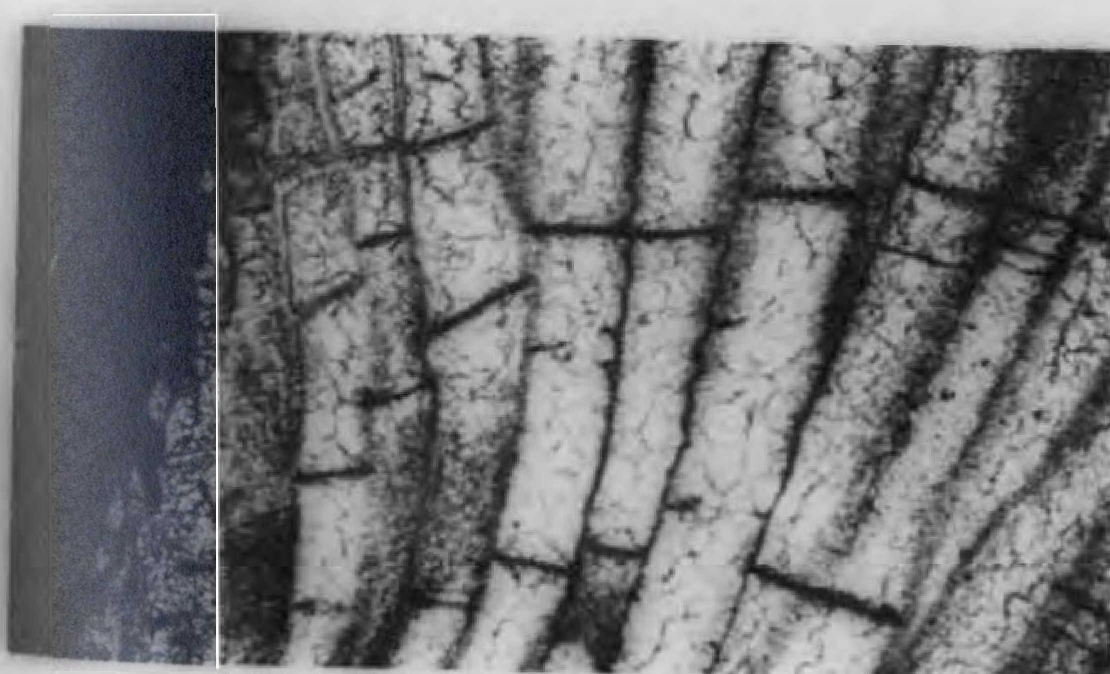


Fig.3

Plate 22

Figs. 1-3   *Diplotrypa schucherti* Fritz, 1966

One of a number of small mound shaped colonies, collected from many localities all along the length of Black Duck Member of the Long Point Formation.

Fig. 1   Transverse section showing polygonal zooecia that appear rounded where they are interrapted by mesopores. ZMS 017: X 25.

Fig. 2   Longitudinal section showing thin zooecial walls becoming crenulate where mesopores intervene. ZMS 017; X 25.

Fig. 3   Oblique longitudinal section showing beaded mesopores. ZMS 017; X 25.

PLATE 22

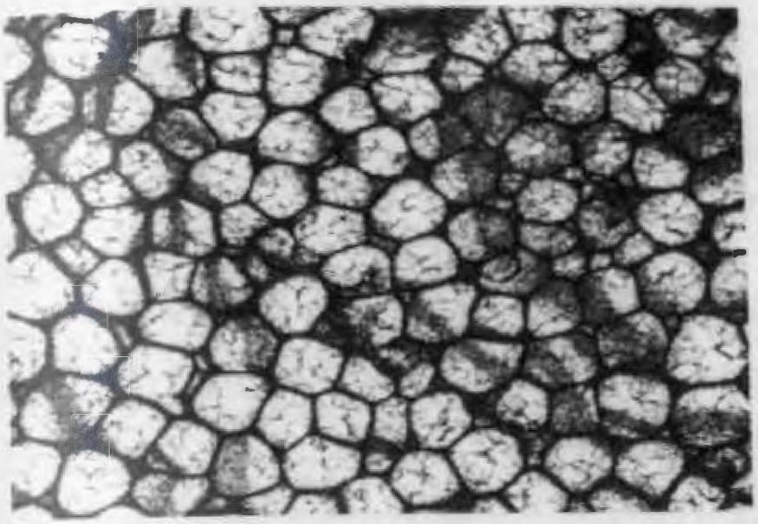


Fig. 1

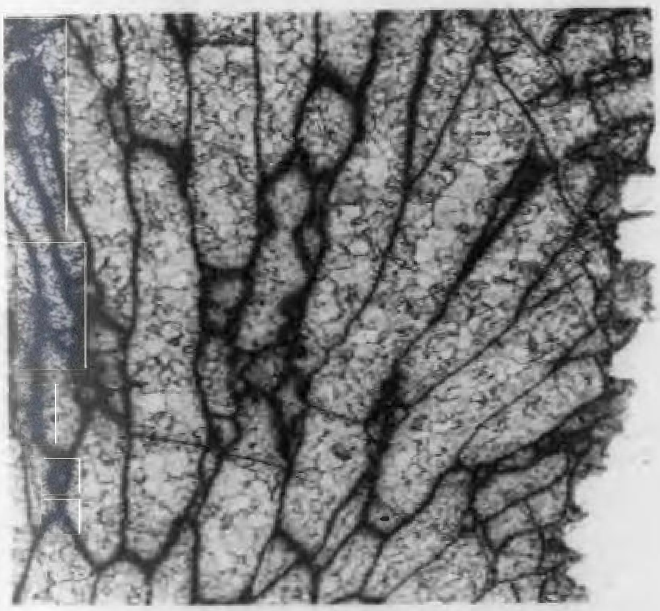


Fig. 2

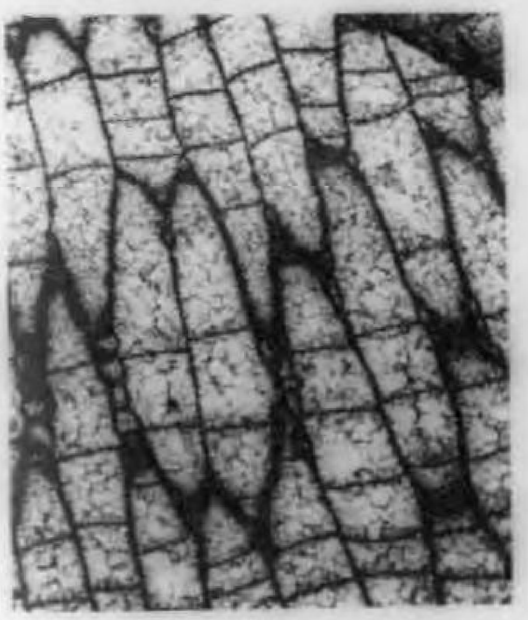


Fig 3

Plate 23

Figs. 1-3 Atactotoechus aff. A. kayi Ross, 1962

Collected from the Black Duck Member of the Long Point Formation two miles southwest of Black Duck Brook on the eastern side of Long Point.

Fig. 1 Shallow tangential section showing rounded zooecia. About six acanthopores present around each zooecium. ZMS 018; X 25.

Fig. 2 Longitudinal section showing the axial region without diaphragms. The undulating zooecial walls are longitudinally laminated. ZMS 018; X 25.

Fig. 3 Longitudinal section showing thickened zooecial walls which display atactotoechus micro-wall structure. ZMS 018; X 25.

PLATE

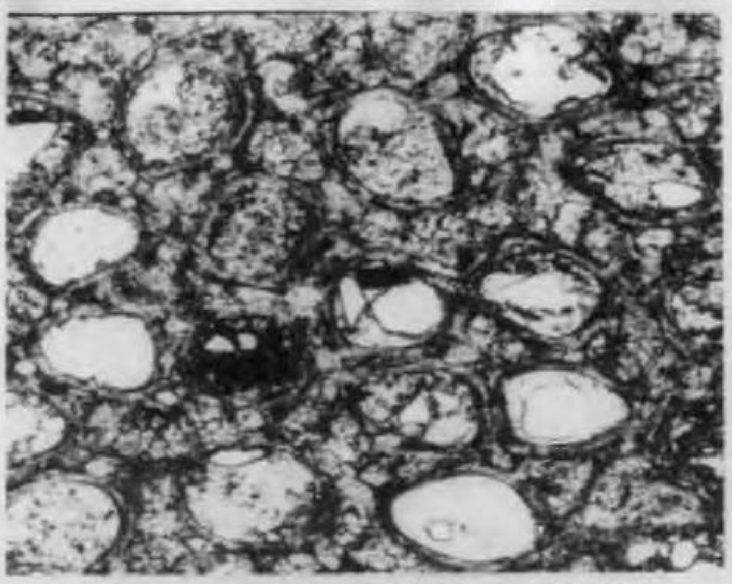


Fig.1

Fig.2

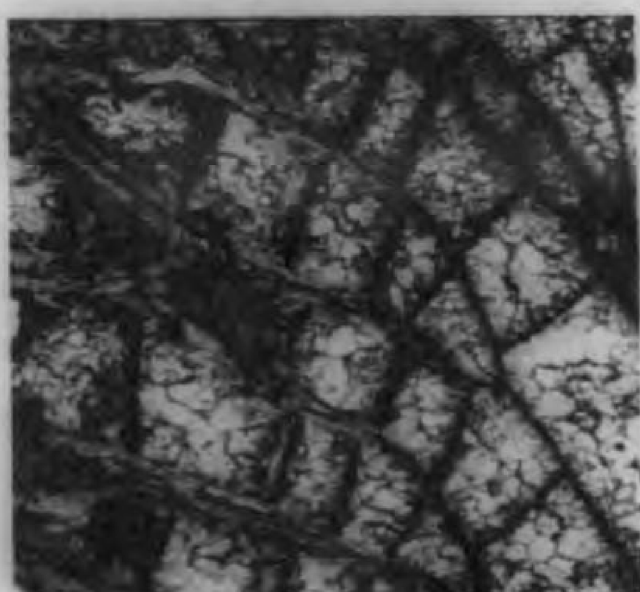


Fig.3

Plate 24

Figs. 1-2	*Atactotoechus* aff. *A. kavi* Ross, 1962
Fig. 1	Tangential section passing through a zooecial tube to show the atactotoechid microstructure of the zooecial wall and the nature of the simple, compound and cystoidal diaphragms. X 150 (*from* Ross, 1962).
Fig. 2	Transverse section of aperture of a zooecium to show the arrangement of the acanthopores. X 150 (*from* Ross, 1962).

PLATE 24

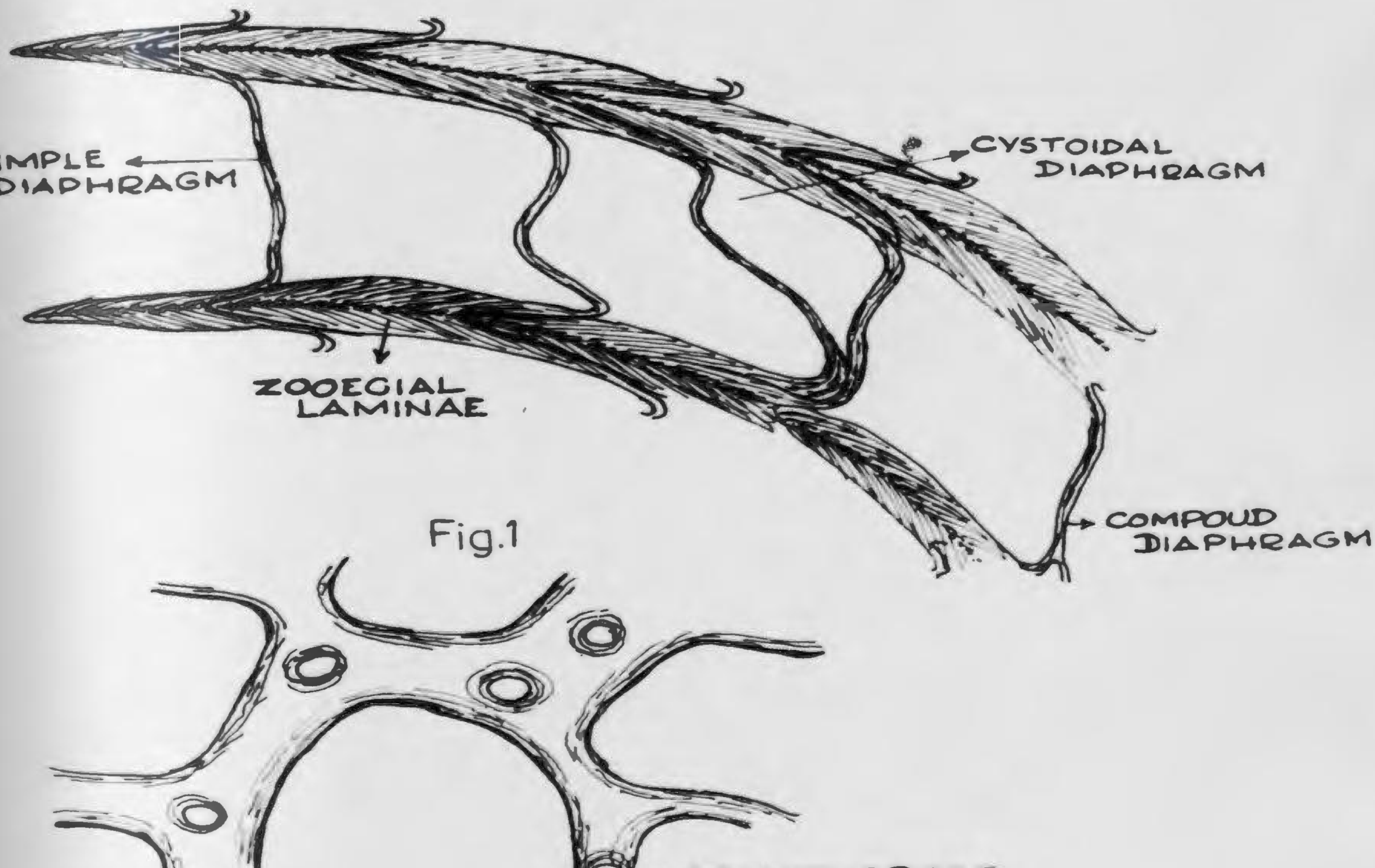


Fig.1

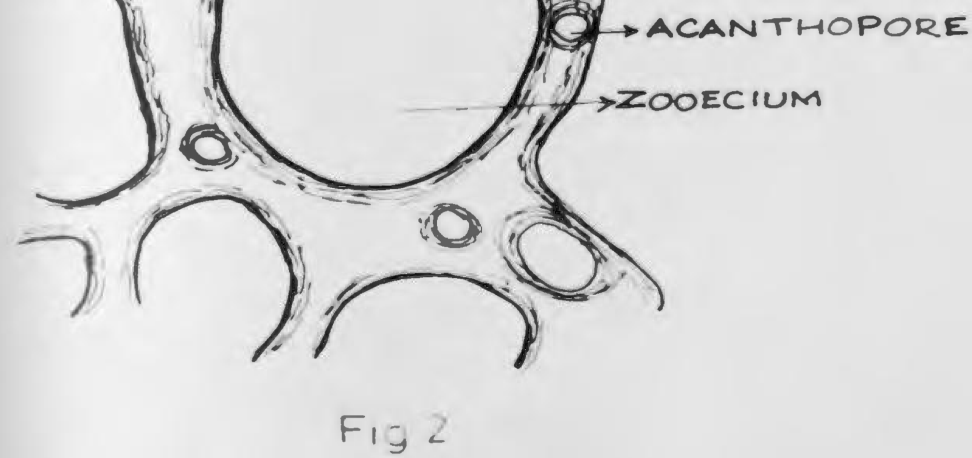


Fig 2

Chapter 5

OTHER FOSSILS

In addition to collecting trilobites and bryozoans, the two groups of fossils studied in detail for this thesis, fossils of other groups were collected where they were obvious or common and these are considered in this chapter in order to give a general, though very incomplete, picture of the fauna of the Long Point Formation. The dendroids Dictyonema and Staurograptus from the Green Point Formation are included since these forms are characteristic of this formation and indicate that it is of lowermost Ordovician age.

Family GONIOCERATIDAE Hyatt, 1884

Genus GONIOCERAS Hall, 1847

Gonioceras anceps Hall, 1847

Plate 25, Fig. 1

Locality and Horizon

Specimen ZMS 019, a four inch fragment of an orthocone with angular flanks collected from the Black Duck Member, two miles northeast of Black Duck Brook village on the eastern side of Long Point.

Description

The orthoconic shell is large, depressed and smooth-surfaced with a flat ventral side and a moderately convex dorsal side. The two sides of the shell meet laterally at an acute angle and these edges form distinct right and left flanks. Dorsally, the flanks are less convex than the axial part of the cone which represents half the total width of the shell. The camerae are wide and narrow and constricted between the axial part of the cone and the flanks. The sutures, on both the dorsal and ventral sides of the axial part of the cone, form broad central lobes. Laterally the lobes curve sharply towards the flanks and become closer to one another. Beyond this they regain their normal distance from one another and the lobes pass into rounded dorsolateral and ventrolateral saddles, the outer sides of which curve back to meet the lateral margin of the shell and one another, thus giving rise to pointed lateral lobes. The subcentral eurysiphonate siphuncle has cyrtochoanitic septal necks. The presence of secondary calcite within the camerae makes it difficult to determine whether or not cameral deposits were originally present.

Discussion

This specimen has all the characteristics of Gonioceras anceps and it is, therefore, regarded as belonging to this species. A Gonioceras from the Long Point Formation was listed by Riley (1962) as Gonioceras cf. G. anceps. G. anceps has also been collected by Wilson (1961) from the Ottawa Formation which is regarded as Black-River to Trenton in age.

Family GONIOCERATIDAE Hyatt, 1884

Genus GONIOCERAS Hall, 1847

Gonioceras aff. G. occidentale Hall, 1861

Plate 25, Figs. 2,3.

Locality and Horizon

Specimen ZMS 020, a large specimen of Gonioceras from the Black Duck member of the Long Point Formation about two miles southwest of Portage.

Description

The orthoconic shell is large and measures 270mm. in length. It is depressed and smooth with a flat ventral side, and a moderately convex dorsal side that meet laterally at an acute angle forming flanks (Pl. 25, Figs. 2,3). The specimen lacks both the posterior end of the cone and the living chamber. The width of the incomplete shell anteriorly is 90mm; tapering is gradual. Secondary calcite deposits within the camerae makes it difficult to ascertain whether these deposits are entirely secondary or represent, wholly or in part, mineralized cameral deposits. Centrally on the dorsal side the sutures make deep broad lobes. Laterally, where the flanks begin, the sutures rise sharply and approach one another. Beyond this they arch upwards as prominent saddles on the flanks. The septa on the flanks are closer to one another than centrally.

Discussion

This is believed to be the largest specimen of Gonioceras so far found in the Long Point Formation. Though the siphuncle is only partly exposed, a decrease in the diameter of the siphuncle towards the living chamber is apparent. The large size of the shell, the decrease in diameter of the siphuncle and the acuteness of the angle at which the septa pass from the main body of the shell to the arch on the flanks are characters found in Gonioceras occidentale Hall (1861). There is a considerable confusion in the literature as to the differences between G.anceps already noted in the Long Point Formation, and G. occidentale. Wilson (1961) states that G.anceps differs from G.occidentale in (1) the central part of the orthocone being broader and tapering more rapidly,

(2) the septa, beyond the point at which the central lobes pass into the lateral saddles, regaining their original distance from one another and maintaining it to the edge of the flanks, and (3) the septa on the flanks being closer to one another than centrally. G.occidentale has been reported from the Ottawa Formation by Wilson (1961) which is regarded as Black River to Trenton in age.

Family	ORTHOCERATIDAE	Mc'Coy, 1844
Subfamily	ORTHOCERATINAE	Mc'Coy, 1844
Genus	ORTHOCERAS	Bruguiere, 1789

Orthoceras aff. *O. regulare* Schlotheim, 1820

Plate 26, Figs. 1,2,3.

Locality and Horizon

Specimen ZMS 021, a weathered orthocone noted in *situ* in the Black Duck Member of the Long Point Formation, about one mile southwest of Black Duck Brook village on the eastern side of Long Point.

Description

The orthocone is very large, about 3 feet in length and 5 inches in diameter. It is almost cylindrical, expanding adapically, and it has a subcentral to slightly ventral, slender siphuncle, measuring one inch in diameter with orthochoanitic septal necks. The sutures are straight (Pl. 26, Figs. 1,2,3).

Discussion

This specimen resembles *Orthoceras regulare* Schlotheim in the features noted above but it differs from it in its larger size and in having a narrower siphuncle. This species has been reported from the Middle Ordovician of North America, Sweden and U.S.S.R. (Sweet in Moore, 1964).

Family	PSEUDORTHOCERATIDAE	Flower and Caster, 1935
Subfamily	SPYROCERATINAE	Shimizu and Obata, 1935
Genus	SPYROCERAS	Hyatt, 1884

Spyroceras aff S.arcuoliratum Hall, 1932

Plate 27, Figs. 1,2.

Locality and Horizon

Specimen ZMS 022, an annulated orthocone from the Black Duck Member of the Long Point Formation, one mile northeast of Tea Cove on the eastern side of Long Point.

Description

The orthocone is slender in shape and circular in cross section. Its original size is not known as the specimen is incomplete. The fragment is 90mm. in length. It represents 18 camerae of a phragmocone with a diameter of 20mm. at its larger end and 10mm. at the smaller, broken end. The siphuncle is subcentral in position and slightly less than 2mm. in diameter. All the annulations are equidsiatnt in their spacing (Pl.27, Figs. 1,2). The external surface shows longitudinal lirae.

Discussion

This specimen resembles Spyroceras arcuoliratum Hall in its oblique surficial annulation and the subcentral position of the siphuncle but it differs in that the rounded annulations are not as broad or broader than the troughs. S.arcuoliratum Hall has been reported by Wilson (1961) from the Ottawa Formation which is regarded as Black River and Trenton in age.

Family	ENDOCERATIDAE	Hyatt.1883
Genus	ENDOCERAS	Hall, 1847

Endoceras aff E.proteiforme Hall, 1847

Plate 27, Figs. 3,4,5,6.

Locality and Horizon

Specimen ZMS 023, a large weathered, incomplete conch collected from the Black Duck Member of the Long Point Formation, one mile northwest of Three Rock Point.

Description

The conch is large, straight and the fragment is 65mm. long. It represents 9 camerae of a gradually expanding phragmocone. The conch is slightly depressed dorso-ventrally. Sutures are deep and run across the vertical axis (Pl. 27, Fig. 3). The siphuncle is large and ventrally placed. It is circular in cross section and has a diameter of 7mm. In vertical section (Pl. 27, Figs. 5,6) the concave septa and the holochoanitic septal necks are distinct.

Discussion

This specimen shows the external and internal features of *Endoceras proteiforme* Hall. *E. proteiforme* has been reported from the Middle to Upper Ordovician of N. America, U.S.S.R. and East Asia. (Glenister and Furnish in Moore, 1964).

Family MACLURITIDAE Fischer, 1885

Genus MACLURITES LeSuer, 1818

Maclurites aff. *M. triangularis* Teichert, 1937

Plate 28, Figs. 1,2.

Locality and Horizon

Specimen ZMS 024, a large, complete shell collected from the Black Duck Member of the Long Point Formation, one mile northwest of Black Duck Brook village.

Description

The shell is large, hyperstrophic and paucispiral with a large umbilicus. The largest diameter measures 55mm. The evolute lower surface is flat while the involute upper surface is convex. The whorls enlarge less rapidly on the lower than the upper surface and this leads to a rapid increase in the vertical diameter of the whorls. Each whorl leaves the preceding one slightly revealed giving rise to an advolute shell.

Discussion

This specimen resembles *Maclurites triangularis* Teichert (1937) in having a large umbilicus and in this respect it differs from *Maclurites manitobensis* Whiteaves (1890). This large *Maclurites* is abundant throughout the strata of Silliman's Fossil Mount (Miller, Youngquist and Collinson, 1954) where some of them attain a diameter of more than 6 inches. In the Long Point Formation some specimens of *Maclurites* also attain this size. *Maclurites triangularis* has been collected by Miller, Youngquist and Collinson (1954) from the Cape Calhoun Formation of Northern Greenland which is regarded as Middle Ordovician in age.

Family MACLURITIDAE Fischer, 1885

Genus MACLURITES LeSuer, 1818

Maclurites aff M.manitobensis Whiteaves, 1890

Plate 28, Figs. 3,4,5.

Locality and Horizon

Specimen ZMS 025, a complete shell collected from the Black Duck Member of the Long Point Formation, two miles northeast of Black Duck Brook village on the eastern side of Long Point.

Description

The shell is small, hyperstrophic, paucispiral and its longest diameter measures 45 mm. It has a flat base (evolute) and strongly convex upper surface (involute). The whorls enlarge much less rapidly on the flat base than they do on the strongly convex upper surface (Pl.28, Fig.3). Involutions of the whorls are convexly rounded to the umbilical edge; the open umbilicus is narrow and deep. Each whorl leaves the preceding one slightly revealed and in section they have a roughly triangular outline which is slightly truncated at the line of contact with the preceding whorl.

Discussion

Rapidly increasing whorls on the convex upper side and a small, deep umbilicus are typical of Maclurites manitobensis Whiteaves. This species is widely found in Silliman's Fossil Mount (Baffin Island) where Knight and Bridge (in Shimer and Shrock, 1944) distinguished two forms of Maclurites, one form with a small and deep umbilicus and the other form with a large umbilicus. M.manitobensis is very widespread and characteristic of the Red River Formation in southern Manitoba. Troedsson (1937) reported it from the Cape Calhoun Series of the Middle Ordovician of northern Greenland. Teichert (1937) reported this form from Melville Peninsula, Lidden Island and northern Baffin Island.

Family	LOPHOSPIRIDAE	Wenz, 1888
Subfamily	LOPHOSPIRINAE	Wenz, 1888
Genus	Lophospira	Whitfield, 1886

Lophospira sp. indet.

Plate 29, Figs. 1,2.

Locality and Horizon

Specimen ZMS 026, an external impression of the shell from the LeRoy Member of the Long Point Formation, one mile southwest of Black Duck Brook on the eastern side of Long Point.

Description

The spire is low conical with an apical angle of about 75°. There are four whorls and each whorl has a strong convex spiral band in the middle of the whorl (Pl. 29, Fig. 1). This convex band runs all the way to the apex and gives an angulated appearance to the whorls. The shell surface bordering this spiral band on either side is shallow and concave. Between the upper concave band and the suture, the whorl is gently convex or nearly flat (Pl. 29, Figs.1,2). Ornamentation indistinct. The dimensions are as follows:

Height 11 mm.

Width at the base 7 mm.

Discussion

The absence of the apertural portion of the shell makes a more specific identification impossible. In its external features this specimen resembles Lophospira. Miller, Youngquist and Collinson (1954) noted Lophospira in the collection made by Gould (1927) from Silliman's Fossil Mount, Baffin Island, which is regarded as Middle Ordovician in age.

Family AULOPORIDAE Milne-Edwards & Haime, 1851

Genus LABYRINTHITES Lambe, 1906

<u>Labyrinthites chidlensis</u> Lambe, 1906

Plate 30, Figs. 1,2.

<u>Locality and Horizon</u>

Specimen ZMS 027, one of a large number of dome-shaped colonies collected from the whole length of the outcrop of the Black Duck Member of the Long Point Formation.

<u>Description</u>

The colony is low-domed in outline, measuring 8 inches in width and 2 inches in height. In transverse section (Pl. 30, Fig. 1) the corallites are oval to polygonal, without septa, and each is connected to neighbouring corallites at one, two, or three of its corners by hollow tubules. Longitudinal sections (Pl. 30 Fig. 2) reveal distinct tabulae, which are flat to low convex or shallow concave, and mural pores in the inter-spaces. The corallites, which are generally separated from one another by interspaces may coalesce and they also seem to be very slightly sinuous. The tubules cross the interspaces.

<u>Discussion</u>

This specimen is identical to specimens of <u>Labyrinthites (Labyrinthites) chidlensis</u> Lambe, identified by Bolton (1965) from the Long Point Formation. Lambe (1906) on the basis of long parallel corallites continuously connected together and the absence of tubules, provisionally placed this genus in the Halysitidae. Duncan (1956) and Hamada (1957) assigned the genus to the Syringoporidae. Sokolov (1955) combined <u>Labyrinthites</u> with <u>Hexismia</u>

Sokolov in the family Hexismiidae, Order Halysitida. Hill and Stumm (1956), however, regard its cylindrical corallites connected by hollow tubules as being more characteristic of the family Auloporidae than of the Family Halysitidae.

Troelsen (1959) found L. chidlensis in the Cape Webster Formation (Middle Ordovician(?), Greenland, associated with Gonioceras of Middle Ordovician Black River and/or Trenton affinities (Wilderness stage). It has also been reported from Middle and Upper (?) Ordovician rocks of northern Greenland, southwestern, central and northeastern Ellesmere Island, south Devon Island, Anderson Island, South Baffin Island, Cape Chidley, central Quebec, north of Great Bear Lake and Alaska (Bolton, 1965).

Family	STREPTELASMATIDAE	Nicholson in Nicholson and Lydekker, 1889
Subfamily	STREPTOLASMATINAE	Nicholson in Nicholson and Lydekker, 1889
Genus	LAMBEOPHYLLUM	Okulitch , 1938

Lambeophyllum aff. L. profundum (Conrad)

Plate 31, Figs. 1,2,3.

Locality and Horizon

Specimen ZMS 028: a complete specimen of Lambeophyllum. Collected from the Beach Point Member of the Long Point Formation, at the level of Black Duck Brook post office on the eastern side of Long Point.

Description

The corallite has a length of 15mm. It is cylindrical-conical in shape and contracted at the base which is pointed. Above the acutely conical base the diameter of the corallite increases rapidly within a short distance until the diameter is about 7 to 8 mm; thereafter increase in diameter is slight. Externally the specimen shows annular undulations and septal ridges. In transverse section (Pl.31, Fig. 2) both primary and secondary septa are present but little developed. In vertical section (Pl.31, Fig. 3) the calyx is deep with steep sides and reaches almost to the bottom of the corallite. No tabular dissepiments.

Discussion

This specimen resembles Lambeophyllum profundum (Conrad) in all its features and an examination of additional material may show that it is the same species. L.profundum has been collected by Wilson (1948) from the Ottawa Formation which is regarded as Black River to Trenton in age.

Family	STROPHOMENIDAE	King, 1846
Subfamily	ÖPIKINAE	Sokolskaya, 1960
Genus	ÖPIKINA	Salmon, 1942

Öpikina aff Ö.gregaria Cooper, 1956

Plate 32, Figs. 1,2.

Locality and Horizon

Specimen ZMS 029, a brachial valve showing distinct cardinalia; from the LeRoy Member of the Long Point Formation, one mile southwest of Black Duck Brook on the eastern side of Long Point.

Description

The shell is subquadrate. It is wider than long. The dimensions are as follows: Length: 16mm.
Hinge width: 21mm.
Thickness: 4mm.

The cardinal extremities make an obtuse angle. The shell has oblique sides while the anterior margin is broadly rounded. Brachial valve is fairly concave in the median and posterior regions. Its posterolateral sides and the anterior margin are sharply deflected. Cardinal process small but strongly developed. The septa are low and subdued.

Discussion

This species resembles Öpikina gregaria Cooper, in having moderate size, fairly prominent ears and delicate ornamentation. Öpikina gregaria has been collected by Cooper (1956) from the Bromide Formation which is regarded as Chazyan to Trenton in age.

Family	STROPHOMENIDAE	King, 1846
Subfamily	ÖPIKINAE	Sokolskaya, 1960
Genus	ÖPIKINA	Salmon, 1942

Öpikina aff. Ö. formosa Cooper, 1956

Plate 32, Figs. 3,4.

Locality and Horizon

Specimen ZMS 030: a brachial valve from the LeRoy Member of the Long Point Formation, one mile northeast of Black Duck Brook village on the eastern side of Long Point.

Description

The shell is subquadrate in outline and slightly wider than long. The dimensions of the brachial valve are as follows:

Length:	21mm.
Width:	20mm.
Hinge width:	32mm.
Height:	4 mm.

The length of the hinge line is equal to the midwidth of the brachial valve. The posterolateral sides are sub-parallel while the anterior margin is somewhat rounded. Distinct costellae, alternating fine and strong, are present on the surface. The brachial valve shows gentle concavity in the posterior half, but greater concavity anterior to the middle where the valve is sharply deflected towards the brachial valve. The interior of the brachial valve shows 5 well developed septa and a stout and long cardinal process. The rim is thickened and where deflection of the valve occurs there is a beaded subperipheral rim.

Discussion

This specimen is most like Öpikina formosa Cooper (1956) in its general shape ~~and~~, in possessing strongly developed cardinal process and in having 5 distinct septa. Ö. formosa has been collected by Cooper (1956) from the Bromide Formation which is regarded as Chazyan to Trenton in age.

Family	LEPTESTIIDAE	Opik, 1933
Subfamily	LEPTESTIINAE	Opik, 1933
Genus	SOWERBYITES	Teichert, 1937

Sowerbyites aff. S. lamellosus Cooper, 1956

Plate 33, Figs. 1,2.

Plate 34, Fig. 1

Locality and Horizon

Specimen ZMS 031: two valves, one showing the interior of a brachial valve the other showing the exterior of a pedicle valve. Collected from the LeRoy Member of the Long Point Formation, two miles southwest of the Black Duck Brook village on the eastern side of Long Point.

Description

The shell is subrectangular in outline with a length equal to about two thirds of the width; greatest shell width at the hinge. The dimensions of the brachial valve are as follows:

Length:	11mm.
Width:	18mm.
Hinge width:	19mm.

The lateral margins of the shell are nearly straight in the posterior half while the anterolateral and anterior margins are well rounded. The cardinal extremities form a right angle. The brachial valve varies in its concavity. It is gently concave in the lateral profile with the greatest concavity at the anterior third where the valve is somewhat sharply bent toward the brachial valve. The posterior two thirds are nearly flat and a faint median sulcus originates at the umbo. The surface of the shell shows about 11 to 12 larger costellae occupying a space of 5 mm. at the anterolateral margins. Finest costellae are present but poorly preserved (Pl. 34, Fig. 1). The interior of the brachial valve shows a low, rounded, thick median septum and 2 low, but wide, lateral septa. The process is moderately elevated (Pl. 33, Fig. 1). The anterior end of the median septum is only slightly elevated.

Discussion

This specimen is characterized by its transverse form, large size and subrectangular outline which places it close to Sowerbyites lamellosus Cooper (1956). It differs from it only in its length and width which are less in S. lamellosus. Cooper (1956) reported S. lamellosos from the Bromide Formation which is regarded as Chazyan to Trenton in age.

Family DENDROGRAPTIDAE Roemer in Frech, 1897

Genus DICTYONEMA Hall, 1851

Dictyonema flabelliforme (Eichwald) 1840

Plate 34, Fig. 2.

Locality and Horizon

Specimen ZMS 032; fragmented rhabdosome (or parts of several rhabdosomes) from the limestones associated with shales in the upper part of the Green Point Formation sequence two miles northeast of Tea Cove on the eastern side of Long Point.

Description

Fragments of fan-shaped appearance (originally parts of a complete cone) made up of numerous almost parallel, wrinkled stipes that have arisen through dichotomous branching. The stipes are united by transverse dissepiments some of which run obliquely. Thecal pattern indeterminate.

Discussion

The fragments of the rhabdosome (or rhabdosomes) are characteristic of Dictyonema flabelliforme (Eichwald) which has an almost world-wide distributior in strata of Lowermost Ordovician (Tremadoc) to Lower Carboniferous age (Bulman, 1955). Its association in this case with Staurograptus indicates a Tremadoc age.

Family	DIPLOGRAPTIDAE	Lapworth, 1873
Subfamily	CLIMACOGRAPTINAE	Frech, 1897
Genus	CLIMACOGRAPTUS	Hall, 1865

Climacograptus aff. C. inuiti similis Wilson, 1948

Plate 35, Figs. 1,2

Locality and Horizon

Specimen ZMS 033: slab with weathered rhabdosome collected from the Misty Cove Member of the Long Point Formation at the northernmost corner of the Clam Bank Cove.

Description

The rhabdosome is biserial, scandent and in the case of the particular specimen considered here, 20 mm. long. It is relatively narrow and bears tabular thecae whose outer walls show sigmoidal curvature. The proximal and distal portions of each theca are parallel to the axis. The apertural margin is horizontal and lies within a well-defined excavation. Each theca is bordered by a thick flange-like ridge which culminates in a spine-like projection. Another spine is borne by the base of the outer edge of each theca. The space between the two spines is concave.

Discussion

This species resembles Climacograptus inuiti similis, in having a thickened aperture with a spine-like termination and a lower spine that results in the thecal wall between the two spines having a concave outline. However, it differs in having 11 thecae instead of 13 thecae in 10mm. distance. C.inuiti similis has been collected by Wilson (1948) from the Ottawa Formation which is regarded as Black-River to Trenton in age.

Family ANISOGRAPTIDAE Bulman, 1950

Genus STAUROGRAPTUS Emmons, 1855

Staurograptus dichotomus Emmons, 1855

Plate 35, Fig. 3.

Locality and Horizon

Specimen ZMS 034; a nearly complete rhabdosome from the limestones associated with shales in the upper part of the Green Point Formation sequence about two miles northeast of Tea Cove on the eastern side of Long Point.

Description

The rhabdosome is small, 10mm. in diameter, and shows a quadriradiate pattern of branching. The branches lie in the same plane, horizontal attitude. Branching is dichotomous and branches of four orders are observed; branches short and straight. Characters of thecae cannot be distinguished.

Discussion

This specimen is identical to Staurograptus dichotomus Emmons (1855). It is common in the Lower Ordovician (Tremadoc) Schaghticoke shales at Schaghticoke, New York where it is associated with Dictyonema flabelliforme (Ruedemann, 1947). This association is also found in Lower Ordovician shales near Greenville, Washington Co., as well as in the Taconic slates of Bensselaer Co., New York (Ruedemann, 1947),and it was first discovered in the Green Point Formation of the Port au Port Peninsula by Schuchert and Dunbar (1934).

Plate 25

Fig. 1 <u>Gonioceras anceps</u> Hall, 1847

Collected from the Black Duck Member of the Long Point Formation, two miles northeast of Black Duck Brook village on the eastern side of Long Point.

Dorsal side of the specimen showing a part of phragmacone indicating the rate of tapering and the curve of the septa at their junction with the flanges. ZMS 019; X 1.

Fig. 2-3 <u>Gonioceras</u> aff. <u>G. occidentale</u> Hall, 1861
Collected from the Black Duck Member of the Long Point Formation, two miles southwest of Portage on the eastern side of Long Point.

Fig. 2 Dorsal side of the specimen showing broad but shallow segments. Note the septa on the flanks are closer to one another than centrally. ZMS 020; X 1.

Fig. 3 Anterior view of broken shell showing the flat ventral side and moderately convex dorsal side, and the position of the siphuncle. ZMX 020; X 1.

PLATE 25

Fig. 1

Fig. 2

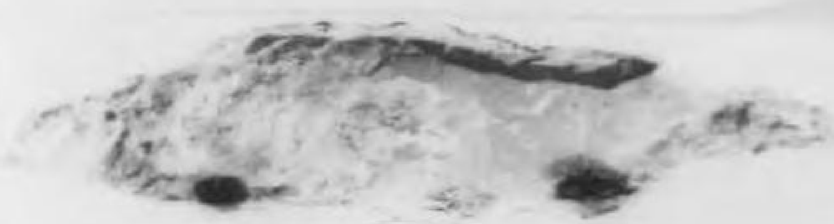


Fig. 3

Plate 26

Fig. 1	Orthoceras aff. O. regulare Schlotheim, 1820
	Collected from the Black Duck Member of the Long Point Formation, one mile southwest of Black Duck Brook on the eastern side of Long Point.
Fig. 1	A general view of the orthocone which measures about three feet in length. ZMS 021.
Fig. 2	Closer view of the same orthocone as in Fig. 1 to show the trace of the siphuncle. ZMS 021.
Fig. 3	Vertical section of part of same specimen showing the siphuncle. ZMS 021.

PLATE 26

Fig. 1

Fig. 2

Fig. 3

Plate 27

Figs. 1-2	<u>Spyroceras</u> aff. <u>S. arcuoliratum</u> Hall, 1932
	Collected from the Black Duck Member of the Long Point Formation, one mile northeast of Tea Cove.
Fig. 1	Lateral view of the specimen showing the annulations which are uniformly spaced. Note annulations and sutures are equidistant in their spacing. ZMS 022; X 1.
Fig. 2	Dorsal view of the specimen showing the obliquity of the sutures. ZMS 022; X 1.
Figs. 3-6	<u>Endoceras</u> aff. <u>E. proteiforme</u> Hall, 1847
	Collected from the Black Duck Member of the Long Point Formation, one mile northwest of Three Rock Point.
Fig. 3	Complete septate internal cast of the specimen ZMS 023; X 1.
Fig. 4	Diagrammatic cross section of the same specimen, showing the ventrally placed large siphuncle. ZMS 023; X 1.
Fig. 5	Vertical section of the conch showing the size and position of the siphuncle, and the holochoanitic septal necks. ZMS 023; X 1.
Fig. 6	Reconstruction based on Fig. 5, ZMS 023; X 1.

PLATE 27

Fig. 1

Fig. 2

Fig. 3

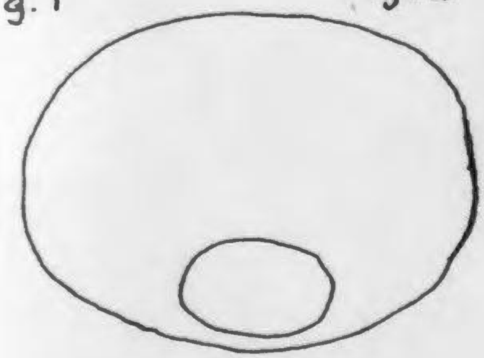


Fig. 4

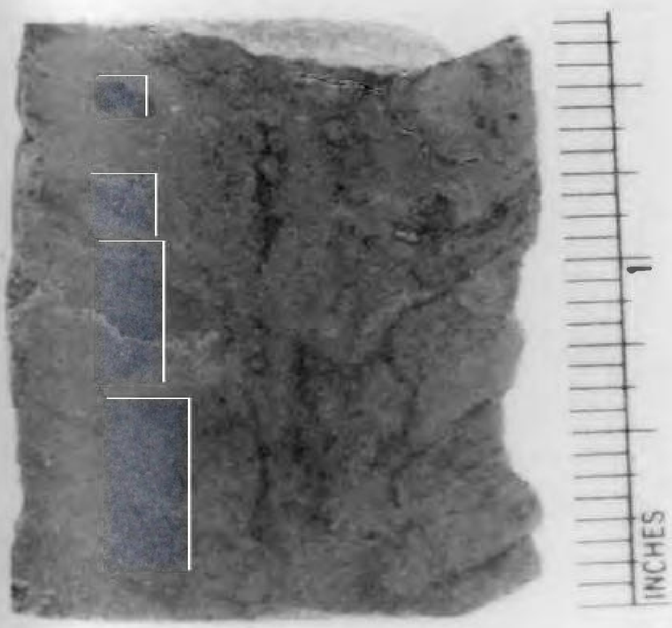


Fig. 5

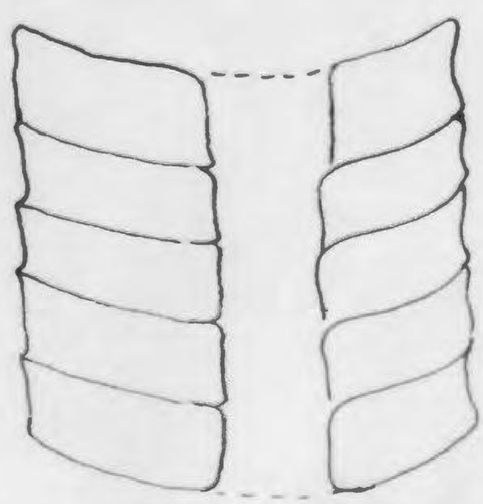


Fig. 6

Plate 28

Figs. 1-2 — *Maclurites* aff. *M. triangularis* Teichert 1937

Collected from Black Duck Member of the Long Point Formation about one mile northwest of Black Duck Brook village on the eastern side of Long Point.

Fig. 1 — Upper surface of the shell showing large umbilicus, convex whorls and the rapid enlargement of the whorls. ZMS 024; X 1.

Fig. 2 — Flat lower surface of the shell exposing all the whorls. ZMS 024; X 1.

Figs. 3-5 — *Maclurites* aff. *M. manitobensis* Whiteaves 1890

Collected from the Black Duck Member of the Long Point Formation, two miles northeast of Black Duck Brook village on the eastern side of Long Point.

Fig. 3 — Drawing of cross section of the shell showing roughly triangular outline of the whorls and the slight gap between succeeding whorls. ZMS 025; X 1.

Fig. 4 — Upper surface of the shell showing small and deep umbilicus and convex whorls. Note each whorl leaving the preceding one slightly. ZMS 025; X 1.

Fig. 5 — Flat lower surface of the same specimen as in Fig. 3, exposing all the whorls. ZMS 025; X 1.

PLATE 28

Fig. 1

Fig. 2

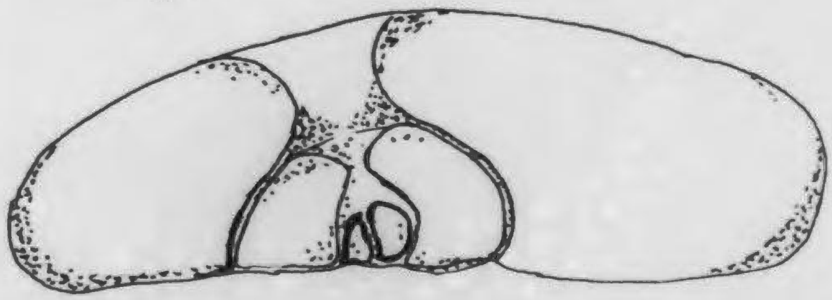


Fig. 3

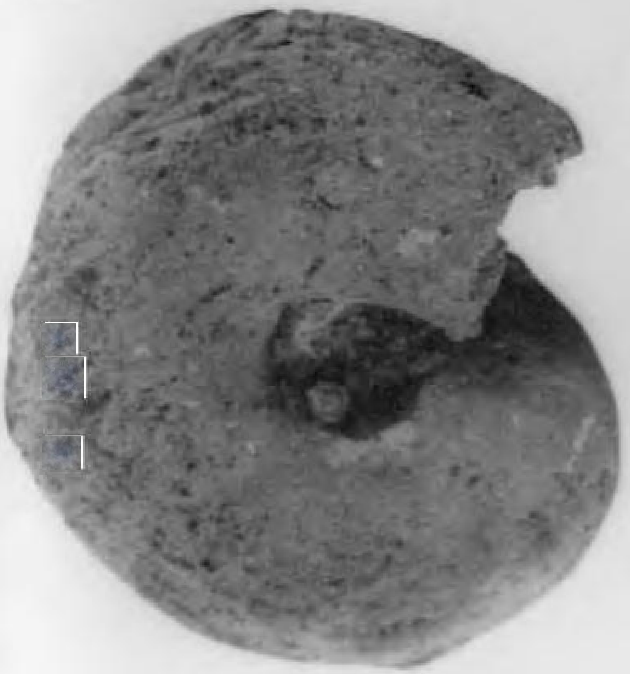


Fig. 4

Fig. 5

Plate 29

Figs. 1-2	*Lophospira* sp. indet.
	Collected from the LeRoy Member of the Long Point Formation, one mile southwest of Black Duck Brook on the eastern side of Long Point.
Fig. 1	External mould of the specimen showing four distinctly angulated whorls. ZMS 026; X 10.
Fig. 2	Drawing of the same specimen based on Fig. 1. ZMS 026; X 15.

PLATE 29

Fig. 1

Fig. 2

Plate 30

Figs. 1-2 <u>Labyrinthites chidlensis</u> Lambe, 1906

Collected from the Black Duck Member of the Long Point Formation from the whole length of formation.

Fig. 1 Transverse section showing oval to polygonal, four to six sided phaceloid corallites, with thick walls. Note the chain-like network formed by the individuals connected by tubules. ZMS 027; X 45.

Fig. 2 Longitudinal section showing slender parallel corallites with thick walls. Note distinct tabulae in the form of thin flat, transverse plates across the corallites. ZMS 027; X 45.

PLATE 3.0

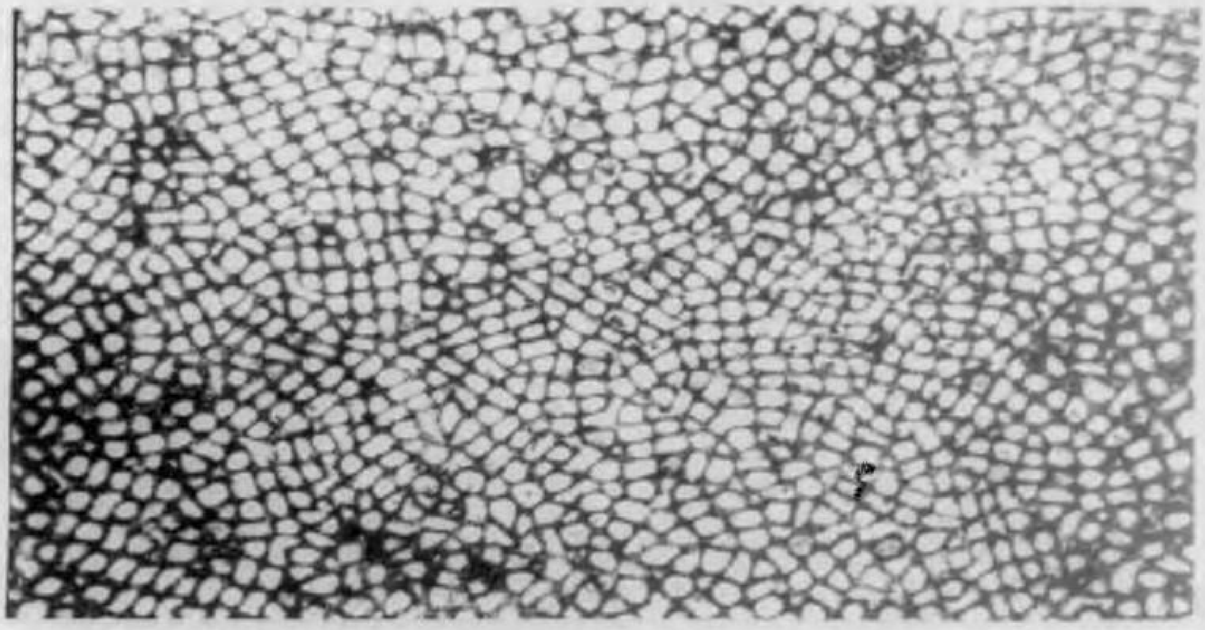


Fig. 1

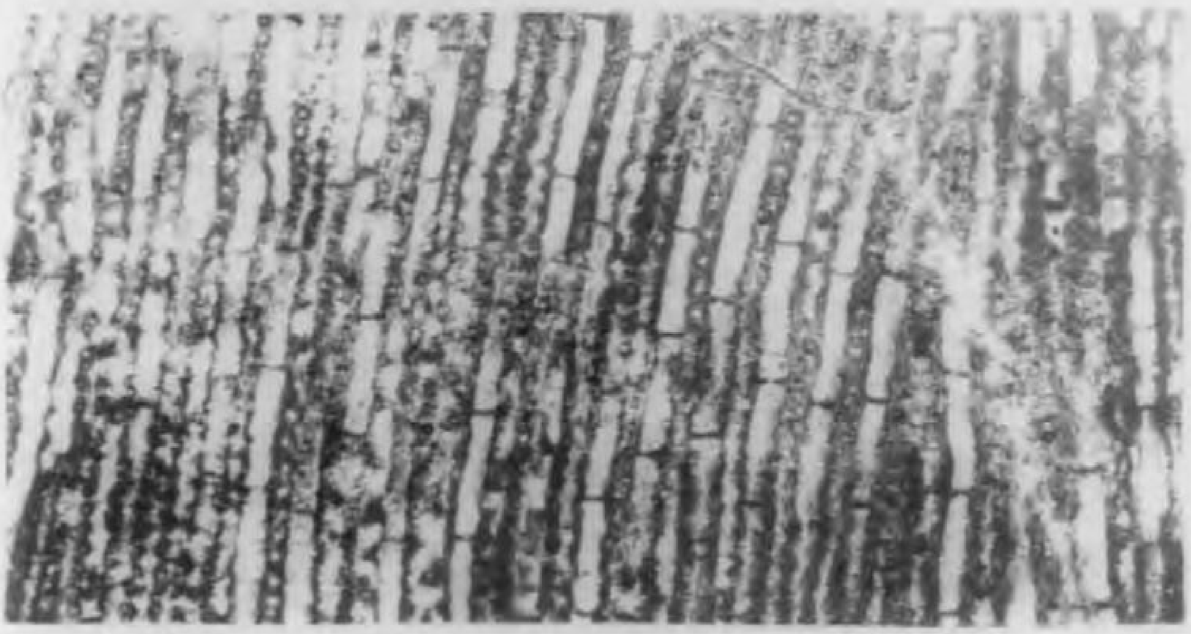


Fig. 2

Plate 31

Figs. 1-3 *Lambeophyllum* aff. *L. profundum* (Conrad)

Collected from the Beach Point Member of the Long Point Formation at the level of Black Duck Brook post office on the eastern side of Long Point.

Fig. 1 Lateral view of corallite Note the sharply pointed base and the annular undulations and septal ridges of the surface. ZMS 028; X 5.

Fig. 2 Transverse section showing primary and secondary septa extending only a short distance from the epitheca. ZMS 028; X 25.

Fig. 3 Longitudinal section showing deep calyx and an absence of tabulae or dissep-iments. ZMS 028; X 25.

PLATE 31

Fig. 1

Fig. 2

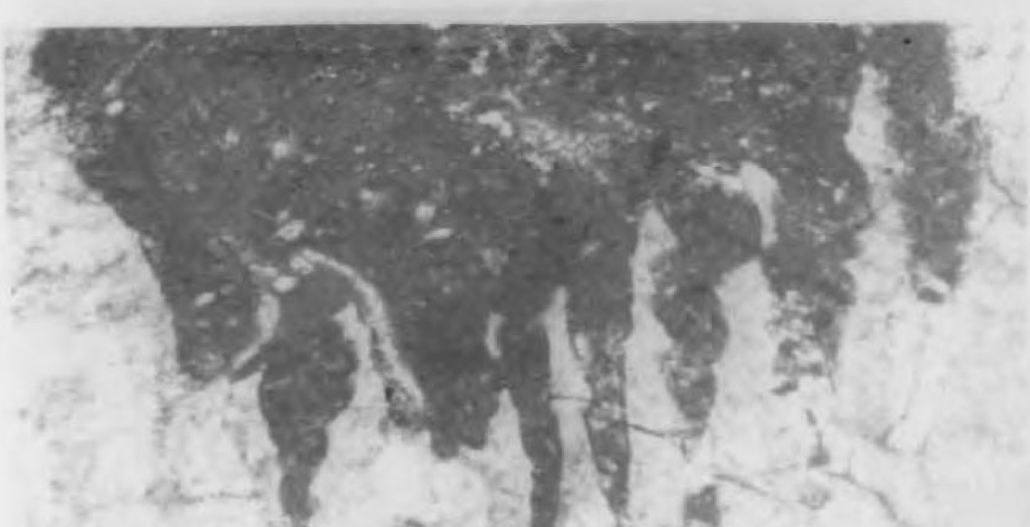


Fig. 3

Plate 32

Figs. 1-2 — <u>Öpikina</u> aff. <u>Ö. gregaria</u> Cooper, 1956

Collected from the LeRoy Member of the Long Point Formation, one mile southwest of Black Duck Brook village on the eastern side of Long Point.

Fig. 1 — Brachial valve with U-shaped outline. Note the stout bilobed cardinal process. ZMS 029; X 4.

Fig. 2 — Reconstruction based on Fig. 1, showing the stout cardinal process and the sub-peripheral rim. ZMS 029; X 4.

Figs. 3-4 — <u>Öpikina</u> aff. <u>Ö. formosa</u> Cooper, 1956

Collected from the LeRoy Member of the Long Point Formation, one mile northeast of Black Duck Brook on the eastern side of Long Point.

Fig. 3 — Brachial valve showing well developed bilobed cardinal process, 5 septa and a distinct sub-peripheral rim. ZMS 030; X 4.

Fig. 4 — Reconstruction based on Fig. 1.

PLATE 32

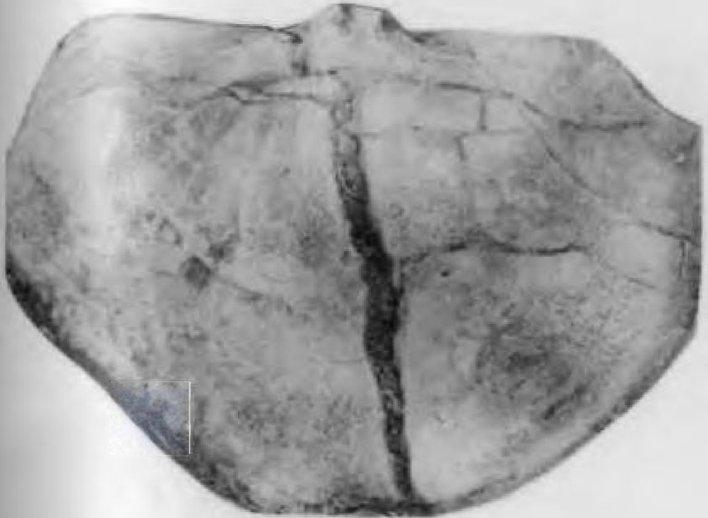


Fig. 1

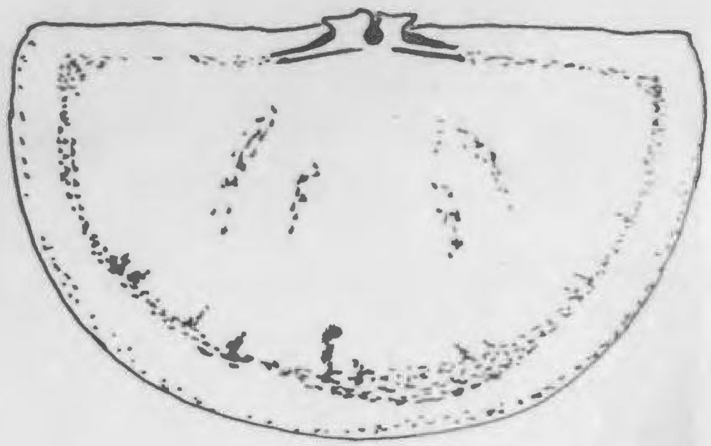


Fig. 2

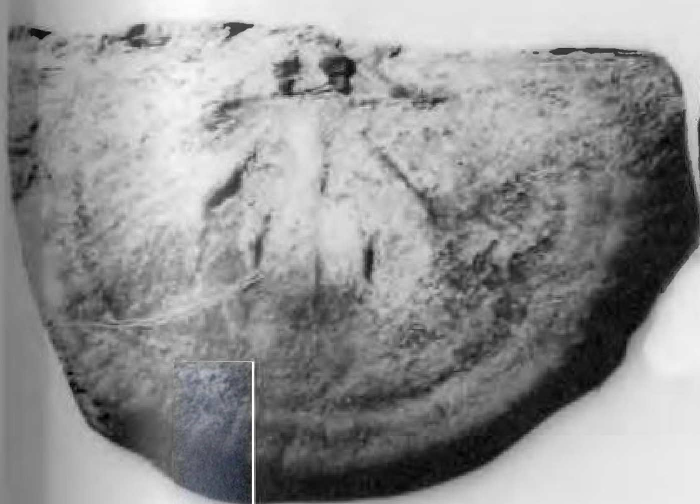


Fig. 3

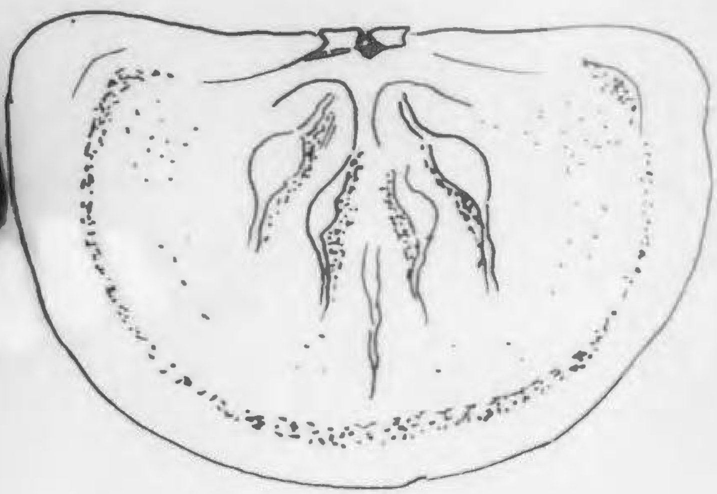


Fig. 4

Plate 33

Figs. 1-2 *Sowerbyites* aff. *S. lamellosus* Cooper, 1956

Collected from the LeRoy Member of the Long Point Formation, two miles southwest of Black Duck Brook on the eastern side of Long Point.

Fig. 1 Interior of brachial valve. The valve is subrectangular in outline, wider than long with a straight hinge line. Note the trilobate cardinal process, median septum with low but wide lateral septa. The sub-peripheral rim is well marked. ZMS 031; X 8.

Fig. 2 Diagrammatic representation of internal morphology of the brachial valve based on Fig. 1.

PLATE 33

Fig. 1

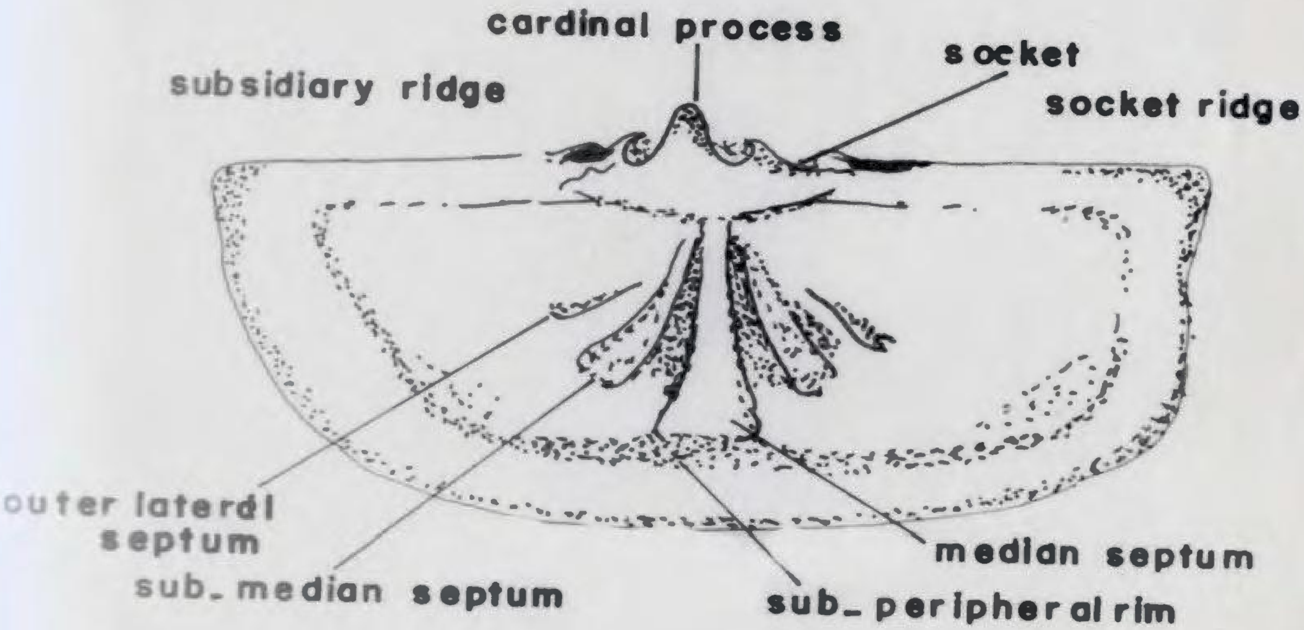


Fig. 2

Plate 34

Fig. 1 <u>Sowerbyites</u> aff. <u>S. lamellosus</u> Cooper, 1956

Collected from the LeRoy Member of the Long Point Formation, two miles southwest of Black Duck Brook village on the eastern side of Long Point.

Exfoliated pedicle valve showing greatest convexity at about the two thirds of the shell. The larger costellae are distinct and have finer costellae between them. The fine costellae can still be distinguished posterolaterally near the right cardinal extremity. ZMS 031; X5.

Fig. 2 <u>Dictyonema flabelliforme</u> (Eichwald) 1840

Collected from the Green Point Formation about two miles northeast of Tea Cove on the eastern side of Long Point.

Parts of several rhabdosomes having a fan-shaped appearance. Note the parallel, wrinkled stipes and transverse dissepiments. ZMS 032; X 5.

PLATE 34

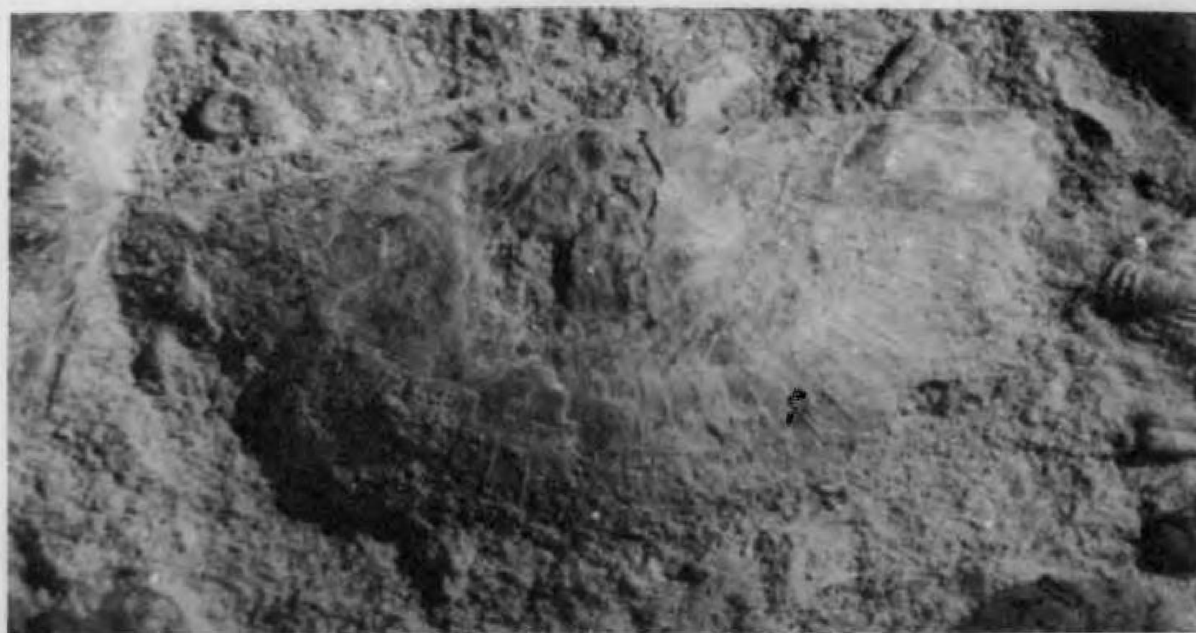


Fig. 1

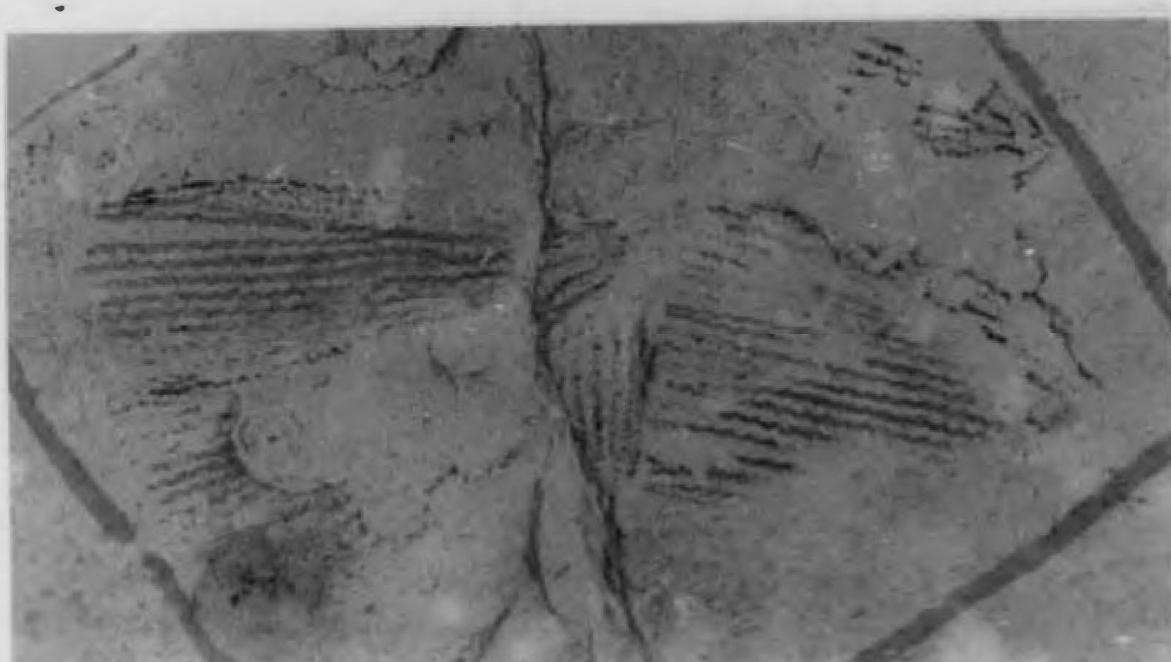


Fig. 2

Plate 35

Figs. 1-2 <u>Climacograptus</u> aff. <u>C. inuiti similis</u> Wilson, 1948

Collected from the Misty Point Member of the Long Point Formation at the northernmost corner of Clam Bank Cove.

Fig. 1 Outline of specimen ZMS 033; X 50.

Fig. 2 Diplograptid type of development illustrated by <u>C. inuiti similis</u>. ZMS 033; X 50.

Fig. 3 <u>Staurograptus dichotomus</u> Emmons, 1855

Collected from the Green Point Formation two miles northeast of Tea Cove.

Nearly complete rhabdosome showing quadriradiate branching, developed by dichotomous division to the 4th order from 4 primary branches. ZMS 034; X 50.

PLATE 35

Fig. 1

Fig. 2

Fig. 3

Chapter 6

STRATIGRAPHY AND CORRELATION

Stratigraphy

The Port au Port Peninsula, a part of the Western Platform of the Appalachian Orogenic Belt in Newfoundland (Kay, 1966), is underlain by an autochthonous sequence of Cambrian and Ordovician sandstones and carbonate rocks. This is mantled by an allochthonous, folded, clastic sequence of red and green sandstones and argillites, belonging to the Humber Arm Group (Cumming, 1967). The Humber Arm Group is considered to be a klippe by Rodgers and Neale (1963). This allochthonous sequence is, in turn, overlain unconformably by rocks of the Long Point Formation.

The Long Point Formation includes fossiliferous limestones, sandstones and shales. The lower two members of the formation, the Tea Cove and Shore Point Members, consist largely of sandstones. The sandy nature of these members, the unconformable contact between the Tea Cove Member and the underlying Humber Arm Group and the presence of cross-lamination and mud-cracks in the Shore Point Member indicate (according to the criteria of Dapples, 1947) that shallow marine platformal conditions existed at the time of their deposition. Unconformity indicates that the sea encroached on the land and cross-lamination shows that currents typical of platformal deposition cross-laminated the accumulating sands. The mud-cracks in the Shore Point Member resulted from temporary withdrawels of the sea from the area which left the water-filled sediments exposed to the atmosphere thus resulting in their desication and the development of a polygonal pattern of cracks. Sedimentation began again when the sea readvanced over the exposed area and fine sandy material was then deposited in the mud-cracks.

The Shore Point Member is succeeded by the more calcareous Portage Member consisting of nodular limestones interbedded with shales. The calcareous sediment, containing much organic debris, and the muds from which this alternation of rock types originated were, most likely, deposited offshore beyond sandy littoral sediments. The latter are represented in the underlying Shore Point Member, within which sandstones are a conspicuous element, but are not present in the Portage Member, and their absence is attributed to the recession of the shore-line that accompanied continuing transgression of the sea during the time that the sediments of the Portage Member were being laid down. Further transgression led to a reduction in the amount of terrigenous material reaching the area and the almost clear waters then provided a suitable environment for benthonic animals and calcareous algae. The remains of these organisms accumulated as calcareous sediments that eventually became the fossiliferous limestones of the Black Duck Member, which conformably overlie the shale-limestone sequence of the Portage Member.

The limestones of the Black Duck Member are characterized by an abundance of the coralla of the tabulate coral _Labyrinthites_. Wherever the corals grew in close association they built up small columnar reefs. Their columnar form indicates that sea level was rising because if sea level had been stationary, the corals would have grown laterally rather than upwards.

Corals grow upwards in order to remain close to sea level where the agitated surface water is well oxygenated and sediment-free, two of the environmental conditions necessary for their growth. Reef corals only grow in warm water and crinoids and other benthonic organisms like bryozoa also grow best in warm waters so that it seems likely that tropical conditions existed in the area that is now western Newfoundland at the time that the Long Point Formation was being laid down. Newfoundland must, therefore, in Middle Ordovician times, have lain close to the equator. This view receives support from the findings of Fell (1968) who investigated the global distribution of Ordovician invertebrates. He recognized two major faunal provinces for the Ordovician, one comprises Europe, Africa and South America and the other includes North America. After these provinces are plotted on a globe, it is found that they form two symmetrically disposed belts around the earth (Plate 36) that are bounded by small circles and disposed on either side of a great circle inclined at an angle of about 70° of arc to the plane of the existing equator. They are in fact, the northern and southern hemispheres of the Ordovician earth and the great circle is the Ordovician equator. The poles were, therefore, displaced by an angle of 70° from their present positions, the north pole lying in the Pacific, west of Hawaii, and the south in the Atlantic, off southwest Africa. Thus during ~~the~~ Ordovician time when warm tropical conditions were prevailing, the miogeosyncline associated with the Appalachian geosyncline provided the required water conditions and islets for a system of reefs supporting an associated

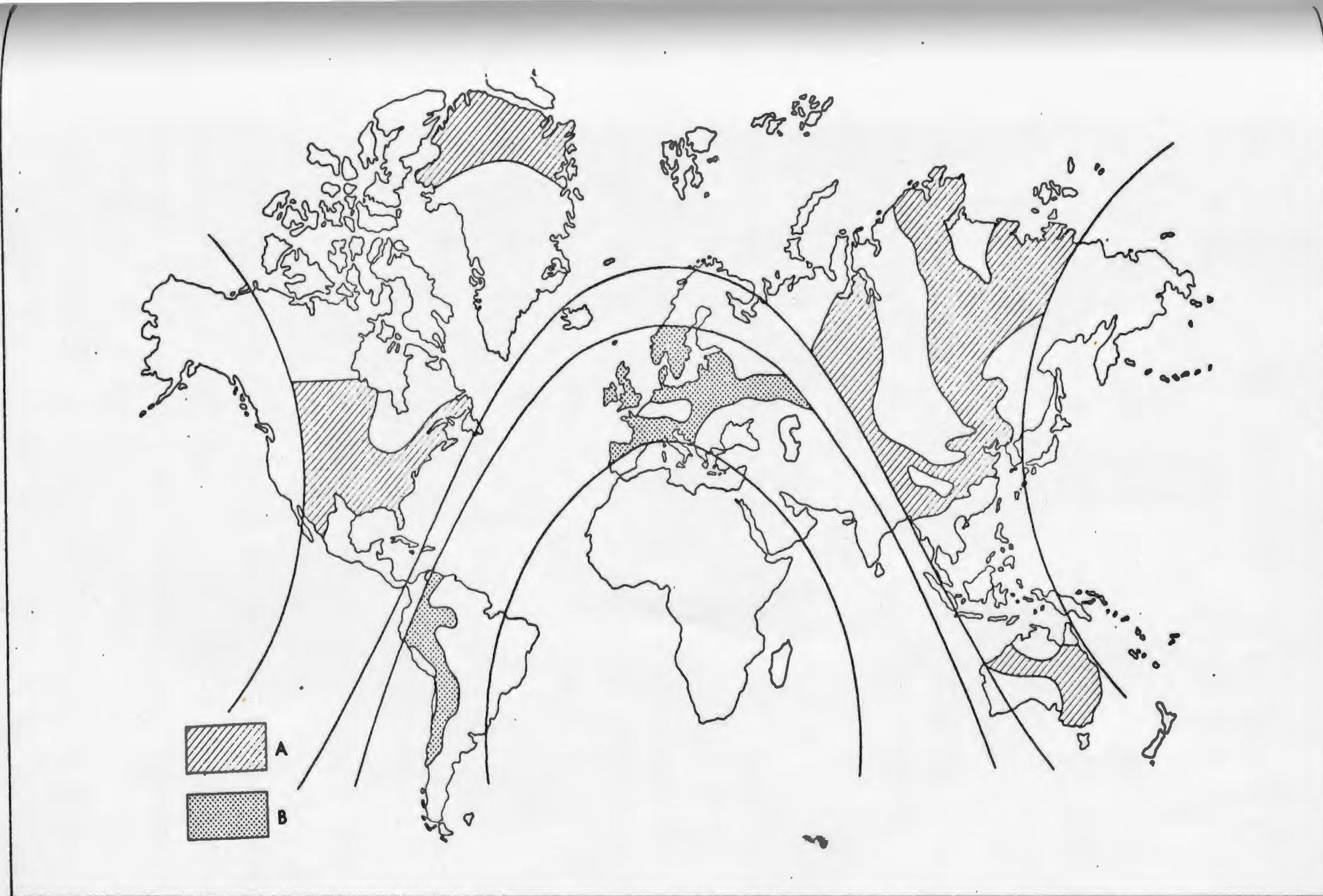


PLATE 36 Broad pattern of distribution of Ordovician faunas : A, northern hemisphere assemblage; B, southern hemisphere assemblage (<u>From</u> Fell, 1968)

fauna, and the present northeast-southwest orientation of the geosyncline is seen to conform closely to the equatorial zone (Fell, 1968).

Although Fell (1968) recognized Newfoundland as lying close to the equator he makes no mention of its Ordovician fauna which clearly belongs with his northwestern tropical region.

Deposition of the Black Duck Member was brought to a close by a temporary regression of the sea which exposed the reef building corals, thus killing them and bringing reef development to an end. The exposed sediments suffered some erosion before the sea once more transgressed over the area and sedimentation was resumed. The LeRoy Member, which thus disconformably overlies the Black Duck Member, consists of limestones interbedded with shales. It is succeeded conformably by the more calcareous Beach Point Member. The LeRoy and Beach Point Members resemble the Portage Member and Black Duck Members respectively and this resemblance is probably due to their having been laid down under somewhat similar environmental conditions although they were apparently unsuitable for the development of reef forming corals as they are absent in these members.

The Misty Cove Member, which is the topmost member of the Long Point Formation, is made up of shales, calcareous sandstones and some thin beds of limestones. Towards the top of the member the sandy and shaly beds become ferruginous and their colour changes from grey or green to purple. The main part of the Misty Cove Member was deposited under deeper water conditions than in the underlying members as the rhabdosomes of the graptolites Climacograptus are abundantly preserved in the beds of this member. The much greater thickness of this member and the dominantly clastic nature of the sequence show that much more clastic debris ~~sediment~~ was reaching the area than hitherto and that the sea floor must have been gradually subsiding in order to accommodate this mass of sediment. The increase in the amount of sediment probably resulted from an isostatic rise of the land area from which the sediment was being derived. This uplift eventually led to such rapid erosion and deposition that red sands and muds were laid down. These are the red sandstones and shales of the uppermost part of the Misty Cove Member. The environment of deposition was still marine as these sandstones contain the remains of brachiopods and other marine organisms.

The Misty Cove Member is succeeded at the northern and southern end of Clam Bank Cove by the red beds of the Clam Bank Formation which were not included in the present study. The relationship between the Long Point Formation and the overlying Clam Bank Formation is unknown because the critical sections are concealed at both ends of Clam Bank Cove and at Salmon Cove, near Three Rock Point.

<u>Correlation</u>

The Long Point Formation of the Port au Port area has been extensively studied stratigraphically since Schuchert and Dunbar (1934) first assigned it its name, but the fossils present have received little attention apart from the brachiopods which were studied by Cooper (1956). In the course of the present study a large number of fossils were collected. These include bryozoans, brachiopods, nautiloids, gastropods, graptolites and trilobites.

The trilobites are not as prolific in genera, in species or apparently in number of specimens as the bryozoans or brachiopods but nonetheless they are an important element of the fauna. Apart from one specimen of illaenid found in the Black Duck Member, all the other trilobites were collected from the overlying LeRoy Member. Most of the Long Point Formation trilobites have an affinity with species found in the Ottawa Formation of the Ottawa-St. Lawrence Lowland.

Two specimens of illaenid were collected from the Long Point Formation, one is related to Illaenus ~~I.~~ lacertus known to occur in Silliman's Fossil Mount (Baffin Island), which is regarded as earliest Upper Ordovician in age (Whittington, 1954), and the other is related to I.alveatus from the Middle Ordovician rocks of the Table Head Group (Whittington, 1965). Elsewhere illaenids are widely recorded from the Caradocian and Ashgillian of North America, Britain, Balto-Scandia, the Siberian platform, eastern Taimyre and northeastern U.S.S.R. (Whittington, 1966). Isotelus collected from the Long Point Formation appears to be closely related to I.gigas from the Hull and Sherman Fall beds of the Ottawa Formation of the Ottawa-St. Lawrence Lowland. The Hull and Sherman Fall members of the Ottawa Formation are regarded as Black River to Trenton in age. Elsewhere Isotelus is known to occur in the Caradoc rocks of North America, Scotland, and U.S.S.R. The two forms of Encrinurus are related to E.trentonensis and E. cybeleformis respectively known from the Leray, Rockland, Sherman Fall and Cobourg beds of the Ottawa Formation (Wilson, 1947). Elsewhere Encrinurus is represented in Britain, Balto-Scandia, North America and ranges from Caradocian to Ashgillian in age (Porterfield to Richmond, including the Black River and Trenton groups and the Cincinnatian of North America, Whittington, 1966). Sphaerocoryphae is fairly common in the LeRoy Member of the Long Point Formation. It is related to S.robusta which is reported from the Sherman Fall beds of the Ottawa Formation. Sphaerocoryphae is also recorded from North America, Scotland and Balto-Scandia ranging from Llanvirn-Llandeilo through Caradoc-Ashgill. Uromystrum is related to U. validum from the Middle Ordovician rocks of the Table Head Group of western Newfoundland. It is also known to occur in the early Caradocian of North America, Greenland and the U.S.S.R. Calyptaulax is the commonest trilobite in the Long Point Formation and it is related to C.incepta from the Middle Ordovician rocks of the Table Head Group of western Newfoundland. It is the most characteristic Caradoc-Ashgill trilobite of North America, the Siberian platform, northeastern U.S.S.R., Balto-Scandia and Britain.

The trilobite assemblage from the Long Point Formation is thus most like that of the Ottawa Formation of the Ottawa-St. Lawrence Lowland, and its age is, therefore, probably between late Middle Ordovician (Trentonian) and early Upper Ordovician (Cincinnatian).

The geographic distribution of the trilobites of the Long Point Formation fauna clearly places the assemblage in the northern region of geographical distribution of trilobites described by Whittington (1966). This includes North America, the Arctic Islands, Greenland, western Ireland, Scotland, Spitzbergen, Baltic-Scandia (including Norway, Sweden and Baltic regions) and U.S.S.R.

The Ordovician bryozoan assemblage of the Long Point Formation includes species of the following genera: _Pachidictya_, _Stictopora_ _Goldfussitrypa_, _Amplexopora_, _Calopora_, _Monotrypella_, _Batostoma_, _Hemiphragma_, _Diplotrypa_ and _Atactotoechus_. _Batostoma_, _Hemiphragma_, and _Amplexopora_ are especially abundant in the Black Duck Member.

This assemblage of bryozoa is similar in generic composition to the assemblages present in the Ottawa Formation of the Ottawa-St. Lawrence Lowland (Fritz, 1957) and the Cape Calhoun Formation of northern Greenland (Troedsson, 1928). _Batostoma_, _Hemiphragma_ and _Amplexopora_ are also common in these assemblages.

The presence of _Stictopora_, _Batostoma_ and _Amplexopora_ in the Long Point Formation suggests a possible correlation with the Middle to Upper Ordovician (upper Wilderness to lower Barneveld Stages) of the Gordon Limestone of Tasmania (Ross, 1961b) and an affinity with the bryozoan fauna of North America and the Baltic Provinces (Bassler, 1911).

Atactotoechus, _Calopora_ and _Stictopora_ from the Long Point Formation have been related to _A. kayi_, known to occur in the Chazyan (Ordovician) of New York State and Vermont, _C. dumalis_ belonging to the upper part of the Denmark Formation or the lower part of Cobourg Formation that shows an age of Trenton, and _S.nicholsoni_ respectively, the last named being from the Tyrone Formation (Trenton) of New York.

The specimens of _Batostoma_ and _Hemiphragma_ collected from the Black Duck Member may be compared with the Ottawa Formation species, _B. winchelli_ and _H. crenulatum_. These species occur in the Sherman

Fall and the Cobourg beds of the Ottawa Formation which is regarded as Black River to Trenton (upper Wilderness to lower Barnevold Stages). Similarly Amplexopora, which is fairly common in the Black Duck Member, has the characteristics of A. evensis from the Caradoc Series of Shropshire that is equated with the lower part of the Barneveld Stages. Goldfussitrypa in the Black Duck Member is like G. esthonia from the Ordovician of the Baltic Provinces. The specimens of Pachidictya and Monotrypella have been related respectively to P. ambigua, from Ellis Bay Formation of Anticosti Island (Upper Ordovician), and to M. aequalis of the Ordovician rocks of Kentucky.

The colonies of Labyrinthites chidlensis, which form small columnar reefs in the Black Duck Member of the Long Point Formation, are identical to the colonies found in the Lake Manicouagan area of central Quebec, the Canadian Arctic Archipelago and the rocks of north-west Greenland (Bolton, 1965). Wherever these colonies have been found they are associated with the gastropods Maclurites and with the nautiloid Gonioceras and this association has been described by Bolton (1965) as diagnostic of the Wilderness Stage of the Middle Ordovician. Elsewhere it is found in Middle and Upper (?) Ordovician rocks of Great Bear Lake, Alaska, and in the upper Ordovician rocks of Tuva, U.S.S.R., (Bolton, 1965).

The solitary coral Lambeophyllum is related to L. profundum which is known from the Leray-Rockland beds of the Ottawa Formation of the Ottawa-St. Lawrence Lowland.

Gonioceras, *Spyroceras*, *Orthoceras* and *Endoceras* are very common nautiloids in the Black Duck Member of the Long Point Formation. They have been related to species indicative of an age corresponding to the upper Wilderness to lower Barneveld Stages. *G.anceps*, *G.occidentale* and *S.arcuoliratum* are known from the Leray-Rockland beds of the Ottawa Formation of the Ottawa-St.Lawrence Lowland, while *O.regulare* is common in the Middle Ordovician rocks of North America, Sweden and the U.S.S.R. (Sweet *in* Moore, 1964). *Endoceras proteiforme* has been reported from the Middle to Upper Ordovician rocks of North America, U.S.S.R. and East Asia (Furnish and Glenister *in* Moore, 1964).

Climacograptus from the Misty Cove Member of the Long Point Formation has been related to *C.inuiti similis* of the Cobourg beds of the Ottawa Formation of the Ottawa-St.Lawrence Lowland.

The assemblage of Ordovician fossils found in the Long Point Formation is part of a general fauna that seems to be of unusually widespread occurrence in the northern hemisphere. It is perhaps best known from the Ottawa Formation of the Ottawa-St.Lawrence Lowland, the Cape Calhoun Formation of northwestern Greenland and equivalent strata in other parts of North America and it is regarded as ranging from upper Middle Ordovician to lower Upper Ordovician (upper Wilderness to upper Barneveld Stages).

BIBLIOGRAPHY

Bassler, R.S., 1911, The Early Paleozoic Bryozoa of the Baltic Provinces: U.S. Nat. Mus. Bull. 77.

Billings, E., 1859, Descriptions of some new species of trilobites from the Lower and Middle Silurian rocks of Canada: Canadian Naturalist (Ottawa), 4, 301-324.

________., 1865, Paleozoic fossils, Geol. Surv. Can. 1, 180-181.

________., 1881, in Murray, A. and Howley, J.P. Geol. Surv. of Newfoundland. See under Murray on page 163.

Boardman, R.S., 1960, Trepostomatous Bryozoa of the Hamilton Group of New York State, Prof. Pap. U.S. Geol. Surv. 4, 301-324.

Bolton, T.E., 1965, Contributions to Canadian Paleontology Part II: Geol. Surv. Can., Bull. 134, 15-24.

Brueckner, W.D., 1966, Stratigraphy and structure of west-central Newfoundland, in Geology of Parts of Atlantic Provinces: Geol. Assoc. Can. and Mineral Assoc. Can., Guidebook 137-151.

Bulman, O.M.B., 1955, in Treatise on Invertebrate Paleontology, Part V, Graptolithina: Kansas Univ. Press.

Cooper, G.A., 1956, Chazyan and Related Brachiopods: Smithson. Misc. Coll., 127, pts. 1 & 2.

Cumming, L.M., 1967, Platform and Klippe Tectonics of western Newfoundland: a review: R. Soc. Can. Special Publication, 10, 10-17.

Dapples, E.C., 1947, Sandstone types and Their Associated Depositional Environments: Jour. of Sed. Pet., 17 No. 3, 91-100.

Dekay, J.E., 1924, Observations on the stratigraphy of trilobites and description of an apparently new genus: Lyceum Natur. Hist. New York, Ann., 1, 174-189.

Duncan, H., 1956, Ordovician and Silurian coral faunas of western United States: U.S. Geol. Surv., Bull. 1021-F.

Emmons, R., Jr., 1855, American Geology, 1, 109.

Fritz, M.A., 1957, Bryozoa (mainly Trypostomata) from the Ottawa Formation (Middle Ordovician) of the Ottawa-St. Lawrence Lowland: Geol. Surv. Can., Bull. 42, 2-75.

__________, 1966, A new Bryozoan species from the Long Point Formation (Ordovician), Western Newfoundland: J. Paleont. 40, 1335-1337.

Furnish, W.M., and Glenister, B.F., 1964, Paleoecology in Treatise on Invertebrate Paleontology, Part K, Mollusca: Kansas Univ. Press.

Hall, J., 1847, Descriptions of the organic remains of the lower divisions of the New York system: N.Y. Geol. Paleont. New York, 1, 338.

__________, 1861, Report of the superintendent of the (Wisconsin) Geological Survey, exhibiting the progress of the work, January 1, 1861 (including descriptions of new species of fossils from the investigations of the Survey): 52, (Madison).

Hamada, T., 1957, On the classification of Halysitidae, 1 and 11: Jour. Fac. Sci., Univ. Tokyo, sec. 2, 10, 393-430.

Hill, D., and Stumm, E.C., 1956, in Treatise on Invertebrate Paleontology, Part F, Coelenterata: Kan. Univ. Press. F444-F477.

Howley, J.P., 1881-1909, Annual report: Geol. Surv. Newfoundland Map published, 1907; republished, 1919 and 1925.

Jukes, J.B., 1842, General Report of the Geological Survey of Newfoundland, 1839-1840: London, England, John Murray, 1 & 11.

Kay, M., 1966, Newfoundland structures and continental drift: Bull. Canadian Petroleum Geology, 14, 613-620.

__________, 1969, Long Point Formation and Taconian Orogony in western Newfoundland: Geol. Soc. Amer., Abs. Annual Meetings, Atlantic City, N.J., pt. 7, 120.

__________, and Colbert, E.H., 1965, Stratigraphy and life history: New York, John Wiley.

Knight, J.B. and Bridge, J., 1944, in Shimer, H.W. and Shrock, R.R., Index fossils of North America, New York, 1-837.

Loeblich, A.R., Jr., 1942, Bryozoa from the Ordovician Bromide Formation, Oklahoma, J. Paleont. , 16, No. 4, 413-436.

Lambe, L.M., 1906, Notes on the fossil corals collected by Mr. A.P. Low at Beechy Island, Southampton Island, and Cape Chidley in 1904: Rept. (Can.) Dom. Govt. Exped. to Hudson Bay and Arctic Islands on board D.G.S. Neptune, 1903-04, App. 4, 322-328.

Logan, W.E., 1863, Geology of Canada: Geol. Survey Canada Rept. Prog. to 1863, 983.

Moore, R.C., 1953, (Editor), Treatise on Invertebrate Paleontology Part G, Bryozoa: Kansas Univ. Press.

__________, 1955, (Editor), Treatise on Invertebrate Paleontology, Part V, Graptolithina: Kansas Univ. Press.

__________, 1956, (Editor), Treatise on Invertebrate Paleontology, Part F, Coelentrata: Kansas Univ. Press.

__________, 1959, (Editor), Treatise on Invertebrate Paleontology, Part O: Kansas Univ. Press.

__________, 1960, (Editor), Treatise on Invertebrate Paleontology, Part 1, Mollusca 1; Kansas Univ. Press.

__________, 1964, (Editor), Treatise on Invertebrate Paleontology, Part K, Mollusca 3: Kansas Univ. Press.

__________, 1965, (Editor), Treatise on Invertebrate Paleontology, Part H, Brachiopoda: Kansas Univ. Press.

Miller, A.K., Youngquist, S.W., and Collinson, C. 1954, Ordovician cephalopod fauna of Baffin Island: Geol. Soc. Amer. Mem. 62, 1-118.

Murray, A., and Howley, J.P., 1881, Geological Survey of Newfoundland (revised reprints of reports, 1864-1880) 342-394.

Phillips, J.R.P., 1960, Restudy of types of seven Ordovician bifoliate bryozoa: Palaeontology, 3, Part 1, 1-25.

__________, 1962, Chazyan (Ordovician) Leptotrypellid and Atactotoechid bryozoa: Palaeontology, 5, Part 4, 727-39.

__________, 1965, Homotrypa and Amplexopora? from the Caradoc Series, Shropshire: Palaeontology, 8, Part 1, 5-10.

Raymond, P.E., 1925, Some trilobites of the Lower Middle Ordovician of eastern North America: Harvard Univ., Mus. Comp. Zoology (Cambridge), Bull. 67, 3-180.

Riley, G.C., 1962, Stephenville map-area, Newfoundland: Geol. Surv. Can., Mem. 323, 1-57.

Rodgers, J., 1965, Long Point and Clam Bank Formations, western Newfoundland: Proc. Geol. Assoc. Can., 16, 83-94.

__________, and Neale, E.R.W., 1963, Possible "Taconic" klippen in western Newfoundland: Am. J. Sci., 261: 730.

Ross, J.P., 1961a, Larger cryptostome Bryozoa of the Ordovician and Silurian, Anticosti Island, Canada-Part II: J. Paleont., 35, No. 2, 331-344.

__________, 1961b, Ordovician, Silurian, and Devonian Bryozoa of Australia: Commonwealth of Australia, Dept. of National Development, Bureau of Mineral Resources, Geology and Geophysics, Bull. No. 50.

__________, 1969, Champlainian (Ordovician) Ectoprocta (Bryozoa) New York State, J. Paleont. 43, No. 2, 257-284.

Schuchert, C., and Dunbar, C.O., 1934, Stratigraphy of western Newfoundland: Geol. Soc. Am., Mem. 1.

Shimer, H.W., and Shrock, R.R., 1944, Index fossils of North America: John Wiley & Sons.

Sokolov, B.S., 1955, Tabulata of the Paleozoic period of the European U.S.S.R. General problems of Classification and history of the development of Tabulata (with characteristics of morphologically close groups), 85, 1-524.

Sullivan, J.W., (ms. 1940), The Geology and Mineral Resources of the Port au Port Peninsula, Newfoundland: Ph.D. thesis (unpublished), Yale University.

Sweet, W.C., 1964, in Treatise on Invertebrate Paleontology, Part K, Mollusca 3: Kansas Univ. Press, K216-K242.

Teichert, C., 1937, Ordovician and Silurian faunas from Arctic Canada: Fifth Thule Exped., 1921-1924 Rept., 1, No. 5, 169.

Troedsson, G.T., 1928, On the Middle and Upper Ordovician Faunas of Northern Greenland. Part II: Medd. om Grønland, 72, No. 1, 1-197.

__________, 1937, On the Cambro-Ordovician faunas of western Quruq tagh, eastern T'ien-shan: Palaeontologica Sinica, new ser. B, No. 2, 74.

Troelsen, J.C., 1950, Contribution to the geology of Northern Greenland, Ellesmere Island and Axel Heiberg Island, Med. om. Grønland, 149, No. 7.

Ulrich, E.O., 1882, American Paleozoic Bryozoa: Cincinnati Soc. Nat. Jour., 5, 121-175, 232-257.

__________, 1893, On Lower Silurian (Ordovician) Bryozoa of Minnesota: Minn. Geol. Surv., 3, 96-332.

Weerasinghe, A., 1970, Stratigraphy and Paleontology of the Ordovician Long Point Formation: unpublished M.Sc. thesis, Memorial University of Newfoundland.

Whittington, H.B., 1953, North American Bathyuridae and Leiostegiidae. (Trilobita): J. Paleont. (Tulsa) 27, 647-678.

__________, 1954, Ordovician trilobites from Silliman's Fossil Mount: Geol. Soc. Amer., Mem. 12, 119-149.

__________, 1965, Trilobites of the Ordovician Table Head Formation, western Newfoundland: Bull. Mus. Comp. Zool., Harvard Univ., 132, No. 4.

__________, 1966, Presidential Address-Phylogeny and Distribution of Ordovician Trilobites: J. Paleont. 40, No. 3, 696-737.

Williams, H., 1964, The Appalachians in northeastern Newfoundland —— A two-sided symmetrical system: Amer. Jour. Sci., 262, 1173-1158.

__________, 1969, Pre-Carboniferous development of Newfoundland Appalachians: Amer. Assoc. Petrol. Geol., Mem. 12, 45-46.

Wilson, A.E., 1947, Trilobita of the Ottawa Formation of the Ottawa-St. Lawrence Lowland: Geol. Surv. Can., Bull. 9, 1-45.

__________, 1948, Miscellaneous Classes of Fossils, Ottawa Formation, Ottawa-St. Lawrence Lowland Valley: Geol. Surv. Can. Bull. 11, 32-50.

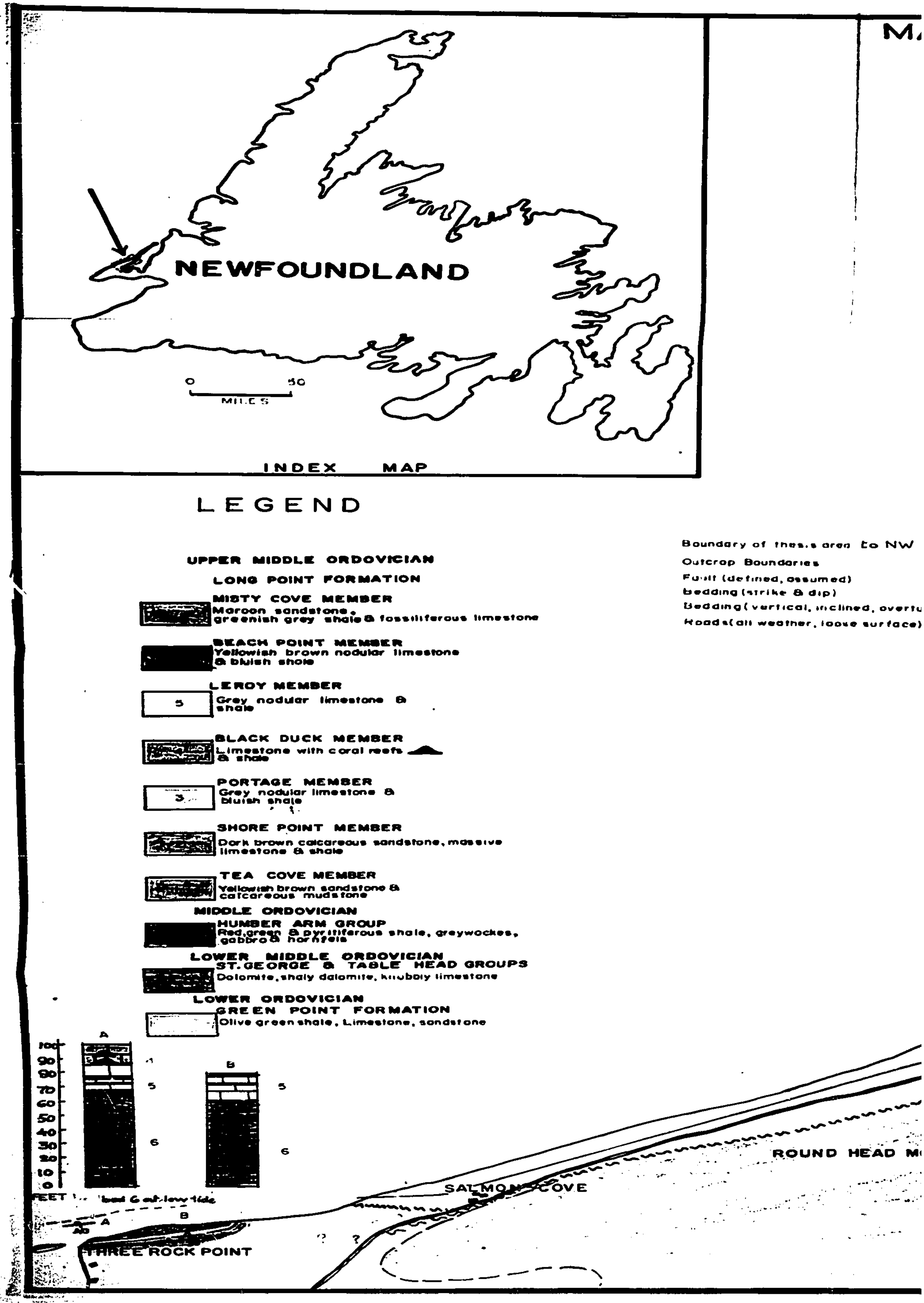
__________, 1961, Cephalopoda of the Ottawa Formation of the Ottawa-St. Lawrence Lowland, Geol. Surv. Can., Bull. 67, 60-62.

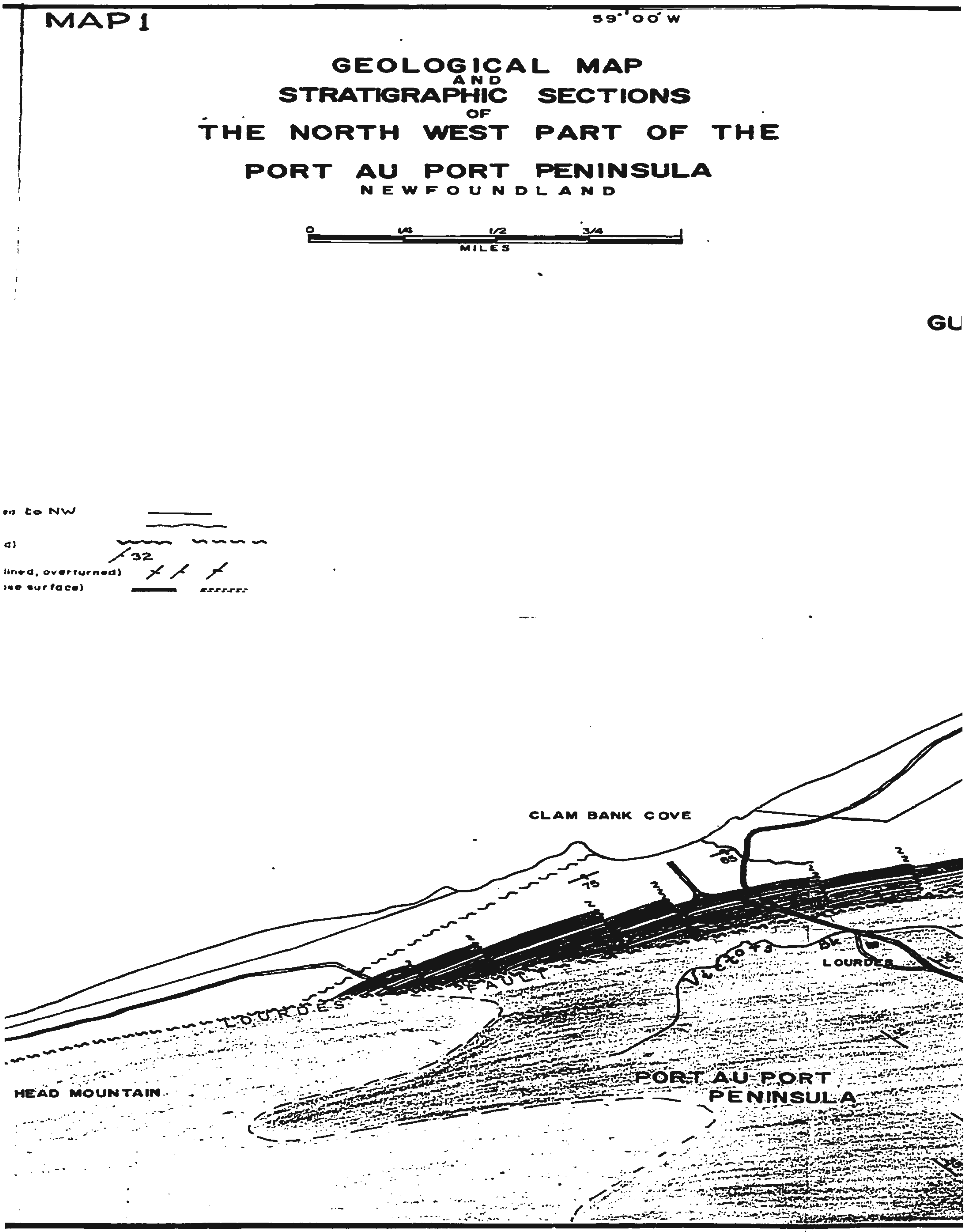
__________, 1964, Brachiopoda of the Ottawa Formation of the Ottawa-St. Lawrence Lowland, Geol. Surv. Can., Bull. 8.

Whiteaves, J.F. 1890, Descriptions of eight new species of Fossils from the Cambro-Silurian rocks of Manitoba, R. Soc. Can., Tr., 7, sec, 4, 75-83.

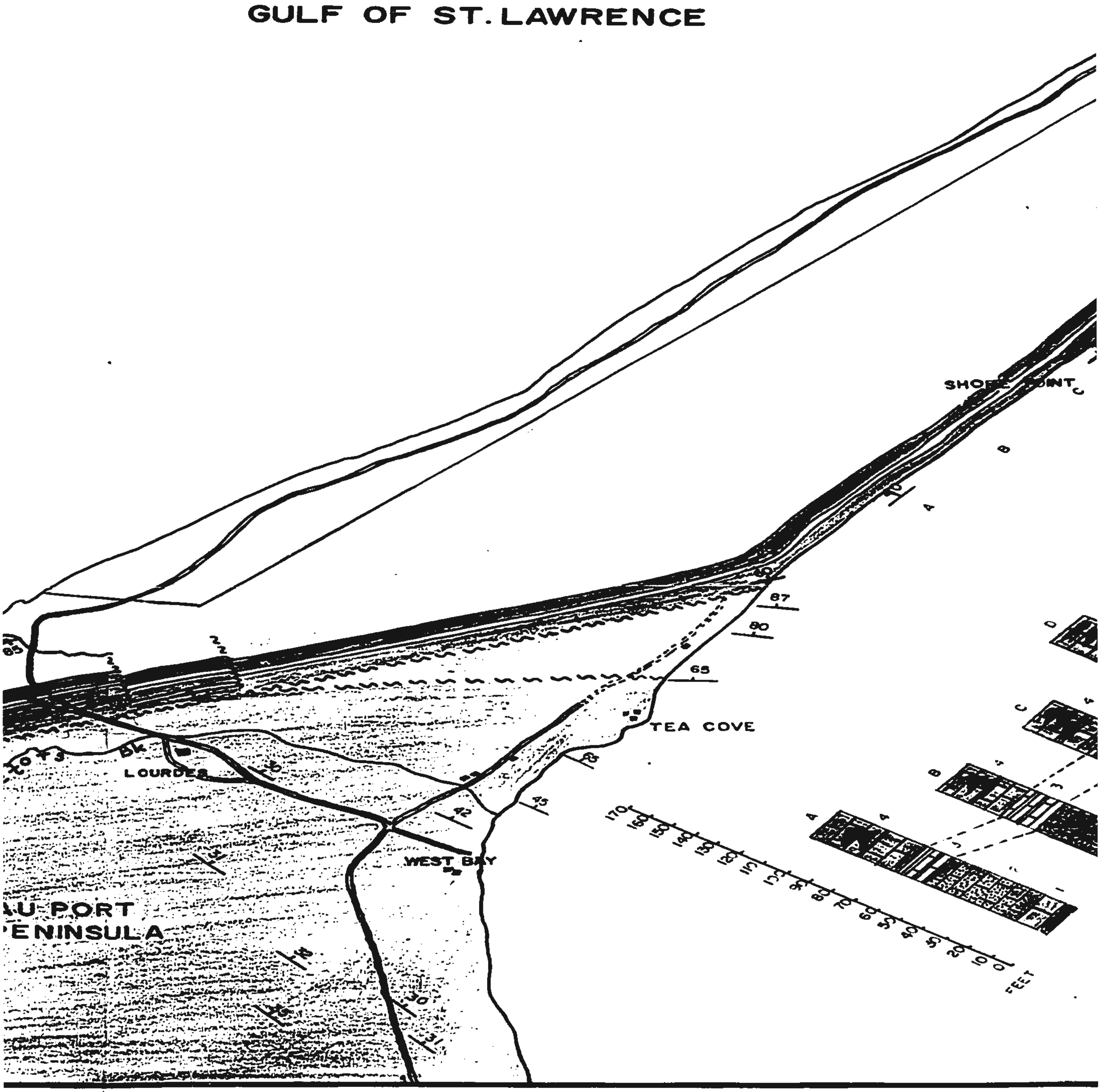
ADDENDUM

Fell, H.B., 1968, The Biogeography and Paleoecology of Ordovician Seas, in Evolution and Environment, edited by Ellen T. Drake, New Haven and London, Yale University Press.

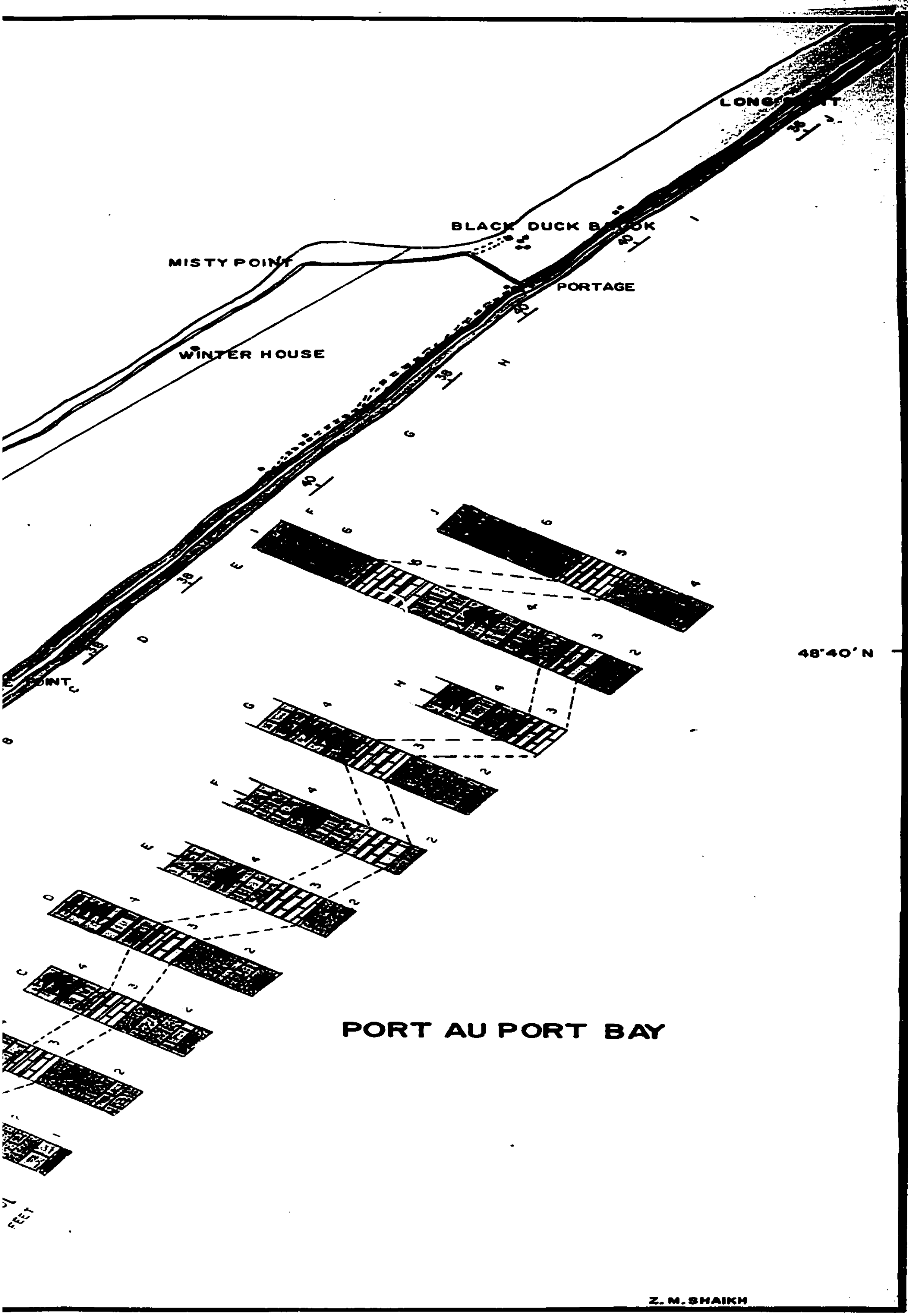

MA
NEWFOUNDLAND
0
50
MILES
INDEX MAP
LEGEND
UPPER MIDDLE ORDOVICIAN
LONG POINT FORMATION
MISTY COVE MEMBER
Maroon sandstone, greenish grey shale & fossiliferous limestone
BEACH POINT MEMBER
Yellowish brown nodular limestone & bluish shale
LEROY MEMBER
5
Grey nodular limestone & shale
BLACK DUCK MEMBER
Limestone with coral reefs & shale
PORTAGE MEMBER
3
Grey nodular limestone & bluish shale
SHORE POINT MEMBER
Dark brown calcareous sandstone, massive limestone & shale
TEA COVE MEMBER
Yellowish brown sandstone & calcareous mudstone
MIDDLE ORDOVICIAN
HUMBER ARM GROUP
Red, green & pyritiferous shale, greywockes, gabbro & hornfels
LOWER MIDDLE ORDOVICIAN
ST. GEORGE & TABLE HEAD GROUPS
Dolomite, shaly dolomite, knobbly limestone
LOWER ORDOVICIAN
GREEN POINT FORMATION
Olive green shale, Limestone, sandstone
Boundary of thesis area to NW
Outcrop Boundaries
Fault (defined, assumed)
Bedding (strike & dip)
Bedding (vertical, inclined, overtu
Roads (all weather, loose surface)
A
B
100
90
80
70
60
50
40
30
20
10
0
FEET
5
6
ROUND HEAD M
SALMON COVE
THREE ROCK POINT


MAP I
59° 00' W
GEOLOGICAL MAP
AND
STRATIGRAPHIC SECTIONS
OF
THE NORTH WEST PART OF THE
PORT AU PORT PENINSULA
NEWFOUNDLAND
0
1/4
1/2
3/4
MILES
GU
to NW
32
lined, overturned)
CLAM BANK COVE
85
75
LOURDES
FAULT
LOURDES
HEAD MOUNTAIN
PORT AU PORT
PENINSULA

THE



GULF OF ST. LAWRENCE
TEA COVE
LOURDES
WEST BAY
AU PORT
PENINSULA
FEET


LONG POINT
BLACK DUCK BROOK
MISTY POINT
PORTAGE
WINTER HOUSE
48°40′ N
PORT AU PORT BAY
Z. M. SHAIKH