STRATIGRAPHY AND PALAEONTOLOGY OF THE ORDOVICIAN LONG POINT FORMATION, PORT AU PORT PENINSULA NEWFOUNDLAND

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BY

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A Thesis

submitted in partial fulfillment of the
requirements for the degree of
MASTER OF SCIENCE

MEMORIAL UNIVERSITY OF NEWFOUNDLAND

1970

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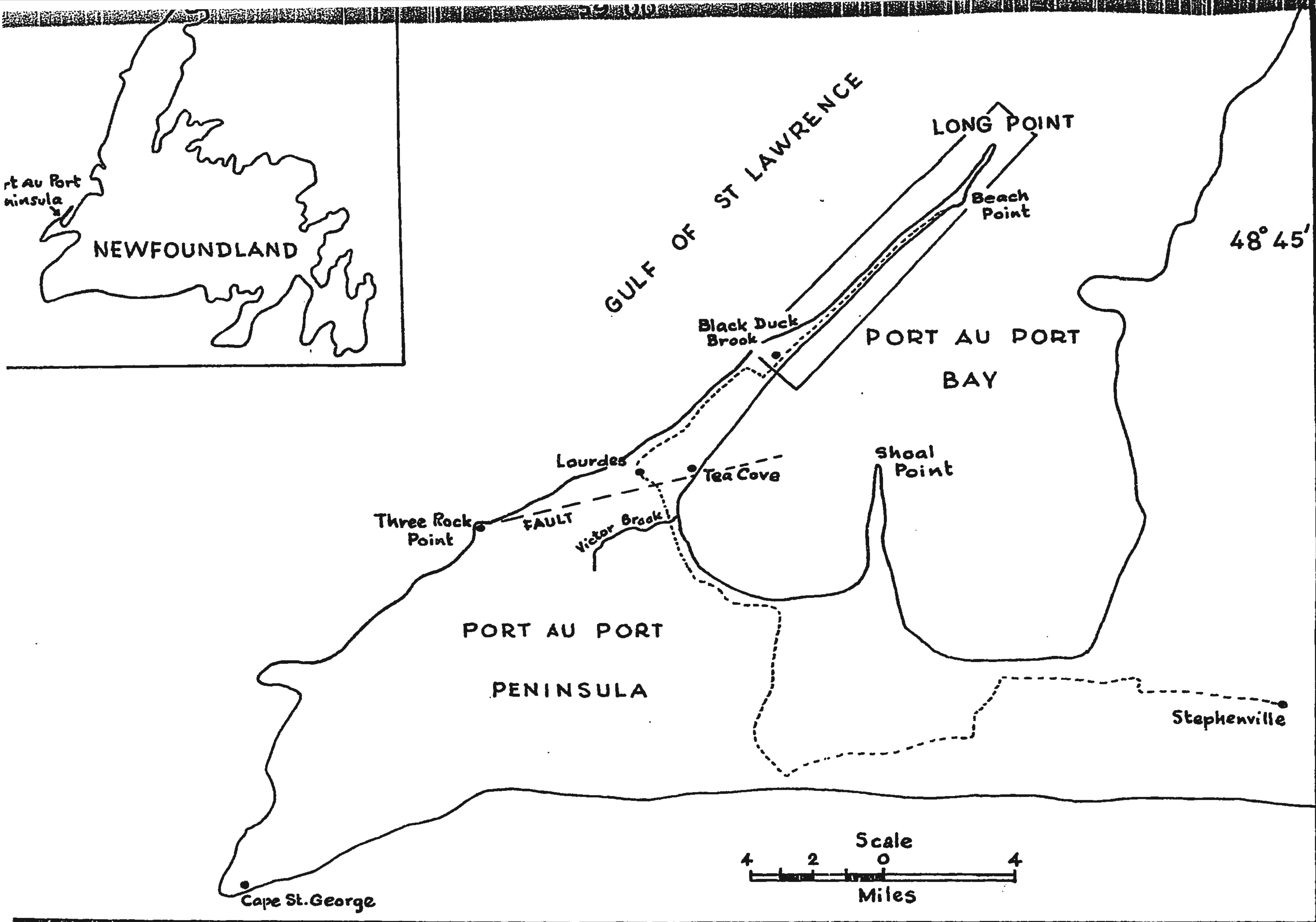


Fig. 1 Map of Port au Port Peninsula
Showing the thesis area within the rectangle and inset showing its relationship with the rest of Newfoundland.

ABSTRACT

The Long Point Formation is present in the north-western part of the Port au Port Peninsula, western Newfoundland. It derives its name from Long Point, a northeastward dagger-like extension of the Peninsula fourteen miles in length. The Formation consists of fossiliferous limestones, sandstones and shales that are well exposed in the coastal cliffs on both sides of Long Point. This thesis presents the results of a study of the stratigraphy and palaeontology of the strata underlying the northern half of Long Point.

On Long Point, beds of the Long Point Formation strike north-east and dip towards the northwest; the dip decreases from 54 degrees at the southern end of the thesis area to less than 10 degrees at the northern end. The beds are little disturbed by the few minor faults present.

The Long Point Formation has been divided by the writer and two other graduate students from Memorial University working in adjoining areas into eight members, the names of which are taken from their type localities. The members from oldest to youngest are: Tea Cove, Shorepoint, Portage, <u>Black Duck</u>, <u>LeRoy</u>, <u>Beachpoint</u>, <u>Misty Cove</u> and Lourdes. Only those underlined are represented in the thesis area. The lithology of these members is as follows: Black Duck - grey limestones with occasional shaly partings and some argillaceous beds; LeRoy - blue-grey crystalline limestones with shaly partings; Beachpoint - grey, knobbly limestone interbedded with blue shale; Misty Cove - calcareous sandstone interbedded with blue shale.

The fossil fauna of the Formation as a whole includes brachiopods, bryozoa, crinoids, gastropods, graptolites, ostracodes, scolecodonts, stromatoporoids, tabulate corals and trilobites. Their relationship to particular members is described and an account is given of all the brachiopods and trilobites collected. Of the other groups present, only the more obvious or common representatives have been described. These include one particularly important form, the tabulate coral _Labyrinthites chidlensis_ which has given rise to small columnar reefs in the Black Duck member. The nature of these reefs and other significant, mainly ecological, aspects of the fauna are discussed.

Details are given of the stratigraphy of the Long Point Formation. The main part of the succession represents the deposits laid down in a transgressive sea. Marine sedimentation was brought to a close by uplift and the nature of the uppermost beds indicates a change in environmental conditions from marine to deltaic or terrestrial.

Fossil evidence indicates that the strata of the Long Point Formation probably range from upper Middle Ordovician to lower Upper Ordovician in age. (Upper Wilderness to Upper Barneveld Stages).

CHAPTER 1

INTRODUCTION

Location and Area

The thesis area constitutes the northern half of the north-eastern extension of the Port au Port Peninsula, known as Long Point., (Fig. 1). The Port au Port Peninsula lies on the south-west coast of Newfoundland, north of St. George Peninsula and south of the Bay of Islands. Long Point is situated between latitudes 48°42' and 48°49' North, and longitudes 58°45' and 59°00' West. The thesis area itself extends for approximately nine miles from Misty Point, Black Duck Cove, in the southwest, to the tip of Long Point in the northeast. It is nearly half a mile wide at the level of Black Duck Brook village, but north-eastwards from this locality it gradually tapers until the tip of Long Point is reached and the rocks underlying this extension of the Port au Port Peninsula disappear beneath the sea.

Accessibility

The thesis area is connected by a partly paved road to Stephenville, the nearest major town southeast of Long Point. A dirt road extends part of the length of Long Point, from Black Duck Brook village to Beach Point. The rest of the area is accessible on foot.

Physiography

The surface of Long Point has a subdued relief, and ranges in elevation from sea-level to about 150 feet. The thesis area slopes gently toward the northwest where it is bounded by the Gulf of St. Lawrence in the west. Along the east side of Long Point there is a steep escarpment forming a line of cliffs along the west side of Port au Port Bay. At Beach Point, one and a half miles south of the tip of Long Point, on the east coast, there is an offshore bar built up of rounded cobbles and pebbles which extends laterally for about 300 feet. A marsh-lagoon is present between the cliff and the offshore bar, and several marshy swamps are also present along the interior of Long Point. A marine terrace is present along the west coast where it forms a conspicuous feature behind the present shore-line.

Summary of Previous Work

J.B. Jukes (1842) pioneered geological studies in western Newfoundland. Although he did not study the geology of the Long Point in detail, he mentioned that the northside of St. George's Bay, between Cape St. George and Indian Head, is underlain mainly by magnesian limestone which dips at a slight angle to the north-northwest.

J. Richardson (1861-1863) was the first to make an extensive study of the geology of western Newfoundland, and he thus laid the foundation for subsequent stratigraphic studies in this region. Richardson's field results were prepared for publication by Sir. William Logan, and appeared in the latter's "Geology of Canada" (1863). Logan did not apply geographic names to the formations observed by Richardson, but numbered them in ascending order from 1 to 16. Later, Logan (1863) replaced the numerals by the letters A to Q. The division O, represents the Long Point Formation as presently recognized (Table 1).

Some ten years later J.P. Howley (1874) (in Schuchert and Dunbar, 1934) studied the Long Point strata and estimated their thickness to be about 800 feet. He collected a number of fossils which were later identified by E. Billings. The nature of this fauna, especially that of the reef-forming coral Tetradium, * led Billings to regard the horizon as of Black River age (Murray & Howley, 1881).

Standard Time Scale		Logan's Divisions	Name	Character	Thickness in feet
MIDDLE ORDOVICIAN	?	Q much extended	Humber Arm Series (With basal member of Cow Head breccias)	A great clastic series, varied in texture and colour. At base, locally thick deposits of very coarse limestone breccia	At least 5,000 possibly 10,000
	Black River	O much extended	Long Point Series	Green-grey shales and light-grey limestones	1,530
	Chazyan	N to K	Table Head Series	Heavy-bedded pure limestone grading upward into black shale	1,380

Table 1: Middle Ordovician Formations of Western Newfoundland (after Schuchert & Dunbar, 1934)

* Incorrect determination of a tabulate coral - see Page 13

The flat lying attitude of the Long Point strata led C.S. Schuchert (1918) (in Schuchert & Dunbar, 1934) to conclude that these strata lay above the Humber Arm Series (Table 1) and hence must be of Upper Ordovician age; yet the fossils collected did not agree with an Upper Ordovician age. Dunbar (1920) (in Schuchert & Dunbar, 1934) considered that the Long Point strata were older than the Humber Arm Series. G.A. Cooper's (in Schuchert & Dunbar, 1934) identification of the brachiopods showed them to be closely allied to brachiopods of the Decorah shale fauna of the Black River Valley, New York, and thus basal Trenton in age.

The strata of the Long Point were first called the Long Point Series by Schuchert and Dunbar (1934). They noted, near the base of the Long Point, a fault extending from Three Rocks Point on the west coast to a point between Rocky Point and the mouth of Victor Brook on the east coast (Fig. 1). They estimated the thickness of the Long Point Series to be at least 1,500 feet and divided the sequence into 5 "beds" as follows:

Bed		Thickness
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.	

Bed		Thickness
	Fauna: Dinorthia aff. D.iphigenia, Valcourea sp., Sowerbyella sericea?, Rafinesquina aff. R.minnesotensis.	536'
4	Unstudied strata from Black Duck Cove to near the lighthouse.	667'
3	(Exposed on both coasts by the lighthouse) Greenish-grey, calcareous shales interbedded with three layers of fine grained limy sandstone. Fauna: Ilaenus victor, Leperditia spp. Ceraurinus aff. C.scofieldi, Gonioceras n.sp., Maclurites n. sp., Rafinesquina aff R.minnesotensis, Sowerbyella aff. S.undulata.	150'
2	(Exposed for 12 miles south of the lighthouse along the eastern shore) Light-grey to dove-coloured sandy limestone series in thin and thick beds with oolitic zones and intraformational conglomerates. Small hemispheric reefs present. Fauna: Monotrypa, Glyptorthis aff. bellarugosa, Camerella aff. C. volborthi, Hesperorthis, Triplesia extans.	50'
1	Lower limestone and shaly limestone of east shore. Exposed for 1½ miles north of Rocky Point, are thick bedded rippled light-grey limestone,	

Bed	Thickness
weathering yellow. The upper 75 feet are knobbly. Fauna: <u>Glyptorthis crispata</u>, <u>Valcourea</u>, <u>Gonioceras</u> n.sp., <u>Maclurites</u> n.sp.	125'

J.W. Sullivan (1940) studied the Long Point strata and changed their lithostratigraphic status from Division to Group. He also confirmed the presence of the major fault at the base of the Long Point Group, extending from northeast to southwest of the Long Point, first recognized by Schuchert and Dunbar (1934). The fossil fauna that Sullivan collected from these beds enabled him to correlate them with the Black River and the basal Trenton of New York, of middle Ordovician age.

The description of the lithology of the Long Point Group as well as the measured sections, included in the Geological Survey of Canada Memoir covering the Stephenville map area (G.C. Riley, 1962), were taken mainly from Sullivan's report (1940). The stratigraphic section of the Group given in the memoir is reproduced below as Table 2.

Table 2: Composite section measured downward from contact with Clam Bank Group at Misty Point, western salient of cove at Black Duck Brook, Port au Port Peninsula.

Bed		Thickness (feet)
7	Thin-bedded, knobbly limestone with occasional sandstone layers. Greenish grey. Very fossiliferous, containing Dinorthis cf. D.iphigenia (Billings), Hesperorthis tricenaria (Conrad), Dalmanella rogata (Sardeson), Sowerbyella sericea (Sowerby), and Rafinesquina cf. R.minnesotensis Winchell.	300
6	Slabby, greenish grey, sandy limestone beds, sparsely fossiliferous. Exposed near inner part of cove at Black Duck Brook.	90
5	Thin-bedded knobbly limestone, light grey, interbedded with greenish-grey shaly layers. A few sandstone layers. Almost entirely unfossiliferous. Exposed along west shore of Long Point between Black Duck Brook and Lighthouse.	443
4	Limestone conglomerate with boulders up to 2 feet in diameter, exposed ½ mile south of lighthouse on west shore of Long Point.	4
3	Shaly, sandy limestone and interbedded shale beds. Found near lighthouse on both sides of point.	

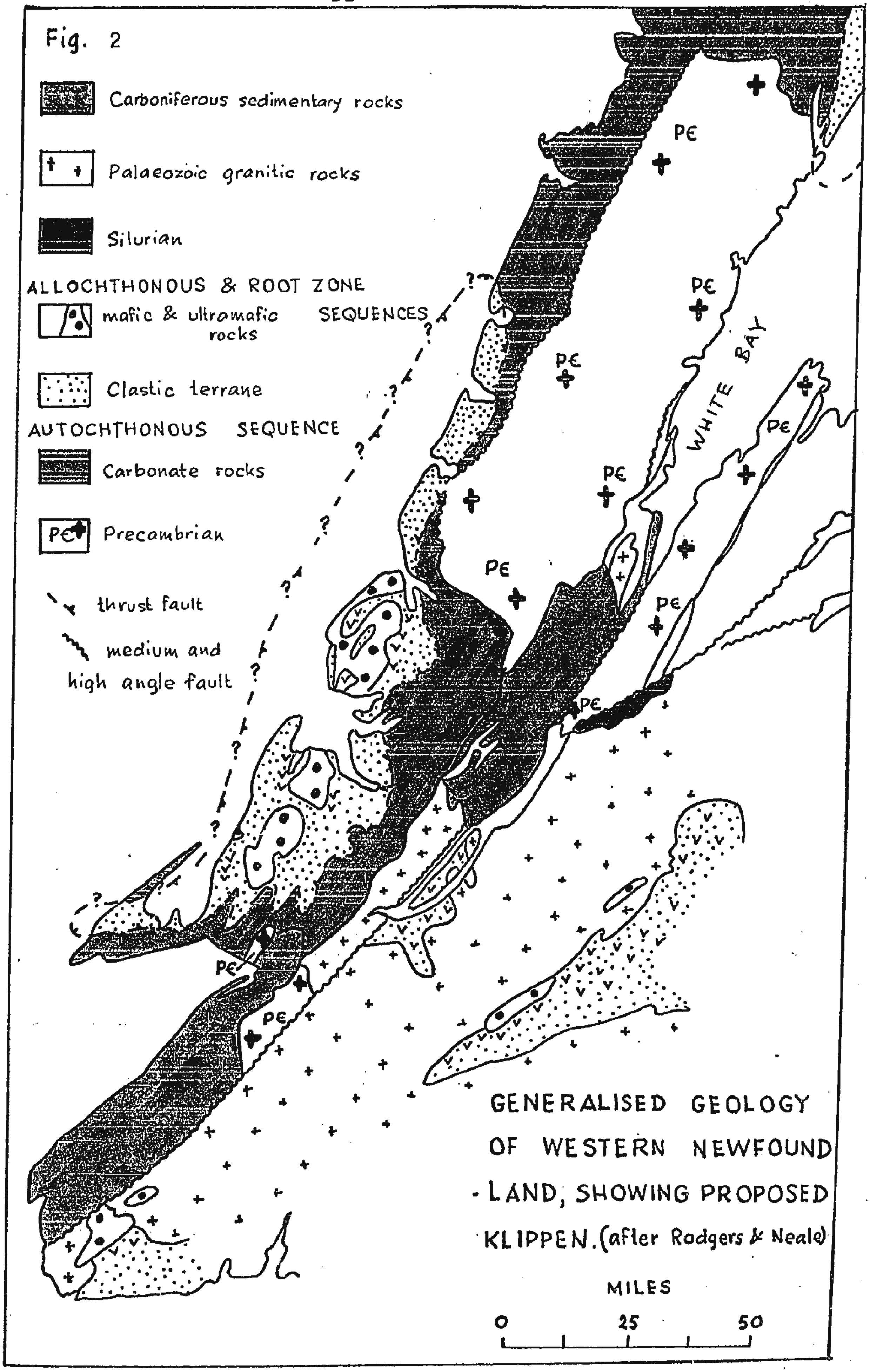
Bed		Thickness (feet)
2	Thin-bedded, knobbly, coarse-grained, light grey, and brownish limestones. Contain reefs of Monotrypa magna Ulrich and is very fossiliferous, including the following: Ceraurus pleurexanthemus (Green), Cryptolithus sp., Encrinurus cybeleformis (Raymond), Illaenus sp., Leperditia fabulites Conrad, Gonioceras cf. G. anceps (Hall), Maclurites 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 several bryozoans. Bed 2 is exposed along most of eastern shore of Long Point to within 2 miles of West Bay village. Also exposed at northeast salient of Three Rocks Cove.	240
1	Thick-bedded, massive, cliff forming grey limestone, grading upward into bed 2. A few greenish-grey shaly layers. Contains Monotrypa magna Ulrich, Maclurites bigsbyi (Hall), Gonioceras cf. G. anceps, Hall, Rafinesquina alternata (Emmons), Rafinesquina cf.R.minnesotensis Winchell, Leperditia fabulites Conrad, Illaenus sp. Bed 1 is found on east side of	

Bed		Thickness (feet)
1 (contd.)	Long Point lying between base of bed 2, two miles northeast of village of West Bay, and Green Point shales and limestones, which lie to southeast of large fault cutting across base of Long Point.	185
	Total	1,432

G.A. Cooper (1956), after restudying the brachiopods, assigned the Long Point Formation to the upper Wilderness Stage (= lowest Trentonian of Kay) (Table 3). He established that there was no marked difference in the age of the fossils found throughout the formation.

J. Rodgers and E.R.W. Neale (1963) considered the possibility of there being Taconic klippen in western Newfoundland. They came to the conclusion that the Humber Arm Group and its equivalents in western Newfoundland are allochthonous masses that were derived from the east as a result of westward transportation due to a combination of lateral compression, resulting in the squeezing up and out of the masses from their original depositional basin, and gravity sliding. They suggested that because the Long Point Formation contains the youngest Ordovician fauna in western Newfoundland, it might have been deposited after the arrival of the klippe (Fig. 2).

Era	Period or Epoch	Stage	Kay 1948	Formation (thickness in feet)	Lithology
	Lower Devonian			Clam Bank Group 1,879'+	Red sandstone, shale, conglomerate, minor limestone
	FAULT CONTACT WITH LONG POINT GROUP				
PALAEOZOIC	MIDDLE ORDOVICIAN	Trenton	Trenton	Long Point Group 1,432'+	Limestone, sandy shale, possibly equivalent to upper part of Humber Arm.
		Wilderness	Bolarian		
		Porterfield	Bolarian	Humber Arm Group 5,000'+	Red, green, and black pyritiferous shales, limestone, greywacke, limestone conglomerate, sandstone; basalt, tuff, agglomerate
		Ashby	Chazyan		
		Marmor	Chazyan		Cow Head Breccia"
		Whiterock	Whiterock	Table Head Group 807'-817'	Black and grey, knobbly weathering, limestone, black carbonaceous shales, black shaly limestone
	EROSIONAL DISCONFORMITY				
	Lower Ordovician			St. George Group 2,400'+	Massive grey, buff, and pink dolomite, shaly dolomite, black limestone
				Green Point Group 1,270'+	Shale, limestone, sandstone (probably in part equivalent to lower part of St. George group; may be in part upper Cambrian



GENERALISED GEOLOGY OF WESTERN NEWFOUNDLAND, SHOWING PROPOSED KLIPPEN. (after Rodgers & Neale)

J. Rodgers (1965) reduced the status of the Long Point strata from Group to Formation. The contrast between the regularity of the Long Point sequence and the crumpling and variability of other formations led him to suggest an unconformity between the Long Point and the Green Point and Humber Arm Formations, rather than a fault as postulated by previous workers.

In 1964, W.D. Brueckner and J. Utting (in Rodgers, 1965) dug out the contact between the Long Point and Green Point Formations and they came to the conclusion that the Long Point strata unconformably overlie those of the Green Point Formation.

Rodgers (1965) interpreted the appearance of coarser sandstones with a maroon cast in the uppermost part of the Long Point Formation within the Long Point-Clam Bank sequence (Table 3) as being essentially due to continuous deposition. The Long Point-Clam Bank Formations are, thus, a single sequence of strata deformed into a relatively simple homocline, with the strata along the Long Point being normal and the strata at Lourdes and Three Rocks Cove being overturned to the southeast. Rodgers (1965) regarded the Long Point-Clam Bank sequence as furnishing a significant aspect of the geological history of western Newfoundland because the unconformity at its base post-dates the arrival of the west Newfoundland "Taconic" klippe if the klippe exists. He assigned the major local pulse of the Taconic orogeny to Middle Ordovician times and inferred that the coarse red beds of the Lower Clam Bank and the disconformity at their base record the Salinic disturbance (Boucot, 1962).

T. Bolton (1965) studied the reef forming bodies within the Long Point Formation and found them to be colonies of the tabulate coral *Labyrinthites chidlensis* (Lambe, 1906). Prior to Bolton's study these 'bodies' were thought to be colonies of the bryozoan *Monotrypa magna* (Schuchert and Dunbar, 1934; Sullivan *in* Riley, 1962) and still earlier they were regarded as a coral of the Tetradium type (Billings *in* Murray and Howley, 1881). *Labyrinthites chidlensis* is considered to be of Middle Ordovician (Wilderness) age (Table 3) and on the basis of this faunal evidence for the age of the Long Point Formation, Bolton (1965) suggested that the contact between the Long Point Formation and the klippe below is a depositional one.

W.D. Brueckner (1966), summarizing the results of work done in west-central Newfoundland by H.D. Lilly, J.H. McKillop, R.K. Stevens, and himself, distinguished three main structural divisions for west-central Newfoundland, and suggested that the Long Point Formation is an "older-neo-autochthonous sequence" of late Middle Ordovician age. He noted that the sequence consists of a lower member, composed mainly of fossiliferous limestone with a thickness of about 250 feet, and an upper, poorly exposed member of shale and sandstone with an estimated thickness of about 2,500 feet.

M. Kay (1969) divided the Long Point Formation into four units:

Unit

4 Shaly and sandy beds.

3 Sandy and shaly basal beds succeeded by well bedded limestone (30 m).

2 Basal sandy and silty beds overlain by bedded limestones with reefs of the coral Labyrinthites (25 m).

1 Sandstone and mud-cracked calcilutite (20 m).

On the basis of the brachiopod fauna from units 2 and 3 (Bilobia, Chaulistomella, Camerella, Glyptorthis, Oepikina, Sowerbyella, Sowerbyites and Strophomena) Kay placed the Long Point Formation in the Valcourian-Ashbyan and Porterfieldian Stages of the Chazyan and Bolarian Series (Table 3) of the Appalachian region. He also suggested that the Mingan limestone of the northern Gulf of St. Lawrence may be the subsurface continuation of the Long Point Formation.

Purpose of Study

The purpose of this work was to investigate:

(a) the lithology and stratigraphy, and

(b) the fossil fauna, with special emphasis on the trilobites and brachiopods, of the Middle Ordovician strata of the Long Point Formation.

The writer was engaged in field work in the thesis area during the summer months of June, July and August 1969. In addition to field work, thin-section study of rocks and a detailed study of fossils were carried out in the department.

Field data were plotted on a base map of 8 inches to the mile prepared from aerial photographs, as satisfactory topographic sheets were not available. Aerial photographs on a scale of 1:10,000 were found particularly useful for the observation of the predominant joint direction, demarcation of the marine terrace along the west coast, and tracing lithologic boundaries.

Acknowledgements

The writer wishes to express his sincere gratitude to all who assisted him in any way during the preparation of this thesis. He is especially indebted to Professor M.M. Anderson of the Geology Department of the Memorial University of Newfoundland, under whose supervision this thesis was written. The writer is also grateful to Dr. H. Williams, Dr. A.F. King, and Dr. L.E. Fahraeus, with whom many helpful discussions were held.

The assistance of Dr. W.T. Dean of the Department of Energy, Mines and Resources, Ottawa, who provided much information on Ordovician trilobites, is gratefully acknowledged.

The writer also wishes to record his thanks to Mr. W. Marsh, photographer with the Geology Department, for photographing all palaeontological specimens, and to Mr. F. Thornhill, technician, for preparing thin sections.

Finally, thanks are extended to graduate students Mr. Z.M. Shaikh and Mr. J. Malpas, with whom many helpful discussions were held.

The writer was supported during his studies by a Departmental Assistantship 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 II

GEOLOGY

General statement

The Long Point Formation is a thick sequence of limestones, shales and sandstones. Rodgers (1965) recognized two members within the Formation, a basal limestone member overlain by a limey sandstone member, but he did not give them formal names. Rodgers (1965) also subdivided the basal limestone member into seven units which he numbered 0 to 6. Kay (1969) subsequently divided the Long Point Formation into four, unnamed units. Thus, no formal subdivisions for the Long Point Formation as a whole have been named to date. The writer, Z.M. Shaikh and Felicity O'Brien, who have studied areas adjacent to the thesis area to the south of Black Duck Brook village, consider that such divisions, based on distinct lithological associations, are necessary for descriptive purposes. They have, therefore, named eight members within the Long Point Formation. The members are as follows:

Formation	Member
L	
O	8 Lourdes
N	7 Misty Cove
G	6 Beachpoint
P	5 LeRoy
O	4 Black Duck
I	3 Portage
N	2 Shorepoint
T	1 Tea Cove

The three lower members were recognized and named by Z.M. Shaikh, the uppermost by F. O'Brien and the remainder, which are the only subdivisions present in the thesis area, by the writer. The Black Duck, LeRoy and Beachpoint members in the thesis area are equivalent to Rodger's (1965) units 4, 5 and 6 (see Table 4).

Member and thickness in feet	Lithology	Rodgers (1965) unit and lithology
Misty Cove (7) 505'+	Calcareous sandstone interbedded with blue shale	
Beachpoint (6) 88'+	Grey knobbly limestone interbedded with blue shale	6. Nodular argillaceous limestone with shaly partings (90')
LeRoy (5) 29'	Blue-grey crystalline limestone with shaly partings	5. Nodular argillaceous limestone interbedded with considerable shale. (30')
D I S C O N F O R M I T Y		
Black Duck (4) 49'+	Grey limestone with occasional shaly partings and some argillaceous layers	4. Nodular limestone, not particularly argillaceous and almost without shaly partings. (45)

Table 4: Members of the Long Point Formation present in the thesis area and their relationship to the units recognized by Rodgers (1965).

<u>Description of Members</u>

BLACK DUCK MEMBER

The base of the Black Duck Member is not exposed in the thesis area as it lies below sea level; its maximum thickness, some 49 feet, is to be found in the coastal cliffs at 48°43'N, 58°53'W, one and quarter miles northeast of Black Duck Brook post-office (Map 1).

This member is almost continuously exposed in the cliffs on the eastern side of Long Point from the southern boundary of the thesis area to about a quarter of a mile beyond the north end of the offshore pebble bar, at Beach Point, where the beds strike beneath the sea.

The Black Duck Member is composed mainly of coarse-grained, massive crystalline limestone which appears buff-grey when freshly fractured. The beds are thick with uneven surfaces. Some argillaceous layers are also present as well as occasional shaly partings. Thin sections of the limestone show that it is a biomicrite (Folk, 1959) composed mainly of finely crystalline calcite and fossil fragments. The finely crystalline calcite consists of uniform sized subtranslucent crystals measuring less than 0.01 mm in diameter. The fossils present are mostly fragments of brachiopod shells, bryozoa, tabulate corals and crinoid ossicles. Randomly distributed, angular quartz grains, ranging from 0.03 to 0.08 mm in diameter, generally form some two percent of the rock but at some horizons where pronounced layering is present, quartz grains constitute up to six percent of the limestone. (Pl. 1, fig. 1).

Occasional, localized lenses of cross-lamination are present throughout the member.

The top of the member is marked by an erosional surface, (Pl. 3, Figs. 1-2) overlain by sandstone containing randomly distributed rounded pebbles that are up to 3 inches or more across.

Fossils are common in these beds, mainly tabulate corals and bryozoa. Reefs of the tabulate coral _Labyrinthites chidlensis_, whose colonies are characterized by their domed heads, are found at intervals along the outcrop of the member; they are almost perpendicular to the bedding ~~of the beds~~. Bryozoan colonies and crinoid ossicles are occasionally abundant. The beds also yield the nautiloids Gonioceras and Endoceras, the gastropod Maclurites, and the trilobites Ceraurinella and Illaenus which are relatively uncommon.

LEROY MEMBER

The rocks of the LeRoy Member are well exposed at the type locality at 48°43'N, 58°53'W, one and a quarter miles northeast of Black Duck Brook post-office on the east coast (Map 1) where it is 29 feet thick. The rocks of the member are well exposed from the type locality northeastwards along the coast to a point about half a mile beyond the north end of the offshore pebble bar where they pass beneath the waters of Port-au-Port Bay.

The beds of this member are of fine to medium-grained, grey to brownish-grey sandy limestone, alternating with beds of calcareous blue-shale. The limestone beds are 1½ to 3 inches thick. The shaly beds are ¼ to 1 inch thick. The lower part of the member contains more shaly beds than the upper part. The beds of the member have even bedding planes.

Thin sections of the limestone show that it is made up mainly of crystalline calcite and quartz-grains. The percentage of quartz-grains increases from 23.6 percent in the beds at the bottom of the sequence to 62 percent in the beds at the top of the member. The quartz-grains are subrounded to rounded and range in size from 0.06 to 1.3 mm in diameter (Pl. 1, Fig. 2), some exhibit undulose extinction. The other minerals present are biotite, muscovite, and feldspar (oligoclase). The upper part of the LeRoy member grades vertically into the lower part of the Beachpoint member. The boundary between the LeRoy and Beachpoint members in this transitional sequence is placed at the first appearance of beds of grey knobbly limestone.

This member of the Long Point Formation is the most fossiliferous of all the members. It is characterized by an abundance of trilobites of which the commonest present are *Illaenus*, *Isotelus*, *Sphaerocoryphe*, *Anataphrus*, *Bumastus*, and *Ceraurinella*. The brachiopod fauna includes the high convexity species of *Rafinesquina* and *Oepikina*, and the low convexity types *Sowerbyella* and *Sowerbyites*. The only cephalopod present is the nautiloid *Endoceras*.

BEACHPOINT MEMBER

The Beachpoint member succeeds the LeRoy member conformably. The Beachpoint member is best exposed at 48°43'N, 58°53'W, one and a quarter miles northeast of Black Duck post-office, along the east coast. Here the upper contact of the member is hidden beneath superficial deposits and the exposed beds have a thickness of 88 feet.

This member is composed of monotonously uniform beds of grey knobbly limestone interbedded with thin beds of friable blue-shale. The limestone beds are 1 to 4 inches thick. They are generally thinner in the lower part of the sequence than in the upper part. The shale beds, usually less than an inch thick, are conversely thinner in the upper part of the sequence and also more widely separated from one another by the limestone beds, than they are in the lower part of the sequence. The limestone beds occasionally show cross-lamination and nodular weathering is common.

The Beachpoint member shows variation in thickness along the strike. It decreases from its maximum of 88 feet in the Black Duck Brook village area to about 11 feet in the cliffs three and a quarter miles northeast of the village, and then, beyond this locality, it gradually increases until near the lighthouse it is 47 feet thick. At the end of Long Point the beds of the Beachpoint member strike beneath the sea.

Thin sections of the limestone show that up to 81 percent of the rock is composed of microcrystalline calcite ooze. A few larger grains of calcite are also present which are about 0.05 mm in diameter. Their larger grain size may be a result of recrystallization of the calcite ooze, as evident along the boundary of the crystals which show phases of intergrowth with the surrounding calcite ooze. The remaining 15 percent of the limestone, consists of subrounded quartz-grains ranging from 0.03 to 0.15 mm in diameter (Pl. 2, Fig. 1), infrequent grains of muscovite, biotite, magnetite and glauconite, together with shell fragments. Shell fragments constitute some 4 percent of the rock.

The upper contact of the member with the Misty Cove Member was observed at only one locality, 75 feet northeast of the lighthouse, where the contact is graditional. Elsewhere this contact is hidden beneath glacial till.

MISTY COVE MEMBER

The Misty Cove member is exposed, almost continuously, along the west coast of Long Point. Its thickness cannot be determined because the uppermost beds are submerged beneath the waters of the Gulf of St. Lawrence. At the type section, 75 feet northeast of the lighthouse along the west coast, the exposed sequence is 34 feet thick. Here, in a transitional zone, thin, grey calcareous sandstone beds interbedded with friable blue-shale succeed the thick grey knobbly limestone beds of the Beachpoint Member.

The calcareous sandstone beds are generally 4 to 6 inches thick. Marine erosion along the west coast has resulted in differential erosion; the less resistant shaly beds have been worn back thus undercutting the intervening more resistant sandstone beds. As a result, the sandstone beds have broken off in large slabs. These slabs now lie along the shore in various attitudes.

The beds of friable blue-shale range from 1 to 9 inches in thickness. They are generally thinner in the lower part of the sequence than they are in its upper part.

Thin section studies of the calcareous sandstone reveal a predominance of quartz-grains which constitute 71 percent of the rock. The quartz-grains are subrounded and range from 0.19 to 0.75 mm in diameter and some show undulose extinction. The quartz-grains are held together by a calcareous cement that constitute 24 percent of the rock. The remainder of the calcareous sandstone is made up of infrequent grains of muscovite, feldspar (oligoclase), and shale fragments (Pl. 2, Fig. 2).

On the west coast, a quarter of a mile south of the lighthouse, there are several exposures of a conglomeratic bed, generally about 3 feet thick, that overlies a shaly bed some 9 inches thick. The conglomerate is composed of dove-grey, subrounded to rounded, flat pebbles, cobbles and boulders of limestone that range from an inch to 2 or more feet in diameter. No preferred orientation of the maximum diameter of the boulders is apparent. The flat pebbles, however, are found surrounding them producing a kind of imbricate structure (Pl. 4, Figs. 1-4).

The origin of this intraformational conglomeratic bed is difficult to interpret. One possible explanation is that it resulted from slumping during which the pebbles were wrapped round the cobbles and boulders. This material has been derived from the break-up of a pre-existing limestone, probably from lower down in the Long Point Formation.

Amongst the fossils present are the brachiopods Orbiculoidea, Bilobia, and Plaesiomys, the graptolite Climacograptus, straight-shelled nautiloids, and scolecodonts. The graptolites, nautiloids, scolecodonts and the brachiopod Plaesiomys are preserved mainly in the calcareous sandstone beds. The brachiopods Orbiculoidea and Bilobia are found in the shaly beds of the member.

STRUCTURE

The Palaeozoic strata of the Long Point have not been greatly deformed. In general the rocks of the thesis area strike northeast, almost parallel to the Long Point, and dip to the northwest. The dip of the beds gradually decreases from

54 degrees at Black Duck Brook village to barely 10 degrees at the tip of Long Point.

A number of minor faults occur. Two groups of faults have been recognized, normal and reverse types (Pl. 3, Fig. 3). Both types are almost invariably confined to the Black Duck Member. The normal faults generally terminate in small-scale monoclines (Pl. 3, Fig. 4) at the boundary of the Black Duck Member with the overlying LeRoy Member and they have throws ranging from a few inches to several feet; the displacements associated with the reverse faults are of a similar order.

Jointing is conspicuous in all exposures and is especially obvious in the Black Duck Member, where three main joint sets are present. The most prominent set strikes between 90 and 105 degrees east of north with individual joints spaced some fifteen or more feet apart. Marine erosion has opened up these prominent joints producing small inlets of the sea (Pl. 5, Fig. 1). This prominent set is thus visible from the air and aerial photographs were found particularly useful for observing them. The other two joint sets are less conspicuous and strike approximately 65 degrees east of north, and 25 degrees east of north respectively.

Approximately 600 feet south of the southern end of the off-shore pebble bar is an area, confined to the Black Duck Member, which appears to have undergone slumping. The beds in this area are considerably contorted. On either side of this area the strata are undisturbed and dip to the northwest (Pl. 5, Fig. 3). The slumped zone has a lateral extent of 150 feet and is 30 feet thick. Fracturing is associated with the folding in the slumped zone (see Fig. 5, Fig. 2).

PLATE 1

Figure

1 Photomicrograph of the limestone from the Black Duck Member showing finely crystalline calcite and fragments of fossils. A cross-section of a crinoid columnal is present to the left of the centre of the photograph. Crossed nicols; x 50.

2 Photomicrograph of sandy limestone from the LeRoy Member. It consists of fine to medium-grained crystals of calcite and subrounded quartz-grains. Crossed nicols; X 50.

PLATE 1

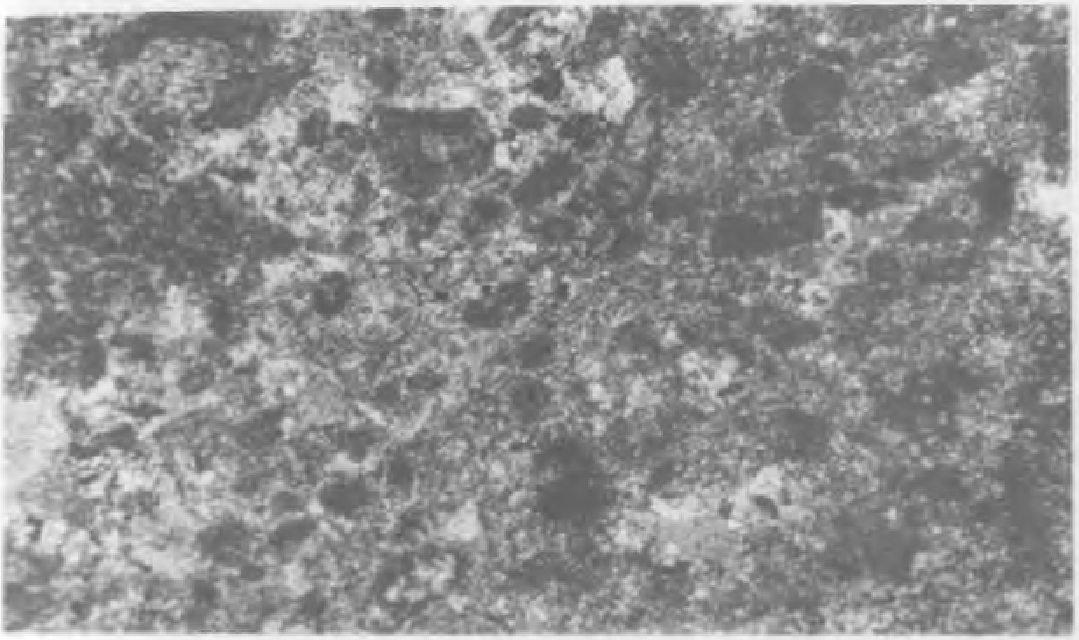


Fig. 1

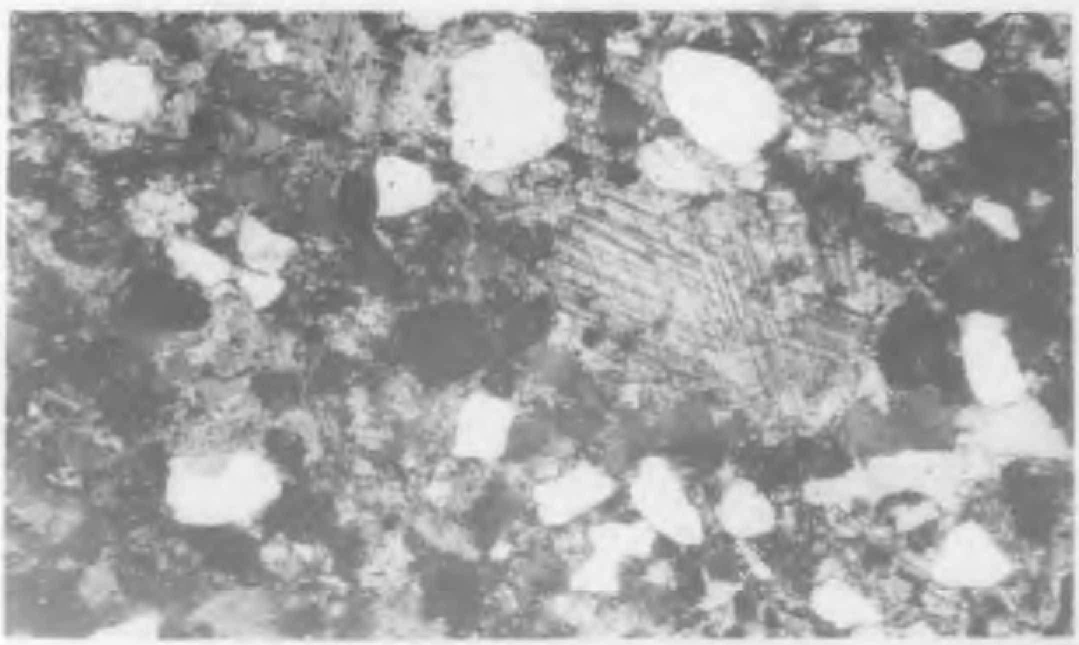


Fig. 2

PLATE 2

Figure

1 Photomicrograph of limestone from the Beachpoint Member showing microcrystalline calcite and scattered, generally larger, subrounded quartz-grains. Crossed nicols; x 50.

2 Photomicrograph of calcareous sandstone from the Misty Cove Member. Well sorted, subrounded quartz-grains constitute 71 percent of the rock in a matrix of calcareous cement. Crossed nicols; x 50.

Fig. 1

Fig. 2

PLATE 3

Figure

1 Erosional surface at the top of the Black Duck Member three miles northeast of Black Duck Brook post-office. The calcareous sandstone has a curved outline due to compaction above the eroded dome shaped top of a tabulate coral reef. The size of the outcrop is about 4 x 6 feet.

2 Erosional surface above the limestones of the Black Duck Member, at the same locality as figure 1. The size of the outcrop is about 6 x 5 feet.

3 Reverse fault in the Black Duck Member, in the cliff overlooking Port au Port Bay, three and a quarter miles northeast of Black Duck Brook post office. The fault plane having an inclination of about 45 degrees with a displacement of beds of the order of about three feet.

4 Normal fault terminating in a small-scale monocline in the LeRoy Member. The beginning of the fault can be seen at the bottom righthand corner of the figure. This flexure dies out when traced upwards.

PLATE 3

Fig. 1

Fig. 2

Fig. 3

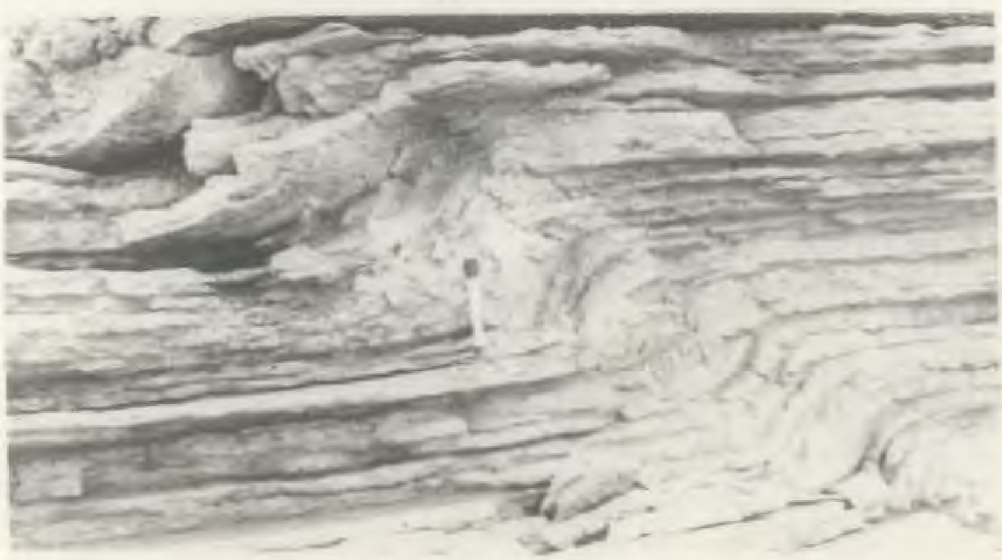


Fig. 4

PLATE 4

Figure	
1 & 2	Intraformational limestone conglomeratic bed on the western side of the Long Point a quarter of a mile south of the lighthouse.
3 & 4	Subrounded, flat, limestone cobbles and boulders with pebbles surrounding them producing a kind of imbricate structure.

PLATE 4

FIG. 1

FIG. 2

FIG. 3

FIG. 4

PLATE 5

Figure

1 Joints in the Black Duck Member on the east coast, along which marine erosion has taken place opening up the joints forming fissures and minor inlets of the sea.

2 Folding in the slumped zone in the Black Duck Member, approximately 600 feet south of the southern end of the off-shore pebble bar, and a fracture surface is seen in the foreground.

3 Slumping in the Black Duck Member, at the same locality as figure 2, also showing a fracture surface in the foreground. The size of the outcrop is about 50 x 35 feet.

Fig. 1

Fig. 2

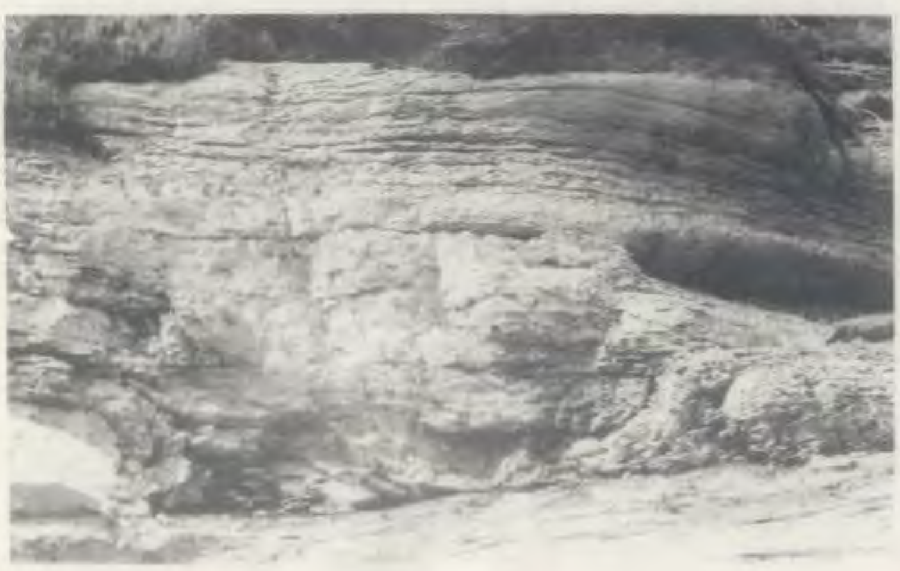


Fig. 3

In the three chapters that follow, the diagnoses accompanying the fossil descriptions are at the generic level. As it was not possible to compare the specimens collected from the Long Point Formation with actual specimens from elsewhere but only with the descriptions of these forms in the literature, species have been given an 'aff' or 'cf' designation. Where the fossil is quoted as 'aff' it is considered to be a related form and where 'cf', a comparable form.

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CHAPTER III

TRILOBITA

Introduction

The trilobites described below are from the Black Duck and LeRoy members of the Long Point Formation. They are classified to family level. The specimens studied have been placed in the collection of the Department of Geology of the Memorial University of Newfoundland.

Morphological terms used here are as defined in Volume O, Arthropoda 1, of the Treatise on Invertebrate Palaeontology (Moore, 1959).

Family PTERYGOMETOPIDAE Reed, 1905

Subfamily PTERYGOMETOPINAE Reed, 1905

Genus CALYPTAULAX Cooper, 1930

Calyptaulax cf. C. incepta Whittington 1965

Plate 6, figs. 1-3

Material. Specimen AZT 1: complete cephalon with an incomplete thorax showing four segments and an indication of others. Specimen AWT 1c: complete cephalon. Specimen AWT 1p: complete pygidium with 7 ring furrows. All specimens are from the LeRoy member. AZT 1, from three feet above the base of the member on the east coast opposite Black Duck Brook post-office. AWT 1c and 1p, from three feet above the base of the member on the east coast three and a half miles northeast of Black Duck Brook post-office.

Diagnosis. The cephalon is semicircular in outline with large schizochroal eyes and proparian sutures. The glabella is expanded forward with distinct glabellar lobation; 2p and 3p lateral

lobes are partially fused by abaxial reduction of shallow 2p lateral glabellar furrows, 1p lobes are distinctly detatched.
<u>Description</u>. The semicircular cephalon is convex, has proparian sutures, and bears large schizochroal eyes. The posterior part of the eye lobes form the highest points on the cephalon. The free cheeks slope steeply outwards beneath the eye lobes. The glabella is expanded anteriorly and is distinctly lobed; the frontal lobe is prolonged sideward and is hypertrophic. The maximum width of the glabella, which is across the frontal lobe, is twice that of the occipital ring. The occipital furrow is depressed distally and is shallower medially. The outer end of the lateral glabellar furrow 1p begins midway between the occipital furrow and lateral glabellar furrow 2p. The 2p lateral glabellar furrow is directed inward and forward, making the lateral lobe 2p sub-quadrangular in outline. The 3p lateral glabellar furrow is well developed and the axial furrow in front of the outer end of the lateral glabellar furrow dies out. The inner ends of lateral glabellar furrows 1p, 2p, and 3p lie along the same exsagittal line. The preoccipital ring is convex medially and has distinctly separated, round lobes laterally. The glabella shows closely spaced tubercles that are also present on the fixed cheek; shallow pits occur in the free cheek outside the prominent eye lobe. The cephalic margin medially forms a small triangular extension that is upturned anteriorly to expose the doublure. The genal angle is rounded.

The thorax has impressed axial furrows. The pleural furrows are complete and anteriorly arcuate.

The pygidium is convex and triangular, and has 7 ring furrows that become shallow and faint posteriorly.

Dimensions: AZT 1.	cephalon	8 mm	sagittal
		6 mm	exsagittal
		12 mm	transverse
	thorax	6 mm	transverse
AWT 1c.	cephalon	9 mm	sagittal
		14 mm	transverse
		6 mm	exsagittal
	eyes	4 mm	long and rise 2 mm vertically from genal surface
AWT 1p.	pygidium	9 mm	sagittal

Discussion. The specimens AZT 1 and AZT 1c resemble Whittington's Holotype GSC 18368, described from Unit 8 of the lower Table Head Formation, and have thus been designated as cf. *Calyptaulax incepta* Whittington 1965. Whittington mentions that this species appears to be the first known representative of an evolving plexus of phacopids in middle and upper Ordovician rocks in North America.

Calyptaulax resembles *Calliops* but differs from it in the obsolescence of 2p distally (Whittington, 1965), so that instead of having separate first and second lateral lobes, they merge with one another. The second lateral glabellar furrows do not, therefore, reach the axial furrows, which they certainly do in *Calliops*. The use of this feature as a critical character for distinguishing between *Calyptaulax* and *Calliops* seems doubtful, particularly as Whittington has ignored this distinction in his description of C. incepta (Whittington, 1965). Consequently if this single criterion is used for distinguishing Calyptaulax from Calliops, it may well be that Whittington's Calyptaulax from the lower Table Head Formation is a Calliops.

Calyptaulax occurs only at definite stratigraphic horizons in the LeRoy member of the Long Point Formation. Although this form is the most abundant trilobite present, its occurrence at these horizons is not uniform when traced laterally. They are found in abundance in irregular patches. This suggests that they accumulated on scattered areas of the sea floor as a result of current sorting.

Family CHEIRURIDAE Salter, 1864

Subfamily CHEIRURINAE Salter, 1864

Genus CERAURINELLA Cooper, 1953

Ceraurinella sp.ind.1.

Plate 7, fig.1; Plate 8, fig.1.

Material. Specimen AWT 2: incomplete exfoliated cephalon, consisting of part of the left side of the glabella together with the left fixigena and eye. A portion of the right genal spine is also present. The specimen is from 7 feet below the top of the Black Duck member, on the east coast, three and a half miles northeast of Black Duck Brook post-office.

Diagnosis. The glabella is subparallel sided and expands slightly forward. The basal glabellar lobe is relatively wide. The eye is positioned opposite lateral glabellar furrow 2p.

Description. The cephalon is broadly semicircular in outline, weakly convex transversely and sagitally and bears moderately long genal spines. The glabella is weakly convex and as it expands only slightly forwards it has subparallel sides. The preglabellar field is narrow. Three pairs of short, deep lateral glabellar furrows are present; 1p is directed inward and slightly backward, 2p is directed inward and forward and 3p is directed inward and forward. The occipital lateral glabellar furrow is deep and parallel to the posterior border furrow. The eye is positioned opposite the second glabellar lobe. The left fixigena is irregularly pitted and also bears fine and coarse granules. The moderately long genal spines are thick and inclined outwards.

Dimensions:	Cephalon	20 mm sagittal
		62 mm transverse at base of cephalon
	glabella	19 mm sagittal
		19 mm transverse at centre of frontal glabellar lobe.

Discussion. The specimen could be mistaken for *Ceraurus* because both have moderately long, thick, genal spines which are inclined outwards. In *Ceraurinella* the genal spines are short and inclined inwards. Furthermore, the glabellar furrow 1p is deep and open, spacing out the lateral glabellar lobes 1p and 2p as in *Ceraurus*. The specimen differs however, from *Ceraurus* in two important characters: 1) the glabella in *Ceraurinella* is subparallel sided and expands slightly forward, whereas in Ceraurus the glabella expands markedly forward, and 2) the eye in Ceraurinella is set back opposite the second glabellar furrow (2p), but is opposite the third glabellar furrow (3p) in Ceraurus.

Ceraurinella sp.ind.2

Plate 8, fig. 2

Material. Specimen AWT 3: incomplete cranidium with the whole of the glabella and right fixigena present. The specimen is from four feet above the base of the LeRoy member on the east coast, four and a half miles northeast of Black Duck Brook post-office.

Description. The glabella is markedly convex with subparallel sides, narrowest across occipital ring and expanding slightly forward. The glabella has three pairs of short, deep, lateral furrows and is ornamented with well distributed tubercles and pits. The axial furrow is deep. The fixed cheek is impressed with closely spaced pits and also bears irregularly spaced granules. The anterior cephalic margin is narrow. On the border of the fixigena opposite 2p there is an indentation, the probable location of the eye.

Remarks. The main difference between specimens AWT 2 and AWT 3 is the form of the glabella. Specimen AWT 2 has a weakly convex glabella, whereas specimen AWT 3 has a markedly convex glabella ornamented with larger tubercles.

Family CHEIRURIDAE Salter, 1864

Subfamily DEIPHONINAE Raymond, 1913

Genus SPHAEROCORYPHAE Angelin, 1854

Sphaerocoryphe aff. S.robusta Walcott

Plate 9, figs. 1-3

Material. Specimen AWT 4: part of the cephalon showing bulbous glabellar frontal lobe, with right fixigena and genal spine. The right eye is partly damaged. The specimen is from two feet above the base of the LeRoy member, on the east coast, one and a quarter miles northeast of Black Duck Brook post-office.

Diagnosis. The cephalon has a characteristic spheroidal glabella, with a bulbous frontal lobe. The eyes are prominent and set far out from the glabella. The free cheek is smaller than the fixed cheek which bears a genal spine.

Description. The cephalon is subtriangular in outline and strongly convex. The glabella is greatly inflated in front of the preoccipital furrow and constricted at the base. The front of the glabella overhangs the anterior margin of the cephalon by half the cephalic length (sag.). There are lateral preoccipital lobes separated by longitudinal furrows from a median preoccipital lobe behind the inflated glabella. The subglobose eyes are prominent and set far out from the glabella. The fixigenae are well developed. The genal spines are slender and long.

Dimensions. cephalon 6mm sagittal
glabellar frontal lobe 4.5 mm transverse
glabellar frontal lobe 4.0 mm sagittal
general spine 5 mm long from base of cephalon.

Remarks. The specimen shows similarity in shape, convexity of cephalon, bulbous nature of the glabella with its constricted base, and in the prominence and shape of the eye, with *Sphaerocoryphe robusta* from the Ottawa Formation of the

Ottawa-St. Lawrence Lowland (Wilson, 1947).

Family ASAPHIDAE Burmeister, 1843

Subfamily ISOTELINAE Angelin, 1854

Genus ANATAPHRUS Whittington, 1954

Anataphrus aff. *A. borraeus* (Whittington)

Plate 10, figs. 1-2; Plate 11, figs. 1-2.

Material. Specimen AWT 5: enrolled specimen with complete exoskeleton and partially damaged thorax. The specimen is from two feet above the base of the LeRoy member, on the east coast, three miles northeast of Black Duck Brook post-office.

Diagnosis. The pygidium is practically the same size as the cephalon. Axial furrows are absent from the whole exoskeleton. The axial and pleural parts thus form a smooth unbroken convex curve in transverse profile. The eye lobes are large. The facial suture is of the asaphid type. There are 8 thoracic segments.

Description. The exoskeleton is almost isopygous and without axial furrows. The 'axial' and pleural parts of the exoskeleton form a smooth convex curve in transverse profile. Articulating processes on the posterior margin of the cephalon and on the thoracic segments show that the axis actually represents two-thirds of the total width of the thorax. The anterior end of the eye lobes are situated at half the cephalic length (sag.). The 'crescentic' eyes are thus located in the posterior half of the cephalon. The facial suture is of the asaphid type. The pre-ocular branches of the facial suture curve outwards immediately beyond the eyes, and then inwards, closely following the margin of the cephalon, to meet anteriorly at its mid-point.

The narrow cephalic border is defined by a very shallow border furrow. The genal angles are rounded.

The thorax consists of 8 segments. The thoracic axis is broader than the pleural region.

The axis is not defined in the pygidium, and the pleural parts are without a border.

Dimensions:	cephalon	24 mm sagittal
		16 mm exsagittal
	thorax 8 segments	31 mm sagittal
	pygidium	18 mm sagittal
	eyes	8 mm sagittal.

Discussion. This specimen was placed in the genus *Anataphrus* as it shows close similarity in its characters to *Anataphrus borraeus* from Baffin Island, (Whittington, 1954). However, the specimen differs from *A. borraeus* in the following characters:-

(a) It is approximately three times larger.

(b) It has a glabellar tubercle immediately in front of the area corresponding to the occipital furrow, which is absent in *A. borraeus* but present in other genera of asaphids.

(c) The eyes are set further apart and nearer the posterior margin of the cephalon.

(d) Anteriorly the pre-ocular branches of the facial suture do not meet the cephalic margin at an angle but lie closely parallel to it around the glabellar.

(c) The post-ocular branches do not run obliquely outwards from the eye to the posterior border of the cephalon but flare out in the typical asaphid manner.

Family ASAPHIDAE Burmeister, 1843

Subfamily ISOTELINAE Angelin, 1854

Genus ISOTELUS DeKay, 1824

Isotelus cf. I.gigas DeKay

Plate 12, figs. 1-5; Plate 13, fig. 1.

Material. Specimen AWT 6: enrolled specimen still retaining much of its exoskeleton. The anterior portion of the cephalon and the posterior end of the pygidium are damaged. The right eye is complete and the left eye is damaged. The specimen is from two feet above the base of the LeRoy member on the east coast, one mile northeast of Black Duck Brook post-office.

Diagnosis. The exoskeleton is oval in outline and has subangular extremities. The cephalon and pygidium have poorly defined, flattened borders. The cephalic axis is vaguely defined with no glabellar furrows. The eyes are medium sized and prominent. The thorax has 8 segments with parallel sides and obliquely grooved pleurae. The pygidial axis is broad with smooth pleural fields.

Description. The exoskeleton is oval in outline. The narrow, flattened border of the cephalon is fairly well defined but around the pygidium, it is poorly defined. The frontal area of the cephalon is moderately long and the cephalic axis is only vaguely defined. The eye is conical, medium sized and situated near the axial furrow. The posterior sections of the facial suture meet the posterior margin of the cephalon inside the genal angle. The lateral sides of the cephalon have been exfoliated to expose the doublure. The doublure has well marked terrace ornamentation which is subparallel to the cephalic border.

The surface of the cephalon is regularly and finely pitted.

The thorax has 8 segments with parallel sides. The axial portion is broad. The proximal part of the pleurae stretch out horizontally, and the distal part is uniformly reflected posteriorly. Each pleura is obliquely crossed by a pleural furrow, and has a subtriangular articulating facet at its antero-lateral extremity.

The pygidial axis is broad and poorly defined with smooth pleural fields. Antero-laterally the pygidium has large articular facets.

The ratio of length to breadth of the exoskeleton is 0.61.

Dimensions.	cephalon	35 mm transverse
		21 mm sagittal (reconstructed)
	thorax	34 mm sagittal
	thoracic axis	16 mm transverse
	pleural segments	13 mm transverse
	pygidium	14 mm sagittal.

Remarks. The external morphology of the specimen resembles that of *I.gigas* described from the Hull beds and Sherman Fall beds localities, of the Ottawa Formation, Ottawa-St. Lawrence Lowland (Wilson, 1947).

Family ILLAENIDA Hawle & Corda, 1847

Subfamily ILLAENINA Hawle & Corda, 1847

Genus ILLAENUS Dalman, 1827

Illaenus sp.ind.1

Plate 14, figs. 1-2.

Material. Specimens AWT 7a & 7b: exoskeleton of both cranidia are exfoliated. The specimens are from three feet above the base of the LeRoy member, on the east coast, three miles northeast of Black Duck Brook post-office.

Diagnosis. The axial region of the cephalon is smooth with an ovoid glabella. The thorax consists of 10 segments with well defined axial furrows, and pleurae without pleural furrows. The pygidium is as large as the cephalon with a short axis narrowing towards the rear. The pleural fields are smooth.

Description. The cephalon is subtrapezohedral in outline with a rounded anterior border. The length (sag.) is about two-thirds the maximum width (tr.). The curvature of dorsal and lateral profiles is deep. The axial furrows defining the glabellar converge slightly forward and disappear at the posterior of cephalon. The outline of the base of the cephalon is doubly scalloped giving rise to two lateral projections as well as a median one.

Dimensions. Both specimens are identical.

length	10 mm sagittal
width	16 mm transverse

Remarks. The specimens are similar to the illustrations of Illaenus sp. described by Whittington, (1965), from the Middle Table Head Formation, Table Cove.

Illaenus sp.ind.2

Plate 15, figs. 1-3

Material. Specimen AWT 8a: consists of three-quarters of a cast of the dorsal surface of the exoskeleton. The specimen is from the LeRoy member, two feet above the pebble beach on the east coast, half a mile northeast of the offshore pebble bar.

Specimen AWT 8b: disarticulated, showing only 7 thoracic segments. The specimen is from four feet below the top of the Black Duck member, on the east coast, four and a quarter miles northeast of Black Duck Brook post-office.

Description. The cephalon is smooth with an ovoid glabella. The eyes are not discernible.

The thorax has 10 segments with the axis narrowing posteriorly. The axial articulating furrows are well defined. The pleurae are without furrows and the outer parts of the pleurae are bent down steeply.

The pygidium is as large as the cephalon. The anterior margin of the pygidium is angulate to conform with the shape of the thoracic pleurae. The axis is short and obsolescent narrowing towards the rear. The pleural fields are smooth.

Dimensions.

AWT 8a	Cephalon	7 mm	sagittal (part)
		24 mm	transverse at base
	thorax	10 mm	sagittal
		24 mm	transverse
	pygidium	12 mm	sagittal (part)
		10 mm	transverse
AWT 8b	thorax	36 mm	transverse

Remarks. The specimens resemble Illaenus sp. alveatus Raymond, 1925, described by Whittington (1965), from the Lower Table Head Formation at Pointe Riche.

Family ILLAENIDAE Hawle & Corda, 1847

Subfamily BUMASTINAE Raymond, 1916

Genus BUMASTUS Murchison, 1839

Bumastus sp.ind.

Plate 14, fig. 3; Plate 16, fig. 1

Material. Specimen AWT 9: most of the exoskeleton of the cranidium is preserved and exfoliated. The specimen is from three feet above the base of the LeRoy member, on the east coast, three miles northeast of Black Duck Brook post-office.

Diagnosis. The glabella is club-shaped. The foremost portions of the cephalic axial furrows end possibly in front of the eyes.

Description. The cephalon is smooth with a club-shaped glabella which is highly convex in lateral profile. The posterior margin of the cephalon is doubly scalloped so that there are two lateral projections and also a median one.

Dimensions. cranidium length 28 mm sagittal
21 mm exsagittal
width 40 mm transverse
axial furrows length 11 mm from the base.

DISCUSSION OF THE TRILOBITE FAUNA OF THE LONG POINT FORMATION OF THE THESIS AREA

Apart from *Calyptaulax*, which is found in abundance, the other trilobites in the thesis area are relatively uncommon. Four families are represented by nine species belonging to seven genera.

These genera are known to occur in other parts of North America and their distribution is as follows:-

Calyptaulax : Tennessee, Virginia, New York, Quebec, Ontario and Newfoundland.

Illaenus : Missouri, Illinois, New York, Ontario Quebec and Newfoundland.

Bumastus : Missouri, Illinois, New York, Iowa and Ontario.

Isotelus : Missouri, Illinois, New York and Ontario.

Anataphrus : Minnesota and Iowa.

Ceraurinella : Virginia, New York and Quebec.

Sphaerocoryphe : New York, Quebec and Ontario (Wilson, 1947); Whittington, 1954, 1966; Moore, 1959).

Five of the genera from the thesis area have a geographic representation elsewhere in northwestern Europe as mentioned below:

Sphaerocoryphe: North Wales; *Illaenus* : Poland, North Wales;

Ceraurinella : Poland, North Wales; *Isotelus* : Scotland, and

Calyptaulax : Britain (Whittington, 1965; 1966).

Bumastus : Britain.

All genera except Anataphrus make their first appearance in the early Middle Ordovician in North America. Anataphrus, however, has not been recognized in pre-early Trentonian strata.

Geographic relationships

Closely related, if not identical genera to those of the Long Point Formation trilobite fauna are present in southern Baffin Island, the Cape Calhoun beds of northwestern Greenland, New York, eastern and northern Iowa, the Baltics, Scandinavia and Scotland (Whittington, 1954; 1966). These widely separated regions lay within the northern geographic region of distribution of Ordovician trilobite faunas, which included North America, the Arctic Islands, Greenland, western Ireland, Scotland, Spitzbergen, Balto-Scandia and the U.S.S.R.

The southern geographic region included the Andean region of South America, central Britain, Normandy, Brittany, central Europe and the Mediterranean area, the Himalayas, China, southeast Asia, Australia and New Zealand (Whittington, 1966).

The presence of several genera common to both geographic regions during Ordovician times implies that some migration and exchange of trilobites was possible between the regions (Whittington, 1966).

Of the trilobites present in the thesis area, Anataphrus is a new record for eastern North America and the Long Point form may have descended from the North American stock of asaphids.

Age and relationships of the trilobite fauna

The species of Illaenus, Isotelus, Ceraurinella, Bumastus, Sphaerocoryphe, and Calyptaulax present in the thesis area are probably related to species of the older trilobite faunal assemblages found in North America, all ranging from the late Chazyan (Middle Ordovician) and persisting into younger strata (see Table 5).

The trilobite assemblage present in the thesis area is thus, a part of a trilobite fauna that seem to have been usually widespread in the northern hemisphere between late Middle Ordovician (Trentonian) and early Upper Ordovician (Cincinnatian) times.

GENUS	Middle Ordovician			Upper Ordovician
	Chazyan	Black-riveran	Trentonian (Barneveld)	
Calyptaulax	—	—	—	—?_?
Illaenus	?_?—	—	—	—?
Anataphrus		?—	—	—
Isotelus	?_?—	—	—	—
Ceraurinella	?—	—	—	?
Sphaeocoryphe	?—	—	—	—
Bumastus	?_?—	—	—	—

Table 5 : Chart showing known stratigraphic ranges in eastern North America and northwestern Europe of trilobite genera represented in the Long Point Formation.

PLATE 6

Calyptaulax cf. *incepta*

Figure

1 Specimen AZT. 1:

Dorsal view of the cephalon with incomplete thorax showing 4 nearly complete segments, and the pleural portions of further segments.

X4.

2 Specimen AWT. 1c:

Dorsal view of the cephalon showing glabella with three lateral glabellar furrows, almost isolated preoccipital lobes, and the large schizochroal eyes. Anterior to the glabella the cephalic margin is upturned.

X 7.

3 Specimen AWT. 1p:

Dorsal view of triangular pygidium with deep axial and pleural furrows anteriorly. The furrows become faint when traced posteriorly. Both pleural and interpleural furrows are also distinct anteriorly.

X 5.

PLATE 6

Fig. 2

Fig. 1

Fig. 3

PLATE 7

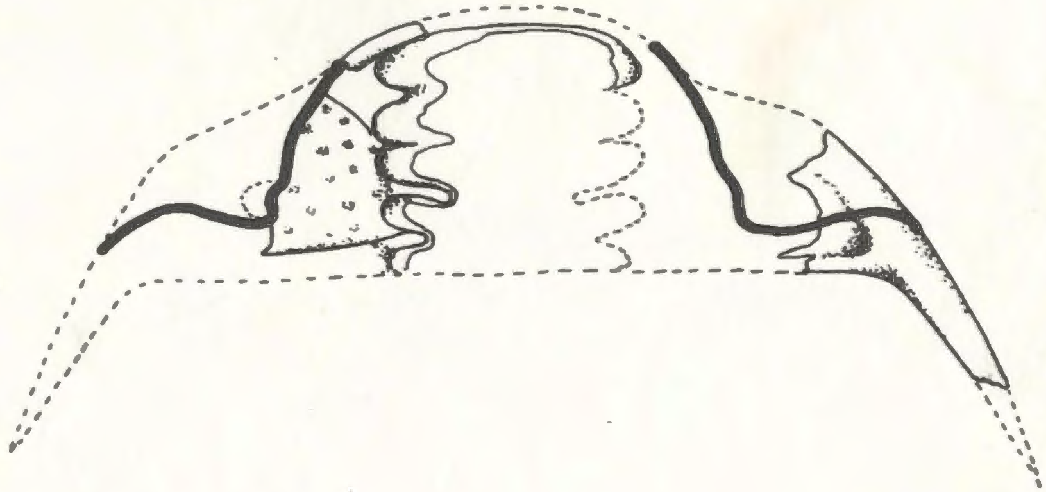


Fig. 1 *Ceraurinella* *sp. ind.* **1** X 1½ (AWT. 2)
Reconstruction of dorsal view
of cephalon.

PLATE 8

Ceraurinella sp.ind. 1

Figure

1 Specimen AWT. 2 :

Dorsal view of exfoliated cephalon, retaining part of the left side of the glabella with left fixigena and eye platform. The eye is situated opposite the lateral glabellar furrow 2p.

X 1½.

Ceraurinella sp.ind. 2

2 Specimen AWT.3 :

Dorsal view of incomplete cranidium with whole glabella and right fixigena present. Note deep axial furrow separating the highly convex glabella from the pitted fixigena.

X 9.

PLATE 8

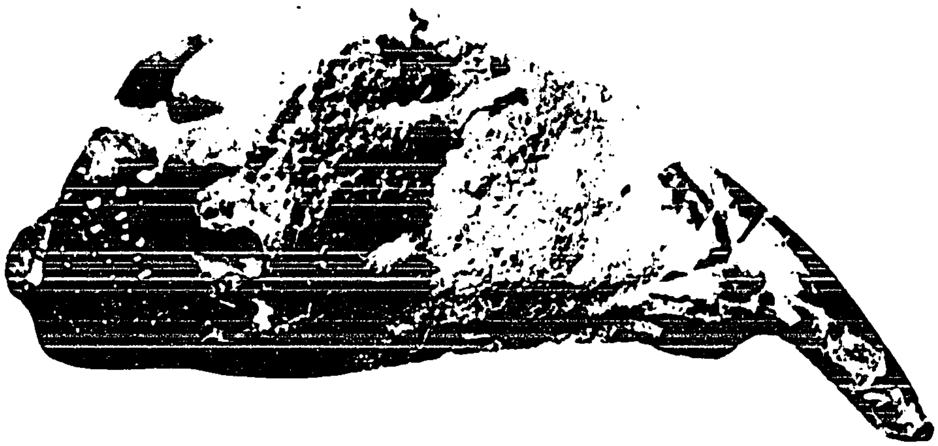


Fig. 1

Fig. 2

PLATE 9

Sphaerocoryphe aff. robusta

Figure

1 Specimen AWT. 4 :

Dorsal view of part of cephalon showing the bulbous frontal lobe.

X 7.

2 Dorsal view of diagrammatic reconstruction of the same cephalon as shown in Fig. 1, showing the inflated frontal glabellar lobe, the lateral preoccipital lobes and the prominent subglobose eyes.

X 7.

3 Right-lateral view of diagrammatic reconstruction of the same cephalon as shown in Fig. 1.

X 7.

Fig. 1

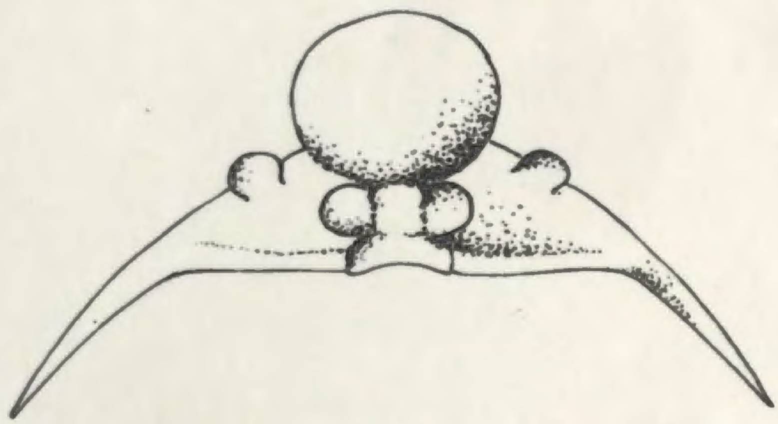


Fig. 2

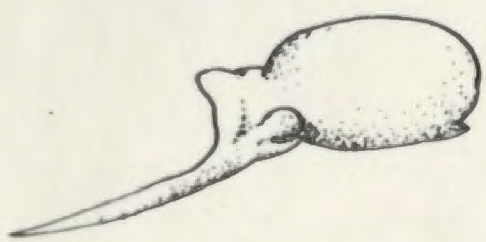


Fig. 3

PLATE 10

<u>Anataphrus</u> aff. <u>borraeus</u>

Figure

1 Specimen AWT. 5 :

Dorsal view of cephalon. Note asaphid type facial suture, and large 'crescentic' eye. The glabellar tubercle is located immediately in front of the area corresponding to the occipital furrow.

X 2½.

2 Specimen AWT. 5 :

Anterior view of cephalon showing pre-ocular part of the facial suture lying parallel with, and close to, the cephalic margin.

X 2½.

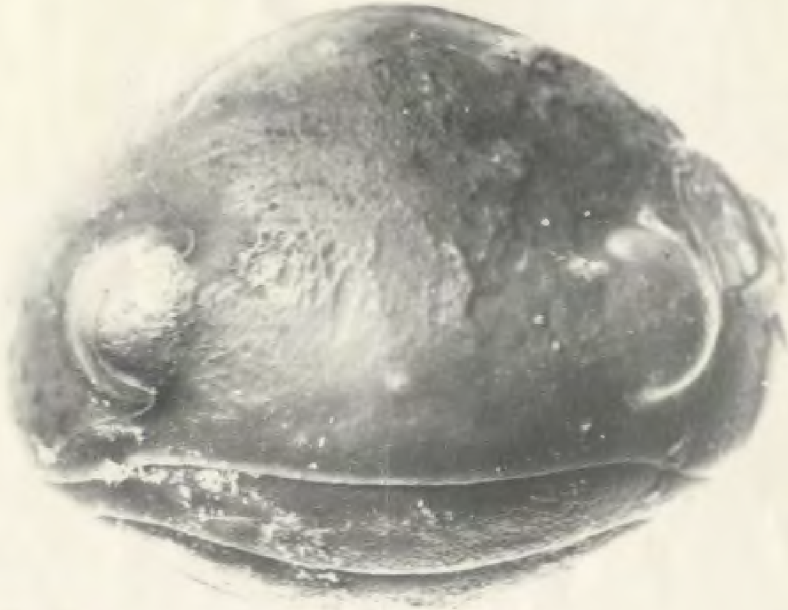


FIG. 1

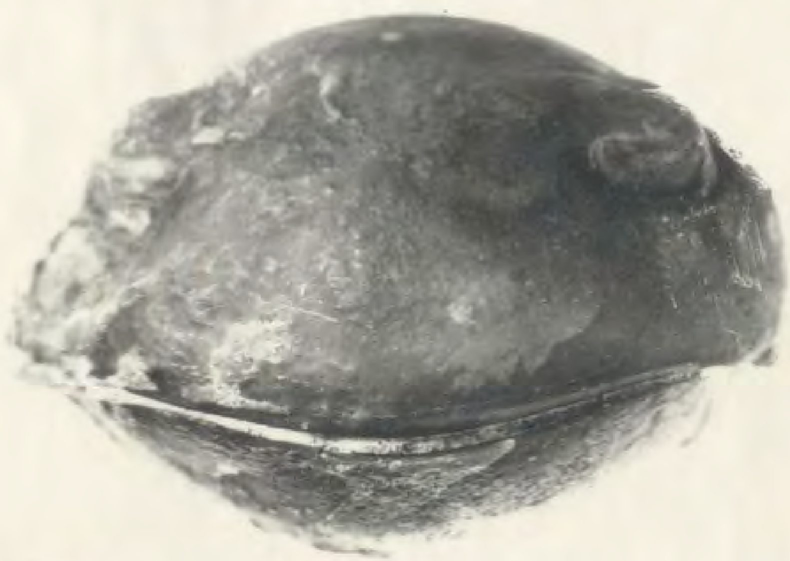


FIG. 2

PLATE 11

Anatapbrus aff. borraeus

Figure

1 Specimen AWT. 5 :

Posterior view, showing thoracic axis which is broader than the pleural region.

X 2½.

2 Specimen AWT. 5 :

Lateral view showing that the exoskeleton is almost isopygous and that it has a smoothly curved lateral profile.

X 2½.

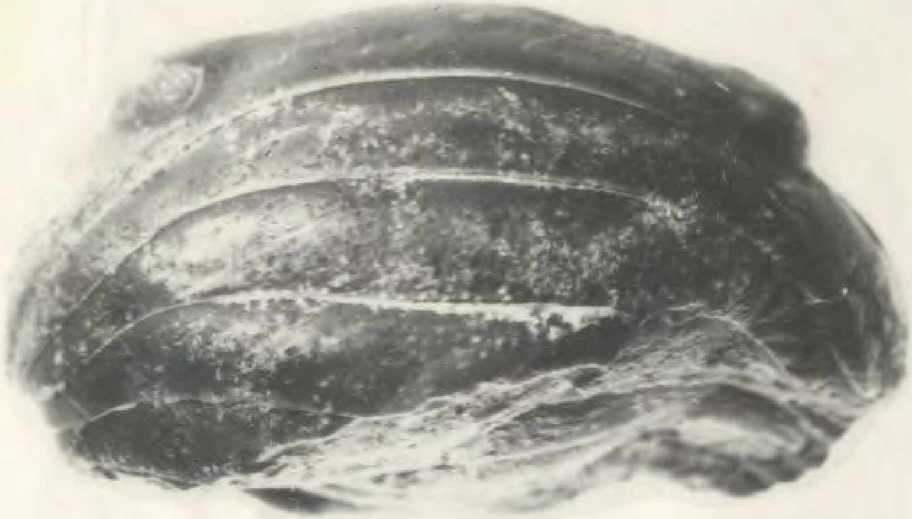


FIG. 1

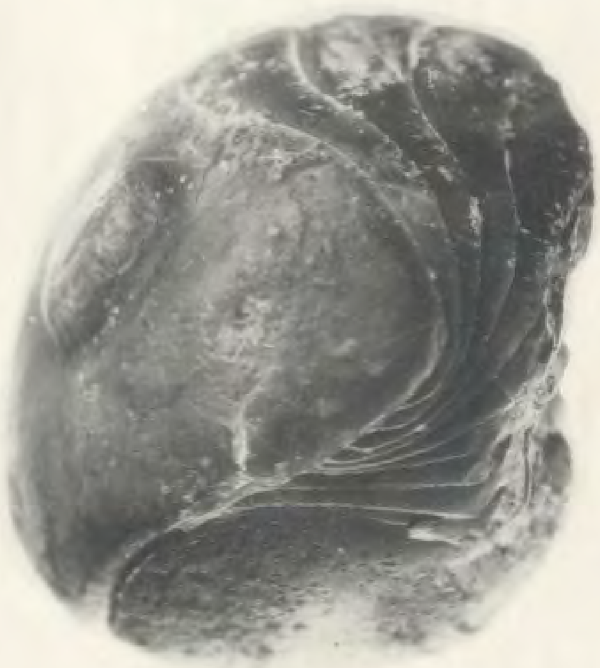


FIG. 2

PLATE 12

Isotelus cf. gigas

Figure

1 Specimen AWT. 6 :

Enrolled specimen showing cephalon with conical eyes.

X 2.

2 Specimen AWT. 6 :

Right-lateral view showing exposed doublure with terrace ornamentation sub-parallel to the cephalic border.

X 2.

3 Specimen AWT. 6 :

Thorax showing elevation of conical eye.

X 2.

4 Specimen AWT. 6 :

Thorax with broad axial portion. Note marked geniculation between the adaxial and abaxial ends, and also the oblique furrows of the pleurae.

X 2.

5 Specimen AWT. 6 :

Dorsal view of pygidium with broad axis and smooth pleural fields.

X 2.

PLATE 12

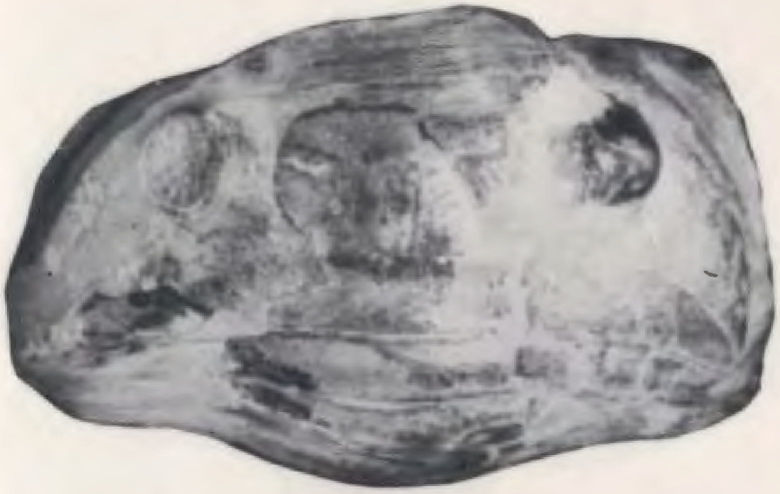


Fig. 1

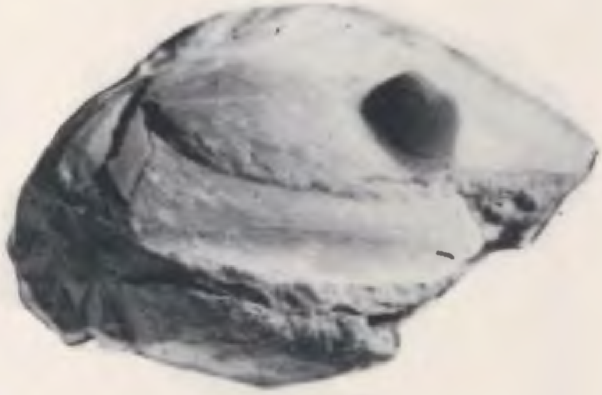


Fig. 2

Fig. 3

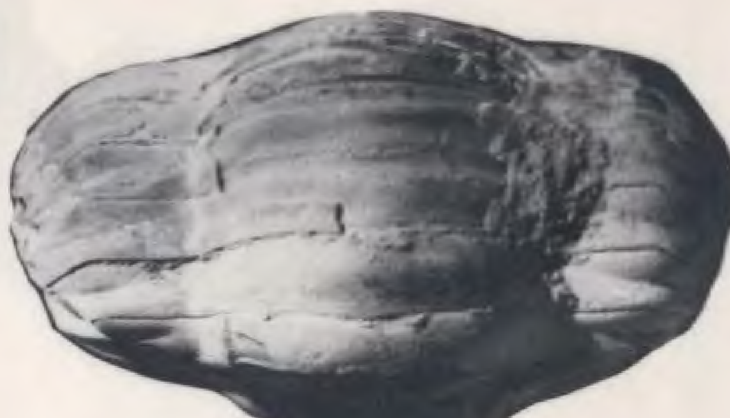


Fig. 4

Fig. 5

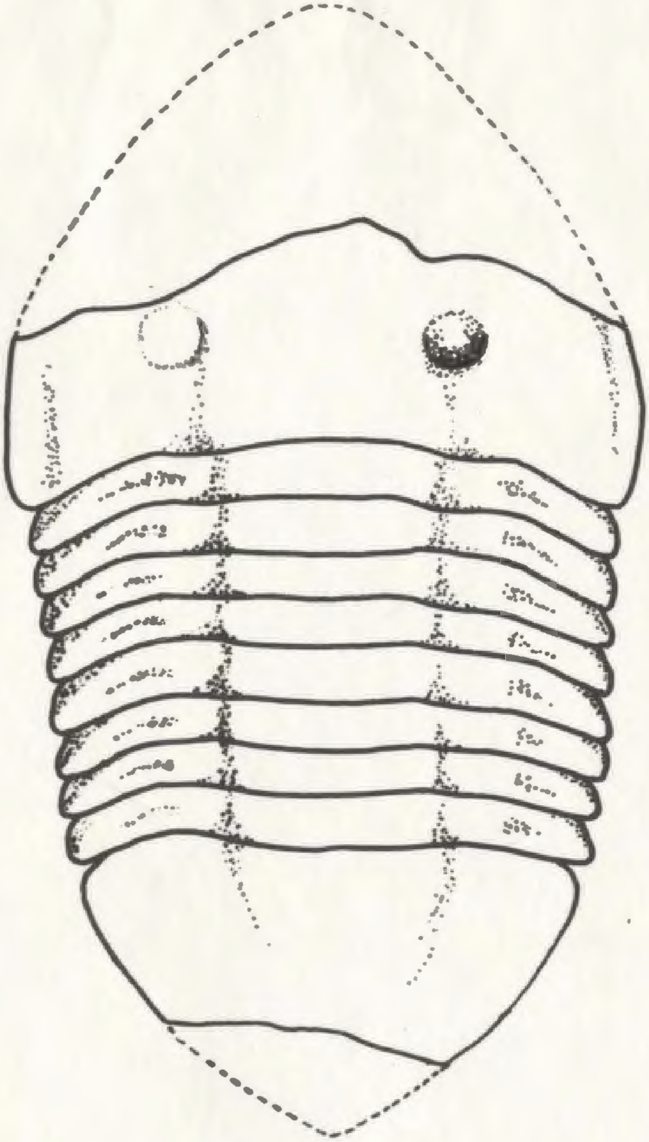


Fig. 1 *Isotelus cf. I. gigas* X 2 (AWT. 6)

Reconstruction of dorsal view of whole specimen.

PLATE 14

Illaenus sp. ind. 1

Figure

1 & 2 Specimens AWT. 7a and AWT. 7b :

Cephalon showing general shape with short dorsal furrows.

X 6.

Bumastus sp.ind.

3 Specimen AWT. 9 :

Dorsal view of part of cephalon.

X 2.

Fig. 1

Fig. 2

Fig. 3

PLATE 15

Illaenus sp.ind. 2

Figure

1 Specimen AWT. 8a :

Cast of dorsal view of specimen showing ovoid cephalon and 10 thoracic segments.

X 3.

2 Mould, of the same specimen as shown in Fig. 1.

X 3.

3 Specimen AWT. 8b :

Dorsal view of disarticulate thorax with 7 thoracic segments.

X 2½.

PLATE 15

Fig. 1

Fig. 2

Fig. 3

PLATE 16

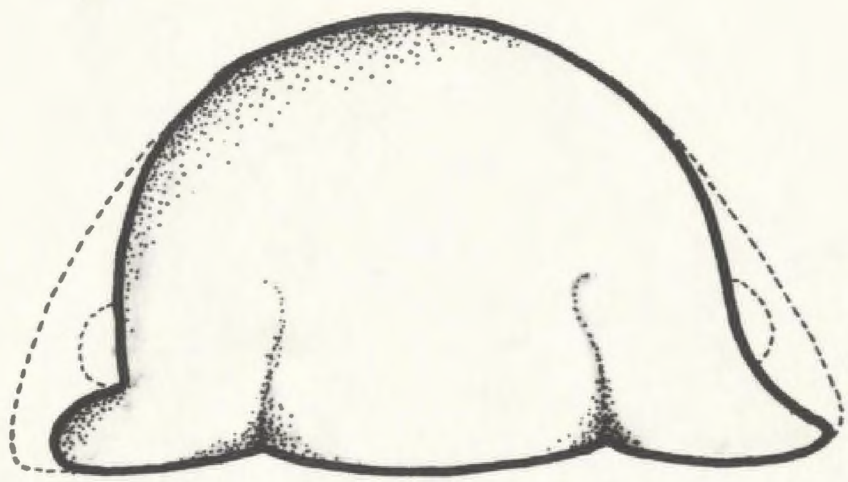


Fig. 1 Bumastus *sp. ind.* X 2 (AWT. 9)
Reconstruction of dorsal view of cephalon.

CHAPTER IV

BRACHIOPODA

Introduction. The brachiopods constitute an important group of fossils in the Long Point Formation. They are present in the Black Duck, LeRoy and Misty Cove Members of the Formation that underlie Long Point. The brachiopods are classified to family level.

Family DISCINIDAE Gray, 1840

Subfamily ORBICULOIDEINAE Schuchert & Le Vene, 1929

Genus ORBICULOIDEA d'Orbigny, 1847

Orbiculoidea aff. O.lamellosa d'Orbigny, 1847

Plate 17, figs. 1-3.

Material. Specimen AWB 1a: Partly exfoliated pedicle valve showing ventral surface. Specimens AWB 1b and AWB 1c: partly exfoliated brachial valves showing dorsal surface. The specimens are from three feet above the base of the Misty Cove member along the west coast, one and a quarter miles south of the southern end of the offshore pebble bar.

Diagnosis. Subcircular valves with concentric ornamentation. Track of pedicle opening relatively narrow extending along posterior slope of pedicle valve.

Description. The valves are subcircular. The pedicle valve is convex with a subcentral apex and a narrow pedicle track that extends only 3 mm from the apex towards the posterior margin so that the pedicle track does not reach the valve margin which is thus entire. The valve is ornamented with concentric growth lines that are coarser near the apex. The maximum diameter of the pedicle valve is 15 mm. The brachial valves are gently convex, their apices are subcentral and they bear concentric growth lines. The maximum diameter for the brachial valve is 14mm.

Remarks. This form is distinguished by the circular outline of its valves, its low convexity, subcentral apex, concentric growth lines, the pedicle groove extending from the apex but not reaching the margin, and its diameter. These characters are very similar to that of the inarticulate brachiopod *Orbiculoidea lamellosa* from the Cobourg beds of the Ottawa Formation (Wilson, 1946).

Family STROPHOMENIDAE King, 1846

Subfamily STROPHOMENIDAE King, 1846

Genus TRIGRAMMARIA Wilson, 1949

Trigrammaria sp.ind.

Plate 18, fig. 1; Plate 19, fig. 1.

Material. Specimen AWB 2: Interior of pedicle valve showing muscle scars. From two feet below the top of the Black Duck member along the east coast, one and a quarter miles northeast of Black Duck Brook post-office.

Diagnosis. The valve is sub-triangular in outline with rounded dorsal median fold, small pedicle muscle scar and simple teeth.

Description. The pedicle valve is convex. It is wider than long with a straight hinge line bearing simple teeth. The umbonal region is gently convex, with sides gently rounded and anterior subnasute margin. The suboval adductor muscle scar is enclosed within larger diductor muscle scars. A small pedicle muscle scar is present.

Dimensions. width 44 mm (max.) below hinge line
median length 38 mm.

Remarks. The specimen was preferably placed in the genus *Trigrammaria* and not *Strophomena* because of its sub-triangular outline, and small pedicle muscle scar (Wilson, 1946).

Family STROPHOMENIDAE King, 1846

Subfamily RAFINESQUININAE Schuchert, 1893

Genus RAFINESQUINA Hall & Clarke, 1892

Refinesquina aff. R. *praecursor* Raymond, 1921

Plate 19, fig. 2

Material. Specimen AWB 3: Complete exterior of pedicle valve, from four feet above the base of the LeRoy member along east coast, three miles northeast of Black Duck Brook post-office.

Diagnosis. Shell concavo-convex or, rarely, resupinate, and wider than long. The hinge line is often slightly greater than midwidth. The valves are broadly U-shaped in outline. They are unequally parvicostellate with feebly concentric rugae which are impersistent postlaterally. Ventral muscle scars are sub-circular with small notothyrial platform. The cardinal extremities are nearly at right angles.

Description. The pedicle valve is wider than long and is broadly U-shaped in outline, with the anterolateral and anterior margins forming a broad smooth curve. Convexity of the valve is low. The valve is unequally parvicostellate with impersistent rugae postlaterally. The concentric growth lines are strong and have a faint crenulated appearance due to crossing of radial costae.

The maximum width of the valve is close to the hinge line. A groove along the periphery of the valve possibly represents the line of regeneration of the damaged valve.

Dimensions.	hinge width	16 mm
	maximum width	17 mm
	median length	12 mm

Remarks. This specimen is similar in its external features to the pedicle valve of Rafinesquina praecursor. It also has a ratio of length to width (1:1.41) that is in accord with the ratio characteristic of R.praecursor (Salmon, 1942).

Rafinesquina aff. R.loxorhytis Meek,

Plate 19, fig. 3

Material. Specimen AWB 4: Complete brachial valve showing interior and the cardinalia. From three feet above the base of the LeRoy member along east coast, three miles northeast of Black Duck Brook post-office.

Description. The brachial valve is U-shaped in outline and is very gently concave with maximum concavity located near the middle of the valve. The hinge line is straight and the cardinal extremities are alate. Postlateral rugae are present. The dental sockets are small. The cardinal process is bilobed and has a very short median ridge. The notothyrial platform is characteristically anchor shaped. Muscle scars are feebly impressed. Small adductor muscle scars have a feebly projecting trans-muscle septum.

Dimensions.	brachial length	39 mm
	hinge width	44 mm
	midwidth	42 mm

Remarks. This specimen resembles Rafinesquina loxorhytis (Meek), in size and morphology (Shimer & Schrock, 1944).

Family STROPHOMENIDAE King, 1846

Subfamily OEPIKINAE Sokolskaya, 1960

Genus OEPIKINA Salmon, 1942

Oepikina cf. O.septata Salmon, 1942

Plate 19, figs. 4-5

Material. Specimens AWB 5a and 5b: Well preserved brachial valve interiors with a bilobed cardinal process and septal ridges. From three feet above the base of the LeRoy member, along east coast, one and a quarter miles northeast of Black Duck Brook post-office.

Diagnosis. The brachial valve has finely granular shell structure with 5 radial ridges in the interior, the median ridge is longer or nearly as long as the lateral pairs. The post-lateral borders of the adductor scars are marked by well developed notches. The outline of the shell is U-shaped, widest at the hinge line, very gently curved and dorsally geniculate.

Description. The outline of the valve is U-shaped with a straight hinge line. The median line of the brachial interior is marked by a ridge starting at the base of the prominent bilobed cardinal process where it is low and broad, which becomes narrower and sharper towards the anterior. There are two pairs of lateral septa; a posterior pair which divides the posterior adductor scars into two more or less unequal areas, and an anterior pair, nearly parallel and long as the median septum, that mark the lateral margins of the anterior adductor scars. The anterior septa are marked by well developed irregular notches. The trans-muscle septa are well developed and are high anteriorly. A marked sub-peripheral rim is present. The surface of the visceral area is highly pustulose, and very faintly fluted with vascular markings. The surface outside the visceral area is finely pustulose, and appears smooth to the unaided eye, but under the microscope is seen to be minutely granular.

Dimensions.	Brachial length	14 mm
(both valves)	hinge width	16 mm
	midwidth	16 mm
	thickness	2.5 mm
	geniculation 9 mm from the beak.	

Discussion. The outward shape of the specimen is like and could be misidentified for *Rafinesquina* or *Leptaena*. However, it differs from them by its presence of 5 internal septa in the brachial valve. The specimen resembles *O.septata* in its distinct pustulose brachial interior, with its stout cardinal process, 5 septa, and a median septum having a low posterior end that becomes narrower and sharper anteriorly (Salmon, 1942).

Family LEPTESTIIDAE Opik, 1933

Subfamily LEPTESTIINAE Opik, 1933

Genus SOWERBYITES Teichert, 1937

Sowerbyites aff. *S.triseptatus* (Willard, 1928)

Plate 20, figs. 1-2; Plate 21, fig. 1.

Material. Specimens AWB 6a and AWB 6b: Complete interiors of brachial valve showing septa, cardinalia and cardinal processes. Both specimens are from three feet above the base of the LeRoy member, on the east coast, opposite Black Duck Brook post-office.

Diagnosis. Shell is semicircular in outline and is wider than long. Straight hinge line. The median septum of the brachial valve extends through the valve in high relief, and the lateral septa are well developed. The cardinal process is trilobed.

Description. The brachial valve is semicircular in outline and is wider than long. The internal surface of the valve is lamellose and it has wrinkled, thin lamellae along its margin. The cardinal extremities are slightly alate. The cardinal process is trilobed and differentiated into a high median crest and two subsidiary lateral ridges. The socket ridges are pointed. The valve is gently concave in the posterior two-thirds but slightly geniculated toward the brachial valve in the anterior third. There is an elevated sub-peripheral rim. Internally, the valve has a single, strongly reliefed median septum with a bulbous anterior end, and a pair of lateral septa which are gently curved. The sub-median septa are slightly divergent and curved. The outer lateral septa are gently curved inward and joined to the median septum at the posterior end.

Dimensions.	length	midwidth	hingewidth
AWB 6a	10 mm	19 mm	20 mm
AWB 6b	9 mm	16 mm	17 mm

Remarks. This species is like S.triseptatus (Willard) in size, the generally alate cardinal extremities and the strong internal features. It is smaller and more convex than S.gildersleevei, and larger and less convex than S.subnastus (Wilson, 1946).

Family LEPTELLINIDAE Ulrich & Cooper, 1936

Subfamily LEPTESTIINNAE Havlicek, 1961

Genus BILOBIA Cooper, 1956

Bilobia cf. B.hemisphaerica Cooper, 1956

Plate 22, figs. 1-4

Material. Specimen AWB 7a: a well preserved complete specimen. Specimen AWB 7b: shell treated with 1:10 acetic acid to expose its internal mould revealing muscle area and pits formed by prominent pseudopunctae. The specimens are from five feet below the top of the exposed sequence of the Misty Cove member on the west coast, one and a half miles south of the north end of the offshore pebble bar.

Diagnosis. Shell concavo-convex, small, with tumid pedicle valve. The cardinal extremities are auriculate with a multicostellate surface which has a few accentuated costellae in a field of fine costella. The teeth are thick with stout dental plates extended as ridges. The brachial valve is nearly hemispherical and the visceral disc is bilobed in character.

Description. The shell is small, concavo-convex, and almost hemispherical in lateral profile. It is wider than long with auriculate cardinal margins. The greatest width is at the hinge line. The anterior margin of the shell shows variation in shape, from broadly round in some specimens to nasute in others. The surface is multicostellate. The posterior swollen part of the pedicle valve in specimen shows 3 accentuated costellae while at the anterior margin there are 17 accentuated costellae in a field of fine costellae. The costellae of the brachial valve are faint. The pedicle valve is nearly hemispherical in lateral profile and narrowly convex in anterior profile. The interarea is short, curved, and acutely hypercline.

The brachial valve is deeply concave with the greatest concavity at about the middle. The interarea is hypercline. The visceral disc is bilobed in character.

The pedicle interior of the umbonal region shows the deeply impressed muscle field. The impressions of dental plates extended as stout ridges are found around the outer margin of the muscle field. Pits formed by prominent pseudopunctae are also present.

Dimensions.	pedicle valve		brachial valve
length	9.5 mm		7.5 mm
hinge width	9.5 mm	mid-width	8.0 mm
thickness	2.5 mm		

Discussion. The specimen could be misidentified as *Leptellina* but for its greater sphericity, and larger pedicle muscle field. The species resembles *Bilobia hemisphaerica* in size, dimensions, external and internal morphology. The species is characterized by the tumid pedicle valve, thus distinguishing it from *B.virginiensis* (Cooper, 1956).

Family SOWERBYELLIDAE Opik, 1930

Subfamily SOWERBYELLINAE Opik, 1930

Genus SOWERBYELLA Jones, 1928

Sowerbyella aff. *S.eximia* Cooper, 1956

Plate 23, figs. 1-2

Material. Specimen AWB 8: A complete shell showing ornamentation of the pedicle and brachial valves. The specimen is from one foot below the top of the LeRoy member, on the east coast, half a mile from the north end of the offshore pebble bar.

Diagnosis. Subrectangular, concavo-convex shell with parvicostellation segregated into segments by accentuated costellae. Costellae are either smooth or beaded. The length is two-thirds the width. The interareas are long and strongly apsacline.

Description. The shell is concavo-convex with a subrectangular outline. The hinge forms the widest part of the shell. The cardinal extremities are broadly rounded.

The pedicle valve is convex in lateral profile, with the maximum convexity in the median region. The anterior profile is strongly and broadly arched. The beak and umbo are inconspicuous. The interareas are long and strongly apsacline.

The brachial valve, deeply concave in the median region, becomes less concave laterally.

The ornamentation consists of unequal sized costellae, with 6 fine costellae separated by a coarser one.

Dimensions.	Hinge width	13 mm
	mid-width	11 mm
	brachial length	7 mm

Remarks. The specimen resembles S. eximia, apart from its size, which is two-thirds that of S. eximia, and in having six fine costellae instead of five between the coarser ones. (Cooper, 1956).

Family CAMERELLIDAE Hall & Clarke, 1894

Subfamily CAMERELLINAE Hall & Clarke, 1894

Genus CAMERELLA Billings, 1859

Camerella cf. C. bicostata Cooper, 1956

Plate 24, figs. 1-6

Material. Specimen AWB 9a: A complete well preserved specimen. Specimen AWB 9b: shell sectioned vertically to expose the septum in the brachial interior. The specimens are from two feet below the top of the Black Duck member, on the east coast, two and a quarter miles northeast of Black Duck Brook post-office.

Diagnosis. Shell is subtriangular in outline and biconvex. The brachial valve is deeper than the ventral valve which is only moderately convex. A deep sulcus and a well elevated fold are present. Costae are well defined and angular.

Description. The shell is subtriangular in outline. The brachial valve is strongly convex, and the pedicle valve is moderately convex. The pedicle valve has a pointed and incurved beak with a relatively large delthyrial foramen. The interarea is narrow. The sulcus is deep with two costae originating 4 to 5 mm interior from the beak. The fold is well elevated with three costae. The flanks of the shell are well rounded and steeply sloping to the margin and bear 4 costae. All costae are angular. The median septum is short.

Dimensions.		
	brachial length	11 mm
	width	14 mm
	thickness	10 mm

Remarks. The specimen resembles *C.bicostata* in external morphology except as regards ~~to~~ its thickness which is less in *C. bicostata*, 7.4 mm. The species is distinguished by its fairly strong elevated fold, well depressed sulcus and the definite number of costae present in the fold, sulcus and flanks. The species is characterized by its large size, 2 costae in the sulcus and the lack of ornamentation in the posterior part (Cooper, 1956).

Family PLAESOMYIDAE Schuchert, 1913

Subfamily PLAESIOMYINAE Schuchert, 1913

Genus CHAULISTOMELLA Cooper, 1956

Chaulistomella cf. C.crassa Cooper, 1956

Plate 23, fig. 3; Plate 25, fig. 1

Material. Specimen AWB 10: part of a pedicle valve interior. The specimen is from three feet below top of the Black Duck member on the east coast, one and a quarter miles northeast of Black Duck Brook post-office.

Diagnosis. The shell is subrectangular and resupinate in profile. The hinge line is wide. The pedicle valve is unevenly convex, the posterior half gently convex and the anterior half gently concave. The muscle field is subquadrate.

Description. The shell is subrectangular in outline and wider than long. The sides are gently rounded and the anterior margin is broadly rounded. The hinge is straight and is slightly wider than the midwidth of the shell. The cardinal extremities form small ears. The valve is unevenly convex in lateral profile, the posterior half is gently convex and the anterior half is gently concave. The antero-median region is gently flattened with lateral extremities deflected moderately in the direction of the brachial valve. The interarea is moderately long. The interior of the valve has an indented muscle field. The muscle field has same length and width, and is slightly over a third of the length of the valve.

Dimensions.	Hinge width	18 mm (reconstructed)
	Brachial length	16 mm
	Midwidth	17 mm

Remarks. This specimen is similar to C. crassa in shape and internal morphology of the pedicle valve. Only two specimens of the species have been found in Oklahoma and is of Porterfieldian in age. The species is considered a rare fossil (Cooper, 1956).

Family PLAESIOMYIDAE Schuchert, 1913

Subfamily PLAESIOMYINAE Schuchert, 1913

Genus PLAESIOMYS Hall & Clarke, 1892

Plaesiomys sp. ind.

Plate 26, figs. 1-4

Material. Specimen AWB 11a: a complete cast of the exterior of a pedicle valve. Specimen AWB 11b: a cast of the interior of a brachial valve. The specimens are from the top of the exposed sequence of the Misty Cove member on the east coast, a quarter mile south of the lighthouse.

Diagnosis. The shell is subquadrate in outline, variably convexo-concave, and moderately convex in lateral profile. The pedicle valve has slightly greater depth than the brachial valve. Costate to costellate. Dental plates are short. The brachial valve has a sulcus originating at the beak and extending to the anterior margin and is shallow throughout its length. The cardinal process is differentiated into a crenulated myophore and shaft.

Description. The pedicle valve is subquadrate in outline with gently convex lateral margins. In lateral profile the shell is moderately convex with the greatest convexity located slightly anterior to the umbo. The front third of the valve is slightly flattened. The surface is costellate. The second order costella branch off from the first order costellaabout the middle of the valve. The fold is not well defined.

The brachial valve is subquadrate in outline, and costellate. The cardinal process is differentiated into a bulbous myophore and a shaft which extends about half the length of the valve.

Dimensions	pedicle valve	brachial valve
length	7.5 mm	7.5 mm
midwidth	9.0 mm	9.0 mm

Remarks: The specimen was placed in the genus *Plaesiomys* because of its close similarity with the illustrations provided in Volume H of the Treatise on Invertebrate Paleontology (Moore, 1965), of the shells of *P.subquadrata* from the Richmondian of Ohio.

Range of Brachiopods from the Long Point Formation

Nine of the eleven varieties of brachiopod from the Black Duck, LeRoy and Misty Cove Members of the Long Point Formation have been related to a particular species. The other two have been identified only to generic level.

Table 6 , indicates the range of these brachiopods in relation to the members of the Long Point Formation. From this table it is observed that the brachiopod fauna collected from the thesis area has an age range that is probably from Ashbian to Cincinnatian within the Ordovician. Since there are several brachiopods of Porterfieldian age and only *Camerella bicostata* is from the Ashbian it seems likely either that *C.bicostata* ranges up into the Porterfieldian or that the Long Point Camerella is not *Camerella* cf. *C.bicostata* but a very similar species, since other species of *Camerella* are known elsewhere from younger Ordovician beds.

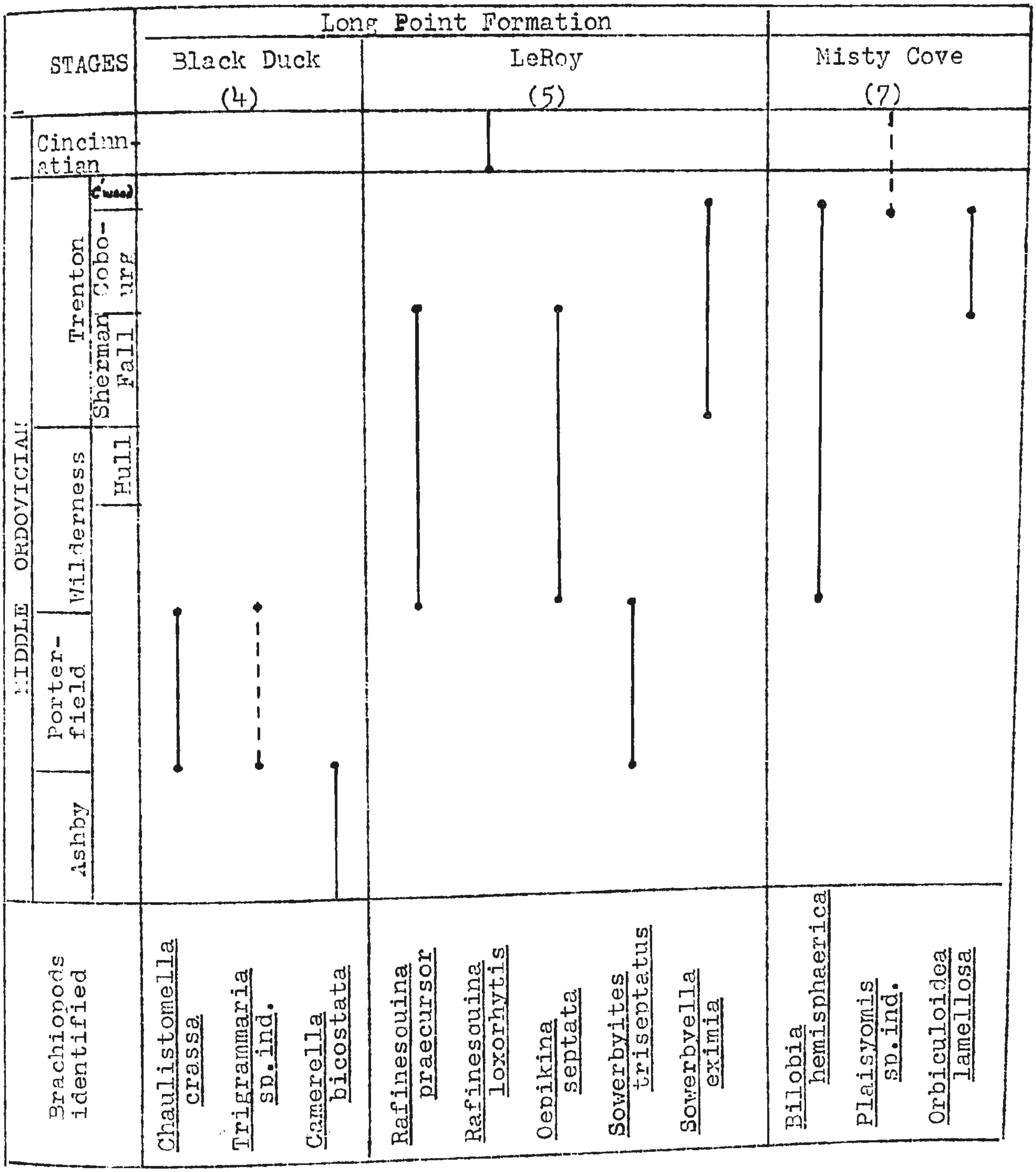


Table 6 : Range of Brachiopods through the Long Point Formation in their respective members.
(after Salmon, 1942; Shimer & Schrock, 1944; Wilson, 1946; Cooper, 1956, Moore, 1965)

PLATE 17

Orbiculoidea aff. O. lamellosa

Figure

1 Specimen AWB 1a:

Partly exfoliated subcircular pedicle valve showing subcentral apex and narrow pedicle track which does not reach the margin.

X 5.

2 and 3 Specimens AWB 1b & AWB 1c:

Partly exfoliated brachial valves with subcentral apices and ornamentation of concentric growth lines.

X5.

PLATE 17

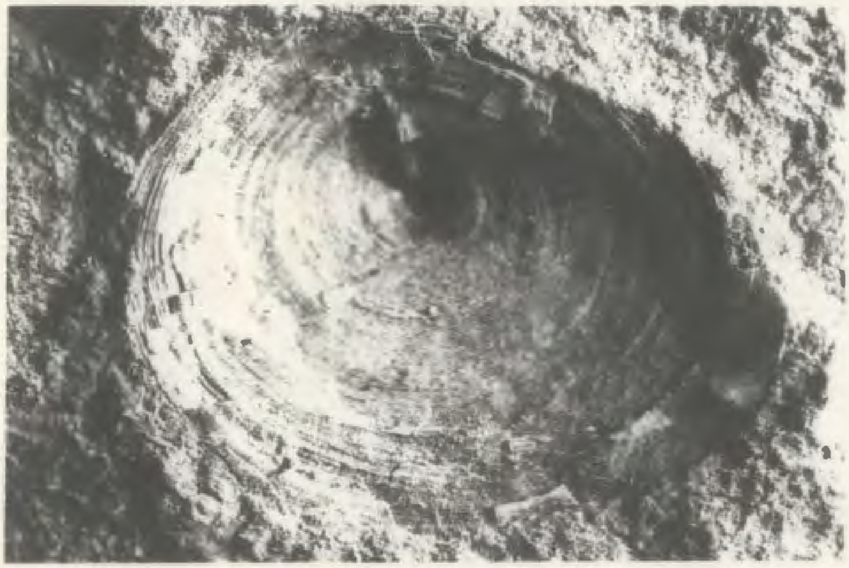


Fig. 1

Fig. 2

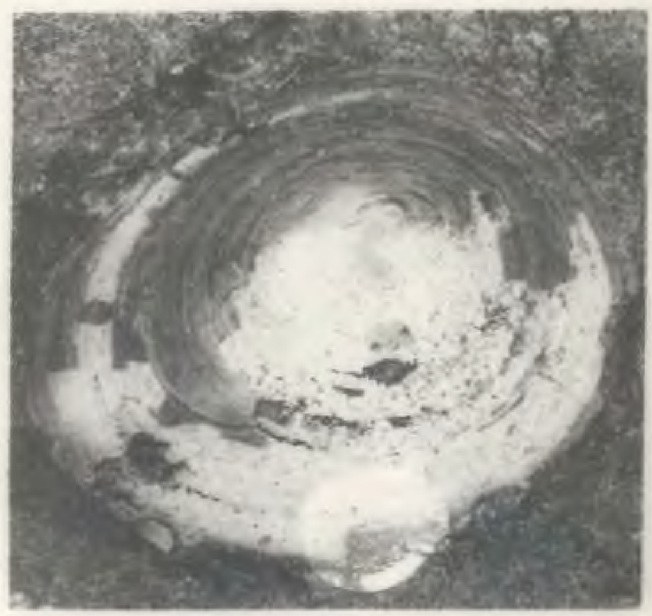
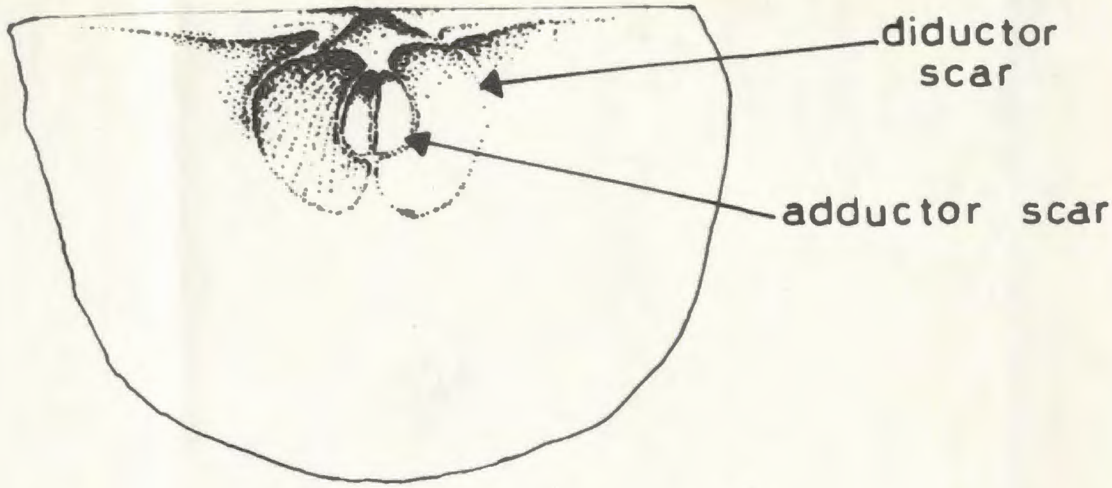


Fig. 3

PLATE 18



a.

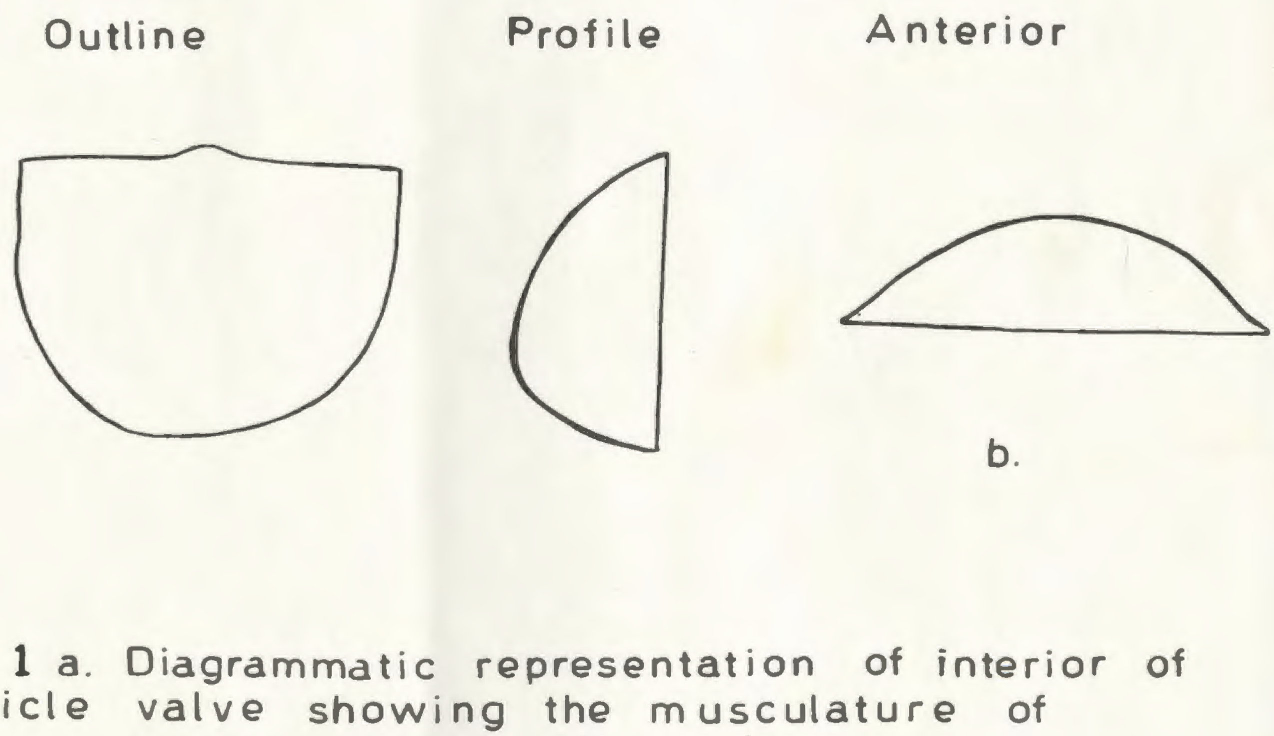


Fig. 1 a. Diagrammatic representation of interior of pedicle valve showing the musculature of *Trigrammaria sp. ind.* x 1½

1 b. Diagram showing High Convexity x1

PLATE 19

Trigrammaria sp.ind.

Figure

1 Specimen AWB 2:

The interior of pedicle valve. Note straight hinge line, simple teeth and small pedicle muscle scar. The suboval adductor muscle scar is enclosed within larger diductor muscle scars.

X 1½.

Rafinesquina aff. R.praecursor

2 Specimen AWB 3:

The complete exterior of pedicle valve showing unequal parvicostellation. Note the maximum width of the valve is close to the hinge line and the U-shaped outline. Note also the regeneration of the damaged margin of the valve.

X 4.

Rafinesquina aff. R. loxorhytis

3 Specimen AWB 4:

The brachial valve showing the complete interior and the cardinalia. The valve is U-shaped in outline with straight hinge line. The cardinal extremities are alate. The cardinal process is bilobed. The notothyrial platform is characteristically anchor-shaped. The muscle scars are feebly impressed. Note the postlateral rugae.

X 1½.

PLATE 19

Oepikina cf. O. septata

Figure	
4 and 5	Specimens AWB 5a and 5b: Brachial valves with U-shaped outline and a pustulose interior. Note the stout bilobed cardinal process, 5 septa, the anterior lateral septa having irregular notches nearly parallel and as long as the median septum. There is a marked sub-peripheral rim and faintly fluted vascular markings. X 4.

PLATE 19

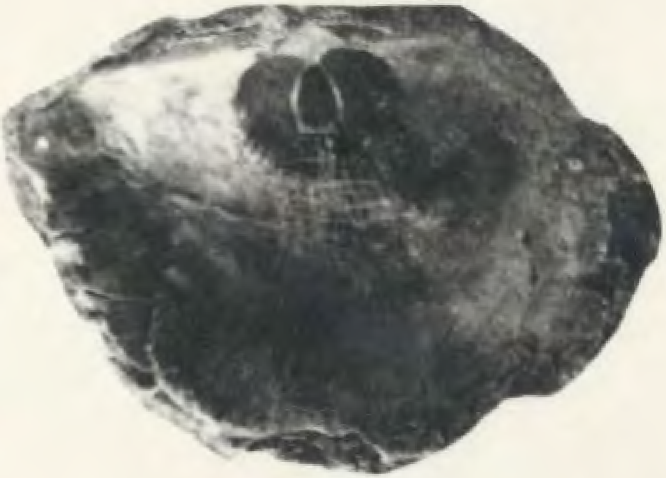


Fig. 1

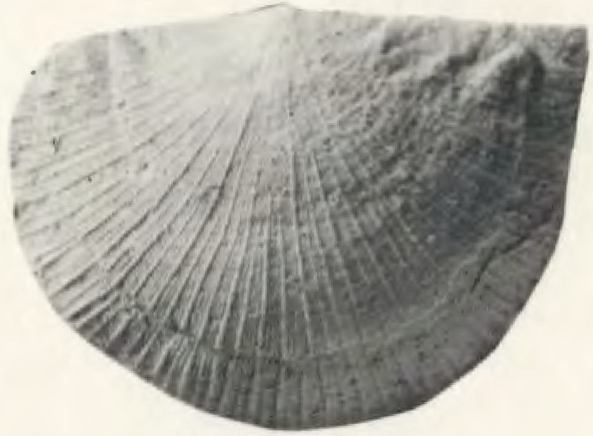


Fig. 2

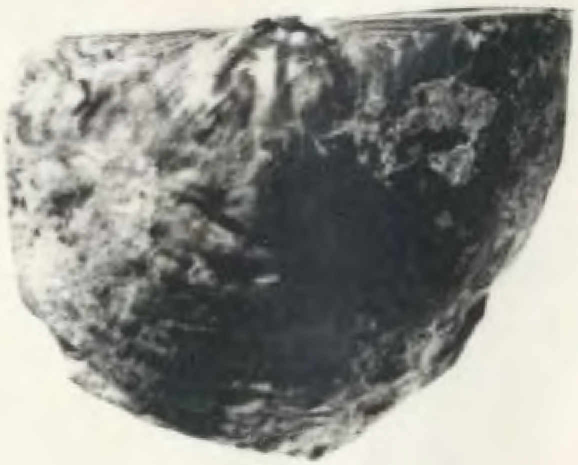


Fig. 3

Fig. 4

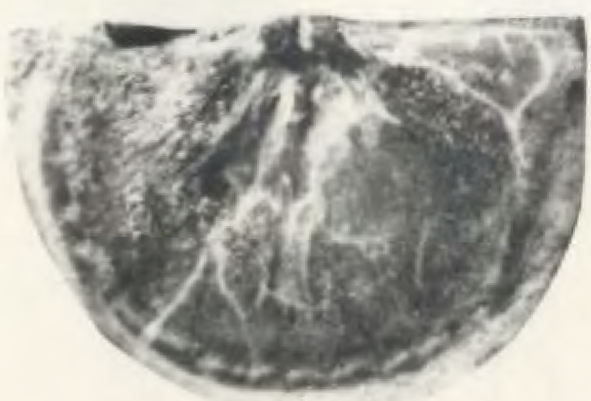


Fig. 5

PLATE 20

Sowerbyites aff. S.triseptatus

Figure

1 Specimen AWB 6a:

Complete interior of brachial valve. The valve is semicircular in outline, wider than long with a straight hinge line. Note the trilobate cardinal process. The median septum has a high relief and the anterior end is bulbous. The sub-median septa are slightly divergent and curved; the outer lateral septa are gently curved inward. The sub-peripheral rim is well marked and elevated.

X $5\frac{1}{2}$.

2 Specimen AWB 6b:

Complete interior of brachial valve. Note the alate cardinal extremities, lamellose interior with wrinkled thin lamellae along the margin.

X $5\frac{1}{2}$.

PLATE 20

Fig. 1

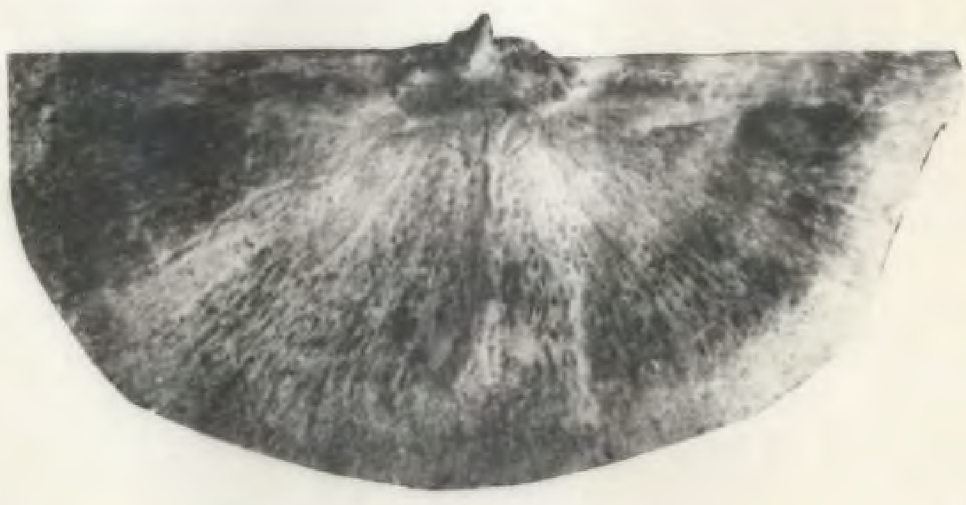


Fig. 2

PLATE 21

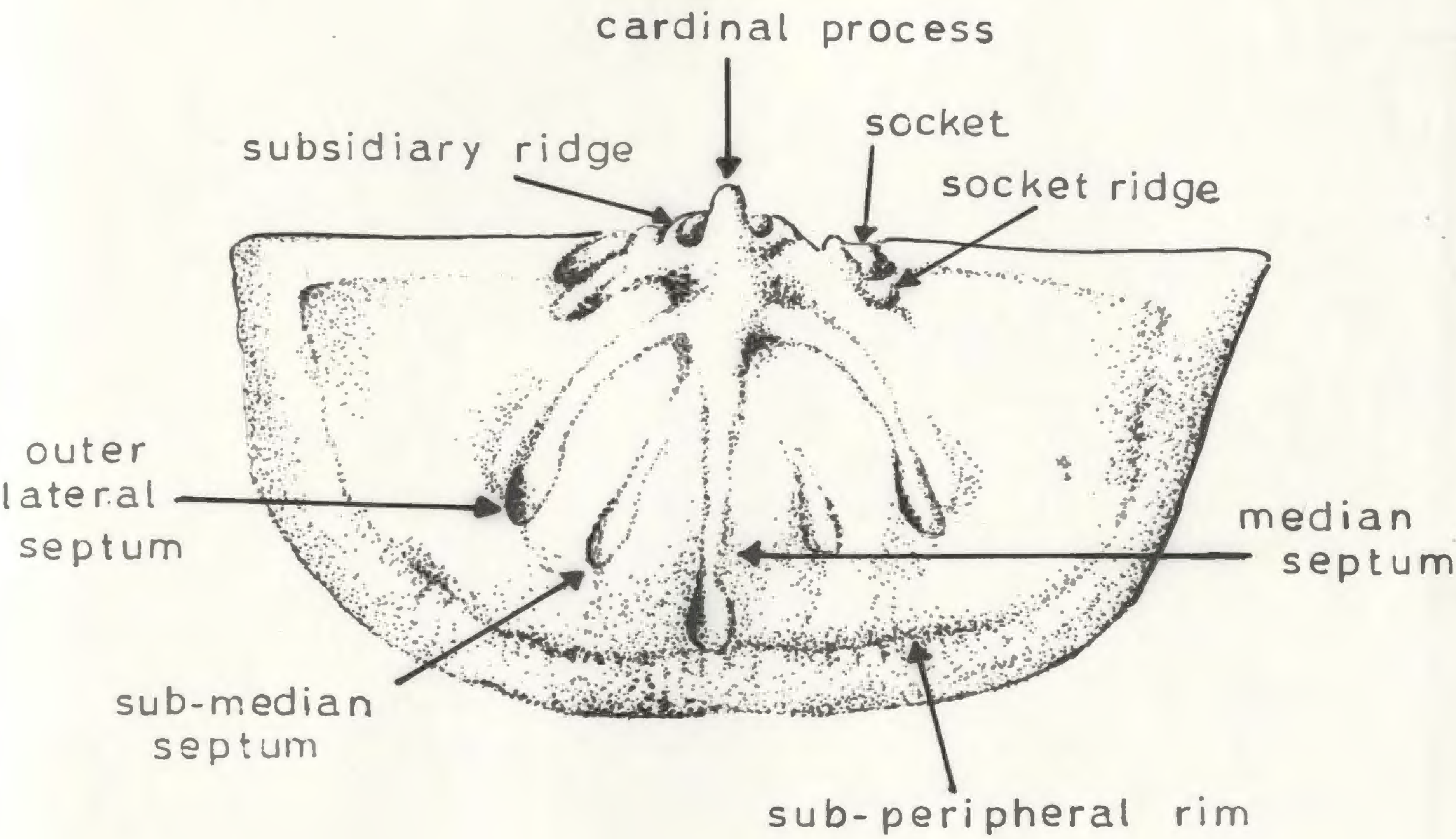


Fig.1 Diagrammatic representation of internal morphology of the brachial valve of ***Sowerbyites aff. S. triseptatus*** X 6.

PLATE 22

Bilobia cf. B.hemisphaerica

Figure

1 Specimen AWB 7a:

Dorsal view of the tumid pedicle valve. Note the nasute shape and multicostellate surface.

X 7.

2 Dorsal view of the brachial valve of the same specimen as in Fig. 1. Note the deep concavity of the valve.

X 7.

3 Specimen AWB 7b:

Umbonal view of the pedicle valve interior, with impressions showing form of the muscle area.

X 7.

4 A reconstruction of fig. 3, showing impressions of dental plates extended as stout ridges around the outer margin of the muscle field, and pits formed by prominent pseudo-punctae.

X 7.

PLATE 22

Fig. 1

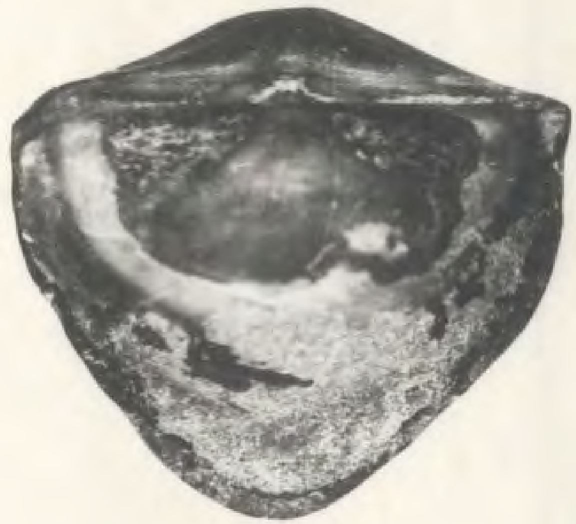


Fig. 2

Fig. 3

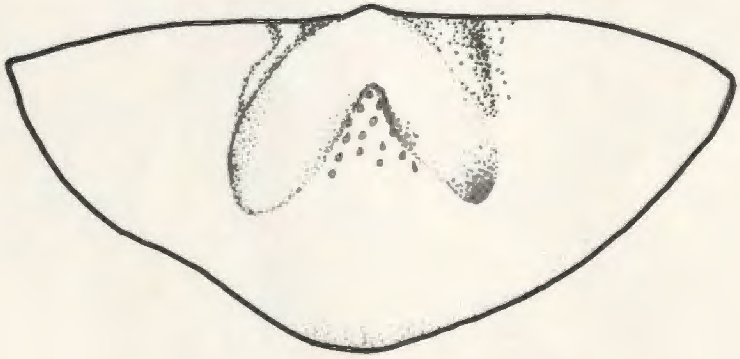


Fig. 4

PLATE 23

Sowerbyella aff. *S.eximia*

Figure

1 Specimen AWB 8:

The brachial valve, showing subrectangular outline and parvicostellation. The hinge forming the widest part. The cardinal extremities are broadly rounded.

X 6.

2 The pedicle valve of the same specimen as in fig. 1.

X 6.

Chaulistomella cf. *C.crassa*

3 Specimen AWB 10:

The pedicle valve with exposed interior. The shell is subrectangular in outline, wider than long with a straight hinge line slightly wider than the midwidth. Note cardinal extremities forming ears and the indented muscle field.

X 4.

PLATE 23

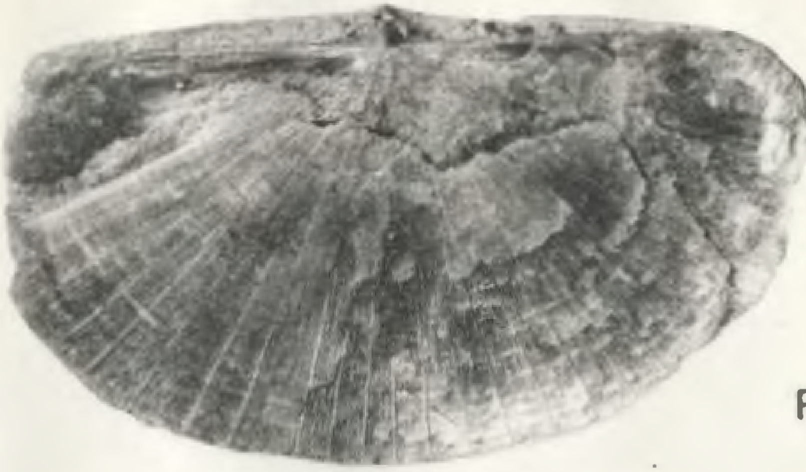


Fig. 1

Fig. 2

Fig. 3

PLATE 24

Camerella cf. C. bicostata.

Figure

1 Specimen AWB 9a:

Drawing of side view showing the convexity of the valves.

X4.

2 Drawing of the brachial view showing fold with two large costae. Note sub-triangular outline of shell and delthyrial foramen.

X 4.

3 Specimen AWB 9b:

Drawing of vertical section through the shell showing the short median septum in the brachial interior.

X4.

4 Drawing of the pedicle view of Specimen AWB 9a showing the sulcus with two large costae.

X 4.

5 Brachial view showing fold with smooth costae.

X 5.

6 Pedicle view showing sulcus with smooth costae.

X 5.

PLATE 24

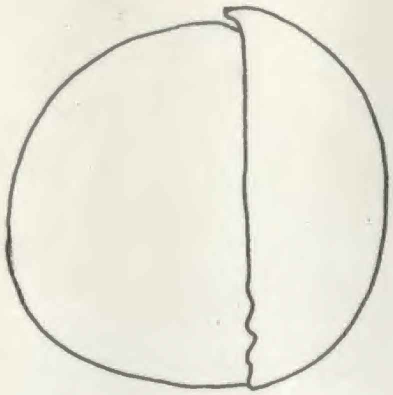


Fig. 1

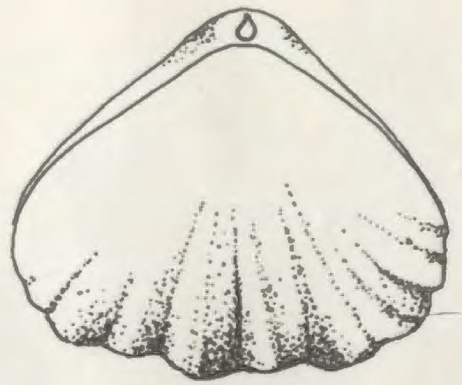


Fig. 2

Fig. 3

Fig. 4

Fig. 5

Fig. 6

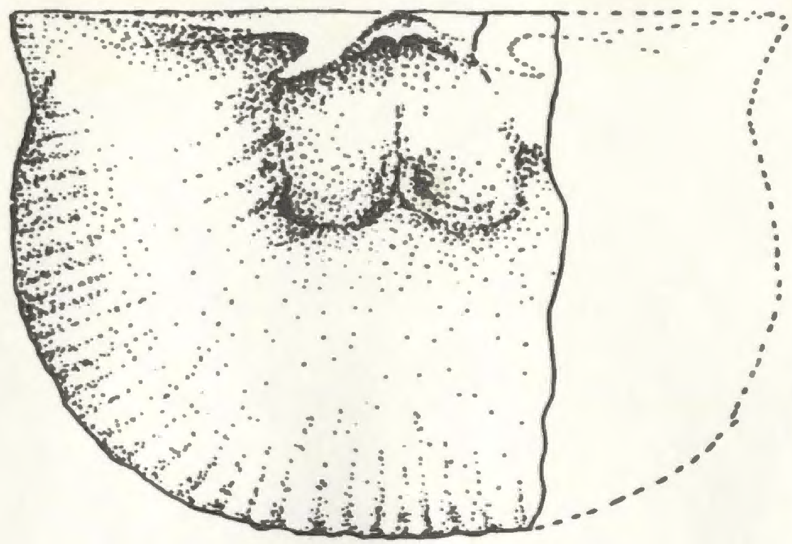


Fig 1. Diagrammatic representation of interior of pedicle valve showing the musculature of *Chaulistomella* cf. *C. crassa* X 4.

PLATE 26

Plaesiomys sp. ind.

Figure

1 Specimen AWB 11a:

Cast of the pedicle valve showing the subquadrate outline and the costellate surface. X 10.

2 Mould of the same specimen as in fig. 1, showing the maximum convexity located slightly anterior to the umbo. Note the second order costella branching off from the first order costella about the middle of the valve. X 10.

3 Specimen AWB 11b:

Mould of the brachial valve, showing costellate surface and differentiated cardinal process. X10.

4 Drawing of brachial valve of the same specimen as fig. 3, showing bulbous myophore and the extended shaft. X 10.

PLATE 26

Fig. 1

Fig. 2

Fig. 3

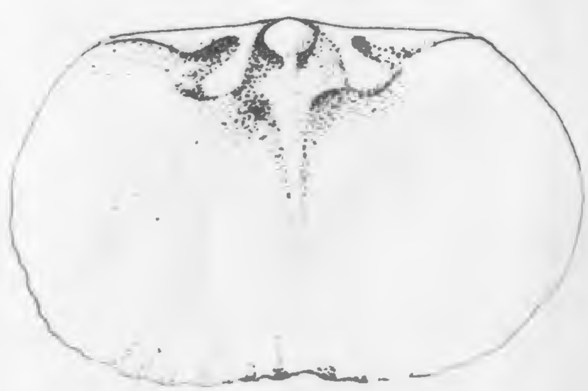


Fig. 4

Chapter V

OTHER FOSSILS

Introduction

In addition to brachiopods and trilobites, which were the two groups of fossils required for this thesis study of the Long Point Formation, other fossils were collected during the course of field-work. These are therefore, generally the more common or obvious representatives of other groups and only reflect the nature of the entire fossil fauna since these groups were not collected systematically. This additional material is described below.

PHYLUM: PROTOCHORDATA

Subfamily DIPLOGRAPTINAE Lapworth, 1873

Genus CLIMACOGRAPTUS Hall, 1865

Climacograptus aff. *C. inuiti similis* Wilson, 1948

Plate 27, fig. 1.

Material. Specimen AWGp 1: incomplete and poorly preserved rhabdosome. This, and other fragmented specimens are from four feet below the top of the exposed sequence of the Misty Cove member, along the west coast, three-quarter of a mile north of the northend of the offshore pebble bar.

Diagnosis. Scandent biserial rhabdosome with two straight, divergent basal spines. Thecae with characteristic sigmoidal curvature resulting in a sharp angular geniculation. The thecae have straight sides parallel to the axis. The thecal aperture is a transverse excavation between two thecae at right angles to the axis, bordered by a rim at its outer edge.

Description. The rhabdosome is parallel-sided throughout its length. The incomplete specimen is 7 mm in length; it widens from 0.7 to 0.8 mm at the level of the first thecal aperture to a maximum width of 0.9 to 1.0 mm at the level of the twelfth thecal aperture. The thecae overlap one another for about one-third of their extent. Each theca shows sigmoidal curvature; the proximal portion is parallel to the axis and the aperture is horizontal. The apertural lip is even, and bears a spine-like projection on its outer margin. There are 9 thecae in the proximal 5 mm of the rhabdosome. These are 0.5 to 0.6 mm long, and 0.3 to 0.4 mm wide near their aperture. Basal spines are present. The left spine is 0.3 mm, and the right spine 0.5 mm, in length.

Discussion. This form differs from C.bicornis in overall size as the latter is generally larger. Thus, the Climacograptid from the Long Point Formation has 12 thecae in 7 mm whereas C.bicornis has 10-12 thecae in 10 mm. The rhabdosome of C.bicornis also tapers more markedly (Elles & Wood, 1906).

The Long Point specimens show some resemblance to C.inuiti but differs from it in the evenness and thickening of the thecal apertures, which terminate in spine-like projections at the outer margins, and also in the presence of the lower spine. Furthermore C.inuiti has a concave outline between the two spines of a theca (Wilson, 1948). These features are, however, apparent in C.inuiti similis from the Cobourg beds of Ottawa (Wilson, 1948). This variety also shows sigmoidal curvature of thecae whose proximal ends are parallel to the axis and thecal apertures that are almost horizontal, with an even lip thickening to culminate in a spine-like projection at their outer edge. In addition they have a second flange-like spine at the base of the outer edge of each theca, and a concave outline between the two spines. Basal spines are, however, not mentioned by Wilson (1948) and consequently the Long Point Climacograptid can only be tentatively likened to C.inuiti similis.

PHYLUM: MOLLUSCA

Family GONIOCERATIDAE Hyatt, 1884

Genus GONIOCERAS Hall, 1847

Gonioceras aff. G.anceps Hall, 1847

Plate 28, figs. 1-4; Plate 29, figs. 1-2

Material. Specimen AWC 1: the anterior three-quarters only of a straight shell with angular flanks. Shell 150 mm + long, and 110 mm along the maximum width of the specimen.

Specimen AWC 2: the anterior portion of a straight shell with the siphuncle partly exposed. Specimens AWC 1 and AWC 2 are from three feet below the top of the Black Duck member along the east coast, three and a half miles northeast of Black Duck Brook post-office.

Specimen AWC 3: fragment of a straight shell. The transverse profile shows the position of the siphuncle. From sevel feet below the top of the Black Duck member along the east coast, one and a half miles northeast of Black Duck Brook post-office.

Diagnosis. Large shell, with flat ventral side and nearly flat dorsal side terminating in angular flanks in cross section. Small siphuncle situated subcentrally.

Description. A large, depressed, smooth surfaced longiconic orthocone with a flat ventral side and a moderately convex dorsal side; apical angle not seen. The two sides of the shell meet laterally as acute angular flanks behind the living chamber. The living chamber is incomplete. The camerae are wide and narrow and constricted between the main part of the cone and the flanks. The sutures form broad central lobes on the dorsal and ventral sides. Laterally, they curve sharply forward at the flanks and become closer to one another. Beyond this they regain their normal distance from one another and the central lobe forms into a rounded lateral saddle, the outer side of which curves back towards the posterior end of the cone. The subcentral eurysiphonate siphuncle has cyrtochoanitic septal necks. Calcite is present within the camerae and is difficult to ascertain whether these deposits are entirely secondary or represents mineralized cameral deposits.

Discussion. There is considerable confusion in the literature as to the differences between G.anceps and G.occidentale (Wilson, 1961). The Long Point specimens have rapid tapering of their shells, and their sutures show a broad central lobe that are features typical of G.anceps and apparently not present in G.occidentale. The regaining of the original distance of septa from one another in the saddles is another character found in G.anceps and not in G.occidentale. The specimens also resemble G.holtedahli but differ from it in the broadly curved form of the septa in the central lobe; whereas in G.holtedahli they are deeply curved (Moore, 1964). The specimen is thus closest to G.anceps in its shell shape, curvature of the septa throughout the cone and in the size and position of the siphuncle.

A Gonioceras from the Long Point Formation has previously been identified as Gonioceras cf. G.anceps (in Riley, 1962).

Family ENDOCERATIDAE Hyatt, 1883

Genus ENDOCERAS Hall, 1847

Endoceras sp.ind.1

Plates 30, figs. 1-4; Plate 31, fig. 1-2

Material. Specimens AWC 4 and AWC 5: incomplete internal molds from three feet above the base of the LeRoy member, along the east coast, three and a half miles northeast of Black Duck Brook post-office.

Diagnosis. Straight, robust, large conch. The shell has a large, ventral siphuncle with holochoanitic septal necks and thin connecting rings. The sutures are almost straight.

Description. Specimens AWC 4 and AWC 5 are internal molds, 56.5 mm and 35 mm in length enclosing 7 and 4 camerae respectively. The conchs are circular in cross-section, and the sutures between the camerae are straight. The diameter of the shell increases from 23 mm (AWC 4) and 18 mm (AWC 5) at the adapical end to 28 mm (AWC 4) and 24 mm (AWC 5) near the dorsal extremity. The siphuncles are large; the diameter adapically is 11 mm for specimen AWC 4 and 10 mm for specimen AWC 5. The septal necks are holochoanitic and the segments expand slightly within the camerae.

Endoceras sp.ind.2

Plate 31, figs. 3-4

Material. Specimen AWC 6: an incomplete internal mold from three feet above the base of the LeRoy member, along the east coast, three and a half miles northeast of Black Duck Brook post-office.

Description. The specimen is 89 mm long representing 9 camerae, two of which are well defined. The camerae are 9 mm long. The conch is circular in cross-section, and the sutures are almost straight. The diameter increases from 38 mm at the adapical end to 44.5 mm near the dorsal extremity. The siphuncle is large, and is 8 mm in diameter and 3 mm from the venter. The septal necks are holochoanitic and segments expand slightly within the camerae.

Remarks. It is difficult to identify the species of the specimens from their poorly preserved and incomplete molds. However, the characters that are observable make it possible to place them in the genus *Endoceras*.

Family MACLURITIDAE Fischer, 1885

Genus MACLURITES Lesueur, 1818

Maclurites sp.ind.1

Plate 32, figs. 1-3

Material. Specimen AWG 1: complete shell from eleven feet below top of the Black Duck member, along the east coast, one and a half miles northeast of the Black Duck Brook post-office.

Diagnosis. Shell large with a flat base and a convex upper surface. The whorls may have subangular crests and the umbilicus walls are steep. The umbilicus may be open.

Description. The shell is large, hyperstrophic, paucispiral, with a flat base and a strongly convex upper surface. Involutions of the whorls are slightly impressed and have subangular crests. The walls of the umbilicus are steep. Ornamentation is not discernible. The internal mold contains exactly three whorls, each whorl leaving the preceding one is slightly revealed. The shell measures 68 mm at the longest diameter, and the depth of the outer whorl is 28 mm.

Maclurites sp.ind.2

Plate 32, fig. 4

Material. Specimen AWG 2: complete specimen which has been subjected to partial weathering. From three feet below the top of the LeRoy member, along the east coast, three and a half miles northeast of Black Duck Brook post-office.

Description. Shell comparatively smaller with disjunct whorls. The shell measures 22.5 mm at the longest diameter and the depth of the outer whorl is 6.5 mm. The umbilicus is open.

Remarks. Specimen AWG 1, has a depth to diameter ratio of about 4:9, which is very similar to that of Maclurites altus from the Ordovician strata of Baffin Island, which has a ratio of 4:7 (Nelson, 1963). The depth to diameter ratio of specimen AWG 2, which is about 2:7, and the presence of an open umbilicus suggests that it may be a different species of Maclurites from specimen AWG 1.

PHYLUM: ECHINODERMATA

Family HOMOCRINIDAE Kirk (emend. Ulrich)

Genus DAEDALOCRINUS Ulrich, 1925

Daedalocrinus aff. D.kirki

Plate 33, figs. 1-4

Material. Specimen AWE 1: complete calyx with part of stem from one foot above the base of the Leroy member, along the east coast, two miles northeast of Black Duck Brook post-office.

Description. The dorsal cup has a relatively simple structure. The short crown is composed of close-sutured plates that lack incorporated interradial elements. The arms are free above the proximal ray plates (radials). There are also two circlets of plates, the basals and infrabasals below the radials which are multiple. The axilary primibrach (primaxil) which is the third or fourth free brach above radials have two adjoining brachials at its distal margin. Primibrachs and secundibrachs are variable in number. The arm structure has two arms to each ray, branching dichotomously on the third or fourth brach (secundibrach). Each pair of arms give rise to long endotomous ramules on their facing, inner sides, borne by subaxils, separated by three or four brachs.

Dimensions.	length of crown	20 mm
	length of cup	4.5 mm
	length or arms (incomplete)	15.5 mm
	width at base of arms	4.5 mm
	width of ossicles	2.5 mm
	length of ossicles	0.75 mm

Remarks. The specimen resembles the species D.kirki, described from the lower Trenton crinoid bed, Kirkfield, Ontario (Moore, 1962).

PHYLUM: COELENTERATA

Family AULOPORIDAE Milne-Edwards & Haime, 1851

Genus LABYRINTHITES Lambe, 1906

Labyrinthites chidlensis Lambe, 1906

Plate 34, figs. 1-3; Plate 35, figs. 1-2

Material. Specimens AWCo 1 and AWCo 2: complete colonies. Both specimens are from two feet below the top of the Black Duck member, along the east coast. The first, three miles northeast of Black Duck Brook post-office, and the second, one and a quarter miles northeast of Black Duck Brook post-office.

Dimensions.		wide	high
	AWCo 1	7.6 inches	3.4 inches
	AWCo 2	5.3 inches	2.3 inches

Diagnosis. Low domed to flat fasciculate colonies composed of slender oval to subpolygonal phaceloid corallites with thick walls and no septa. Corallites are connected by tubes to form a network. Tabulae are complete, horizontal to concave.

Description. Low domed (AWCo 1) to flat (AWCo 2) colonies, composed of slender oval to subpolygonal phaceloid corallites with thick walls and no septa. The subpolygonal corallites are 4 to 6 sided and are 0.2 to 0.3 mm in diameter. The corallites are separated from one another by intervening spaces which range from 0.1 to 0.2 mm. The corallites, however, are connected by tubes to form a syringaporid like network. Some corallites occasionally coalesce forming a common wall. Tabulae are present and are horizontal to concave.

Remarks. The specimen is part of a hemispherical colony of the tabulate coral which is found in the form of reefs in the Black Duck member. The species was previously misidentified as a coral of the Tetradium type (Billings in Murray and Howley, 1881), and as a species of the Bryozoan Monotrypa, M.magna (Schuchert & Dunbar, 1934; Sullivan in Riley, 1962). The considered coral colonies here are from the same beds as the specimens described by Bolton (1965).

PHYLUM: BRYOZOA

Family TREMATOPORIDAE Miller, 1889

Genus DIPLOTRYPA Nicholson, 1879

Diplotrypa schucherti Fritz, 1966

Plate 36, figs. 1-3

Material. Specimen AWBy 1: small mound-shaped colony measuring 1 inch to 2 inches in width and ½ inch in height, from six feet below the top of the Black Duck Member, one and a half miles northeast of Black Duck Brook post-office along the east coast.

Diagnosis. Massive zoaria. Microscopic features include the presence of integrate walls, horizontal diaphragms and an absence of acanthopores.

Description. Tangenital section shows angular zooecia normally polygonal in outline, but somewhat rounded where interrupted by mesopores. Mesopores occur singly or in small groups with thin and integrated walls, triangular or more commonly quadrangular in outline. Acanthopores are absent. In longitudinal section zooecial walls are thin and uniform in thickness throughout their length but crenulate where mesopores intervene. Diaphragms are generally horizontal, more or less evenly spaced and lacking zonal crowding. Mesopores are beaded with closely spaced horizontal diaphragms.

Discussion. Small colonial forms of bryozoa from the Long Point Formation, such as the specimen were previously thought to represent a young colony of the reef-forming Monotrypa (now identified as Labyrinthites).

This colonial form, however, was re-examined by Fritz (1966) who revealed that it was a new species of the bryozoan genus *Diplotrypa* Nicholson, which she named *Diplotrypa schucherti*.

The following features of the specimen which are identical to the features in *D.schucherti* helps it to be assigned to that form:-

a) Macroscopic, massive zoaria,

b) Microscopic representation of integrate walls, horizontal diaphragms, and the absence of acanthopores.

PHYLUM: ANNELIDA

Genus ŒNONITES Hinde, 1879

Œnonites aff. Œ. crepitus Eller, 1942

Maxilla I, Plate 37, fig. 1

Material. Specimen AWSL. 1: Nearly complete jaw, from two feet above the top of the beach in the Misty Cove member, half a mile northeast of the northern end of the offshore pebble bar.

Description. The jaw is long with a nearly straight inner margin (1.0 mm in length) and a slightly curved outer margin. It has extreme sharp conical denticles. The first denticle is large and points backward and it is followed by three small denticles almost perpendicular to the inner margin that are succeeded by larger denticles decreasing in size to the posterior end. A large fossa occupies three-quarters of the length of the jaw.

Remarks. The specimen resembles Œnonites crepitus of the Erindale member (Cincinnatian series), Streetville, Ontario, in the general shape of fossa, size and the arrangement of the denticles (Eller, 1942).

Genus ŒNONITES Hinde, 1879

Œnonites aff. Œ. coggeshalli Eller, 1945

Maxilla II, Plate 37, figs. 2-3

Material. Specimen AWSL. 1: nearly complete jaws from two feet above the top of the beach in the Misty Cove member, half a mile northeast of the northern end of the offshore pebble bar.

Description. Elongate jaws measuring 1.2 mm (fig. 2) and 0.9 mm (fig. 3) in length. A series of 14 sharp conical denticles extend the length of the jaws. The first denticle is large and curved succeeded by smaller denticles gradually decreasing in size. All denticles are pointed to the posterior. An irregular fossa extends the length of the jaw.

Remarks. The specimens are similar in size, shape and form of denticles to Œ. coggeshalli from the Cobourg beds at Collingwood, Ontario, except for the number of denticles in the specimen are 14 and Œ. coggeshalli has 16 in number (Eller, 1945).

Genus ŒNONITES Hinde, 1879

Œnonites aff. Œ. adversus Eller, 1945

Maxilla II, Plate 37, fig. 4

Material. Specimen AWSL.1: nearly complete jaw, from two feet above the top of the beach in the Misty Cove member, half a mile northeast of the northern end of the offshore pebble bar.

Description. Small jaw, 0.8 mm in length, with wide anterior and narrow posterior ends. A series of about 18 denticles extend the full length of the jaw; the first two denticles large and pointing forward and the remainder minute and directing backward. At mid-length of the jaw the denticles change direction and point towards the outer side. A small narrow fossa is present in the posterior half of the jaw. The underside of the jaw is convex and the posterior upper side of the jaw is concave.

Remarks. The specimen is similar to Œ. adversus from the Upper Cobourg beds of Collingwood, Ontario, except for the number of denticles which is 18 in the specimen from Long Point, and 20 in the specimen from Ontario (Eller, 1945).

Genus LEODICITES Eller, 1940

Leodicites aff. L.absolutus Eller, 1945

Maxilla II, Plate 37, fig. 5

Material. Specimen AWSL 1: nearly complete jaw, from two feet above the top of the beach in the Misty Cove member, half a mile northeast of the northern end of the offshore pebble bar.

Description. The outline of the jaw is "V" shaped and is 0.65 mm in length. A series of 14 blunt denticles extend the full length of the jaw. The first three denticles succeeding the fang are of medium size, and the remainder are small and compact. The inner margin of the jaw is curved in the anterior end and becomes straight at the posterior end. The outer margin of the jaw extends into a blunt shank.

Remarks. The specimen closely resembles L.absolutus from the Rockland beds at Lowville. (Eller, 1945).

UNCLASSIFIED FORM

(Feather-stitch Trail)

Plate 38, Figs. 1-2

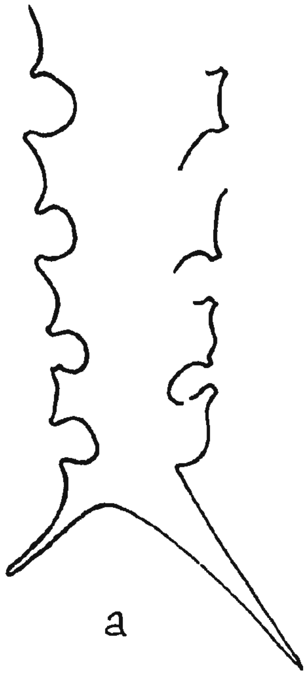
Material. Specimen AWU: from two feet above the top of the pebble beach in the LeRoy member, half a mile northeast of the northern end of the offshore pebble bar along the east coast.

Description. Specimen show a zig-zag feather-stitch pattern trail 23.5 mm long, 1 mm wide, having same form in relief. The progression exhibits a "drag" culminating in rounded impressions at left and right oblique lines. The rounded impressions have a constant distance of 4 mm on the right of midline, and 3.5 mm to left of midline.

Discussion. The trail suggests a progression of a shaft bearing two diverging muscle pads at each end, and the whole set oblique to the line of progression.

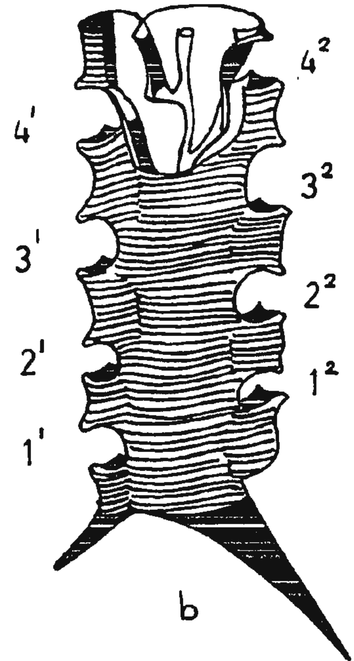
A similar feather stitch trail has been reported from the Cobourg beds, localities 81 and 92 (Wilson, 1948).

PLATE 27



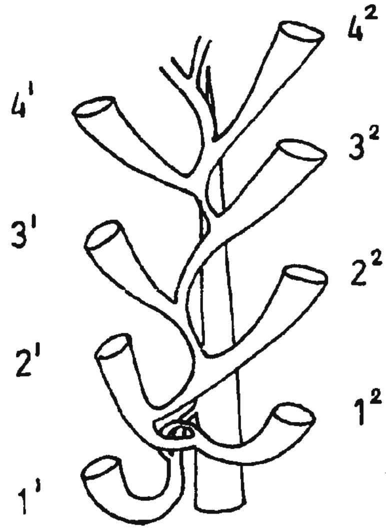
a

Outline of specimen
X 10.



b

Diplograptid type of development illustrated by *Climacograptus aff.C.inuiti similis*.



c

Thecal diagram illustrating progressive trend in development of the proximal end. Numbering is according to convention indicating their order of budding Th 1' - first-formed theca developed from sicula. Th 1² - next-formed theca, budded from th1'.

Fig. 1 *Climacograptus aff.C.inuiti similis*

PLATE 28

<u>Gonioceras</u> aff. <u>G.anceps</u>

Figure

1 Specimen AWC 1:

Dorsal view showing incomplete living chamber and part of the orthoconic shell. Note broad central lobes and posteriorly directed saddles. Laterally the septa are closer to one another where the central lobe passes into the saddles on the flanks.

X $\frac{1}{2}$.

2 Specimen AWC 2:

Anterior portion of a shell fragment showing the posterior end of the living chamber and a part of the siphuncle behind it.

X $\frac{1}{4}$.

3 Specimen AWC 3:

Dorsal view of a shell fragment showing the position of the siphuncle and relation to the flanks. Note the mineral deposits within the camerae.

X $1\frac{1}{4}$.

4 Vental view of the same specimen as fig. 3, showing flat surface.

X $1\frac{1}{4}$.

PLATE 28

Fig. 1

Fig. 2

Fig. 3

Fig. 4

PLATE 29

Gonioceras aff. G.anceps

Figure

1 Specimen AWC 3:

Anterior view of broken shell showing the flat ventral side, and the position of the siphuncle.

X 2.

2 Reconstruction of the same specimen as in fig. 1, to show the true cross-sectional form when the lateral flanks were present.

X 2.

PLATE 2

Fig. 1

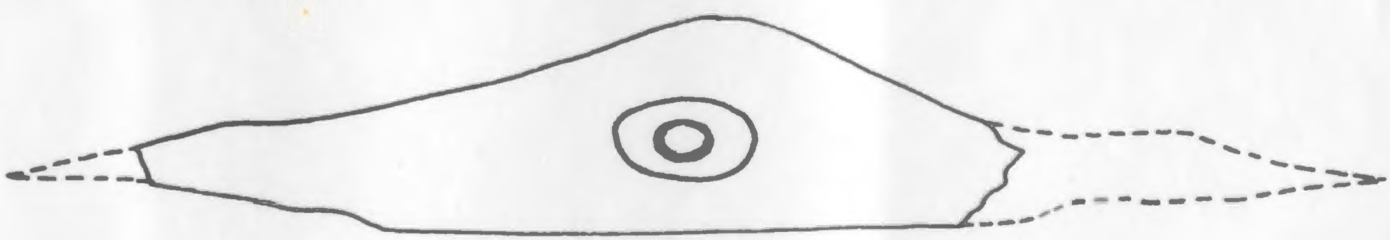


Fig. 2

PLATE 30

Endoceras sp.ind.1

Figure

1 Specimen AWC 5:

Fragment of cone sectioned vertically to show the size and position of the siphuncle, and the holochoanitic septal necks. Note the slightly expanding camerae.

X $2\frac{1}{2}$.

2 View of the completely septate internal mold of the same specimen as in fig. 1.

X $2\frac{1}{2}$.

3 Reconstruction of fig. 1.

X $1\frac{3}{4}$.

4 Diagrammatic cross-section of the specimen to show the size and position of the siphuncle.

X $1\frac{1}{2}$.

PLATE 30

Fig. 1

Fig. 2

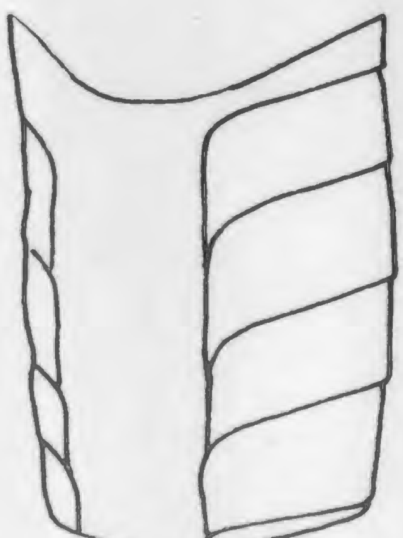


Fig. 3

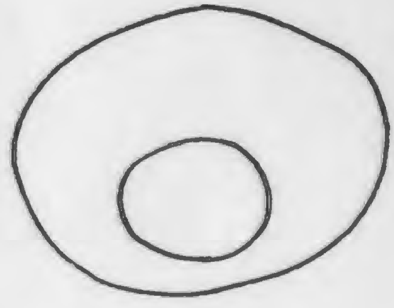


Fig. 4

PLATE 31

Endoceras sp.ind. 1

Figure

1 Specimen AWC 4:

Longitudinal section of fragment of cone showing the position of the siphuncle, septa and holochoanitic septal necks.

X 2.

2 View of the completely septate internal mold of the same specimen as fig. 1.

X 1¾.

Endoceras sp.ind. 2

3 Specimen AWC 6:

Septate internal mold. Note the nearly straight septa.

X 1½.

4 Longitudinal section of the same specimen as in fig. 3 exposing the holochoanitic septal necks.

X 1½.

PLATE 31

Fig. 1

Fig. 2

Fig. 3

Fig. 4

PLATE 32

Maclurites sp.ind. 1

Figure

1 Specimen AWG 1:

Upper view showing large outer whorl and deep umbilicus. Note each whorl leaving the preceding one slightly.

X 1.

2 Basal view of same specimen as in fig. 1, showing flat base.

X 1.

3 Drawing of a longitudinal section of the same specimen as in fig. 1, showing the convex upper surface and flat base. Note three whorls, each whorl leaving the preceding one slightly. The umbilicus is deep.

X 1.

Maclurites sp.ind. 2

4 Specimen AWG 2:

Upper view showing disjunct whorls and the open umbilicus.

X 2½.

PLATE 32

Fig. 1

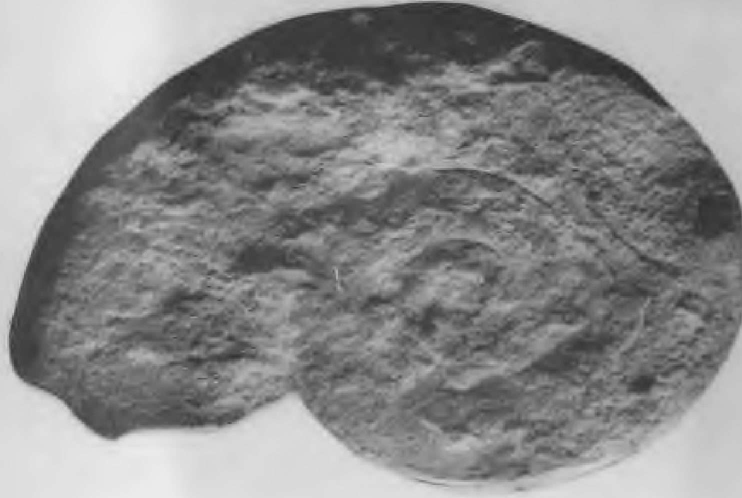


Fig. 2

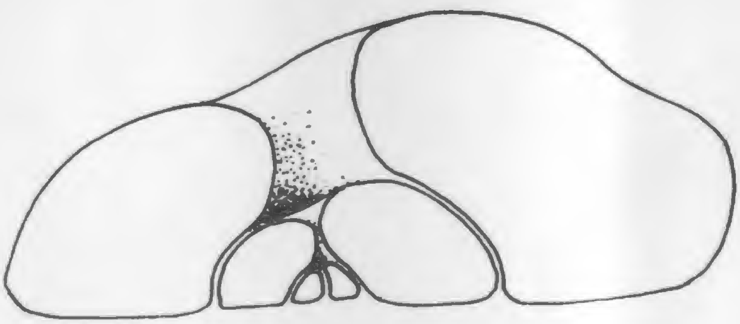


Fig. 3

Fig. 4

PLATE 33

Daedalocrinus aff. D.kirki

Figure

1 Specimen AWE 1:

Diagrammatic representation of same specimen as in fig. 3. Note the dichotomous branching of the arms and the endotomous branching of the ramules.

X 1½.

2 Daedalocrinus Ulrich (M.Ord., Ontario), Homocrinidae; showing distinct branching of arms (after Moore, 1962).

3 Crown of the crinoid.

X 3.

4 Part of the stem showing ossicles.

X 4.

PLATE 33

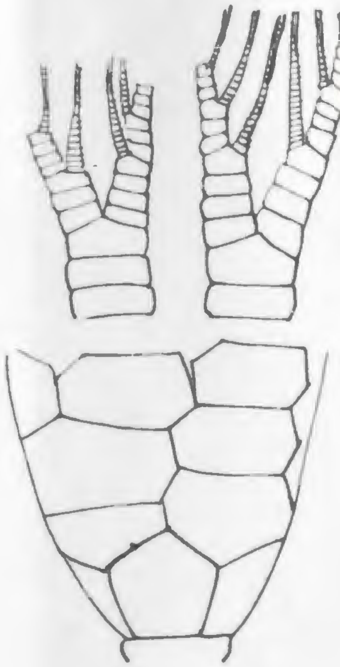


Fig. 1

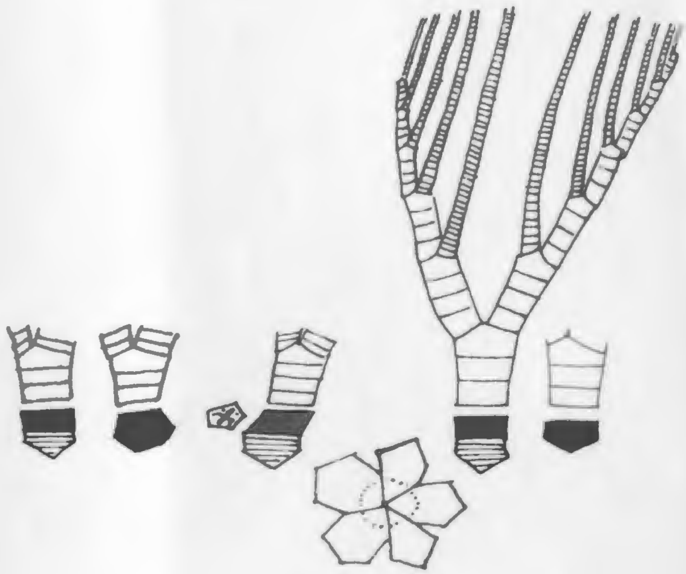


Fig. 2

Fig. 3

Fig. 4

PLATE 34

Labyrinthites chidlensis

Figure

1 The upper surface of a domed coral reef made up of hemispherical colonies of Labyrinthites.

2 A view of the same reef as in fig. 1, showing the lateral extension of a reef.

3 A view of the complete extension (29 feet) of the same reef as in fig. 1, in the Black Duck member.

PLATE 34

FIG. 1

FIG. 2

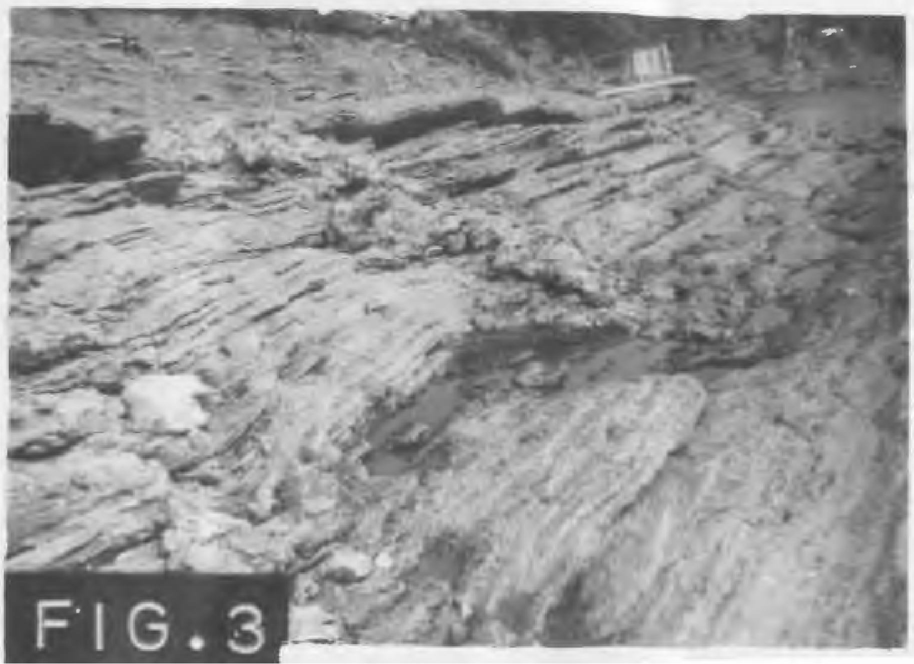


FIG. 3

PLATE 35

Labyrinthites chidlensis

Figure

1 Specimen AWCo 1

Transverse section exhibiting oval and subpolygonal corallites. Note intervening spaces in between corallites and connecting tubes forming a network.

X 45.

2 Longitudinal section of same specimen as in fig. 1, showing slender corallites with thick walls and tabulae. Note some corallites coalescing to form common walls.

X 45.

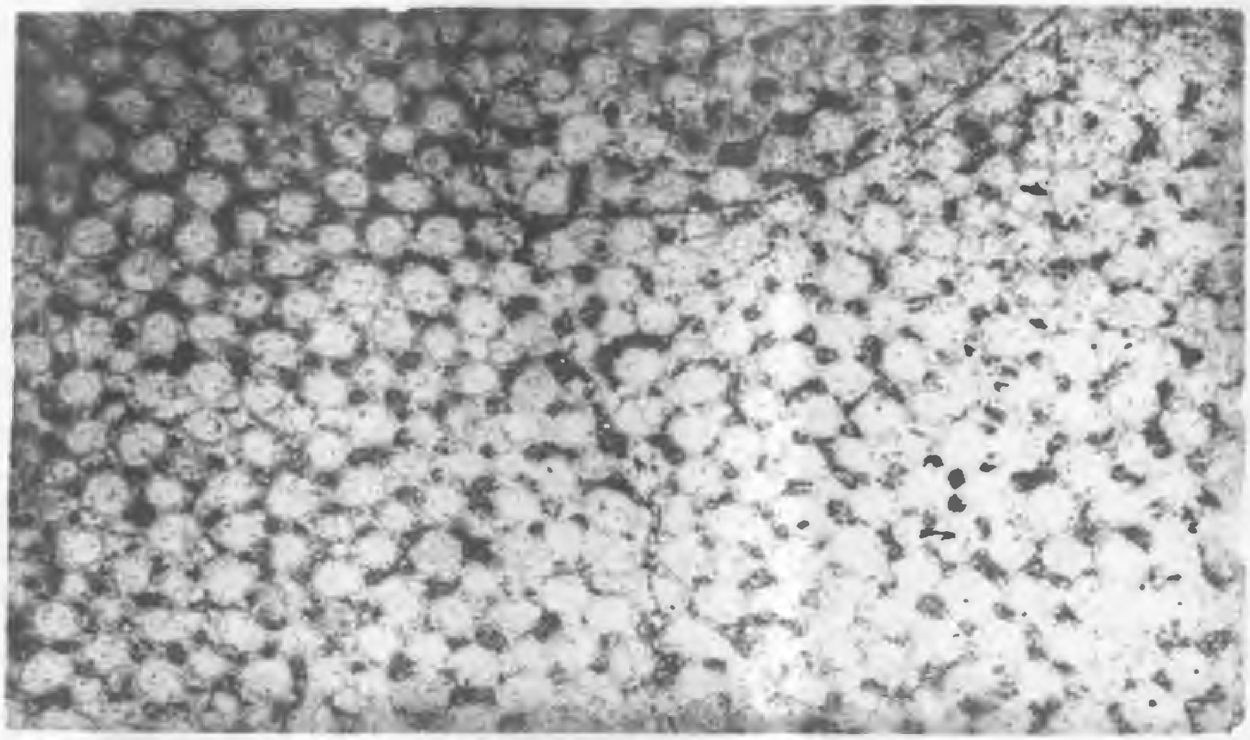


Fig. 1

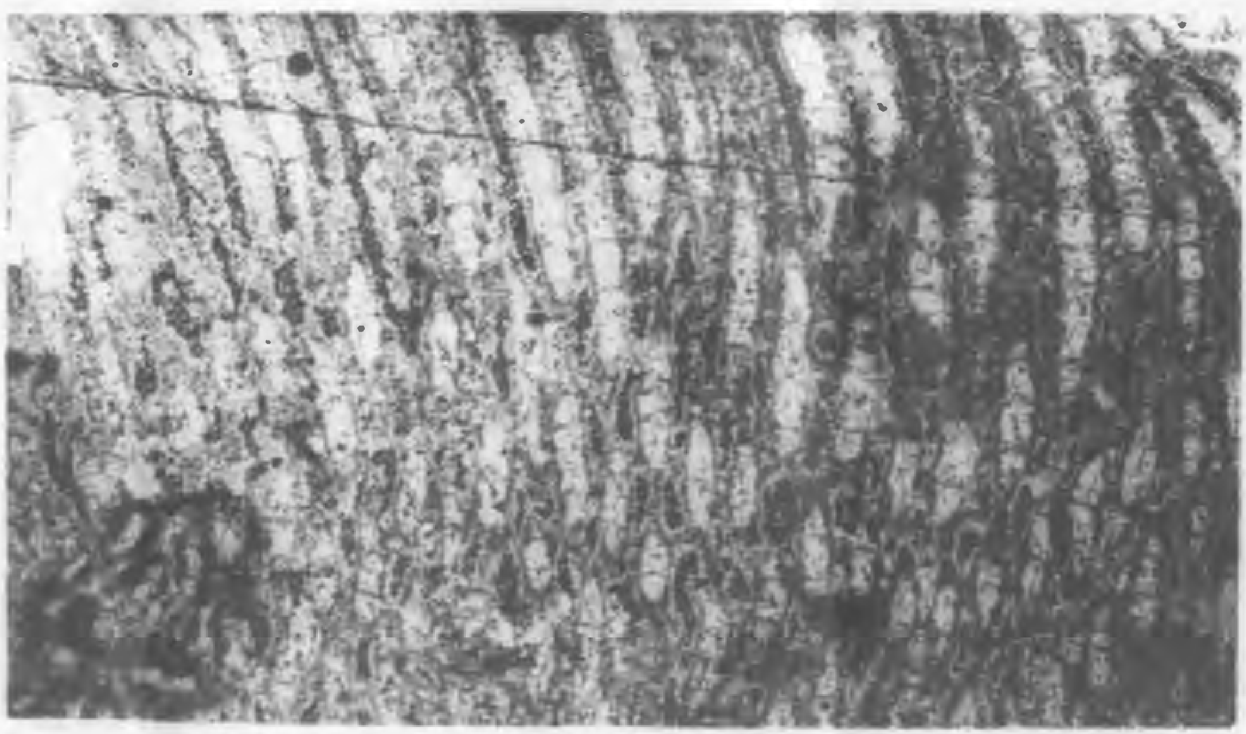


Fig. 2

PLATE 36

<u>Diplotrypa schucherti</u>

Figure

1 Specimen AWBy 1:

The basal view of the zoarium.

X 1.

2 Tangenital section of the same specimen as fig. 1, showing angular and polygonal zooecia. The zooecia are rounded where interrupted by mesopores.

X 45.

3 Longitudinal section of the same specimen as fig. 1, showing continuous beaded mesopores and interrupted growth. Note generally horizontal diaphragms and zooecial walls thin and uniform in thickness.

X 45.

PLATE 36

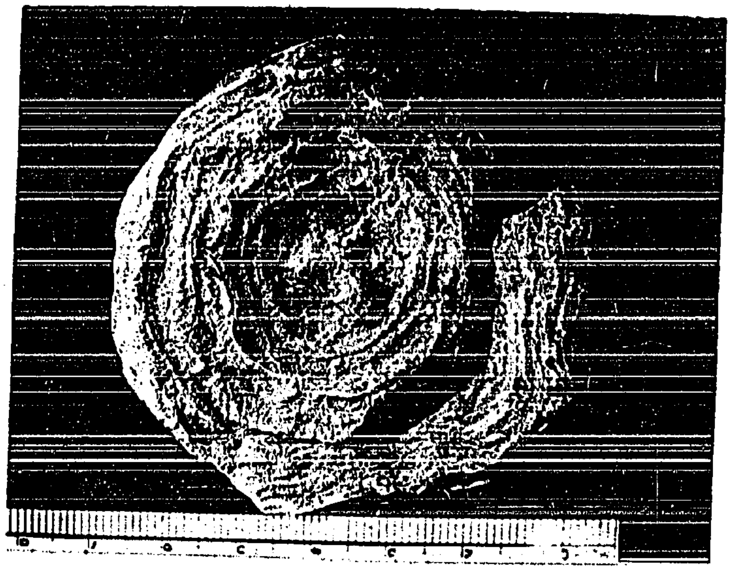


Fig.1

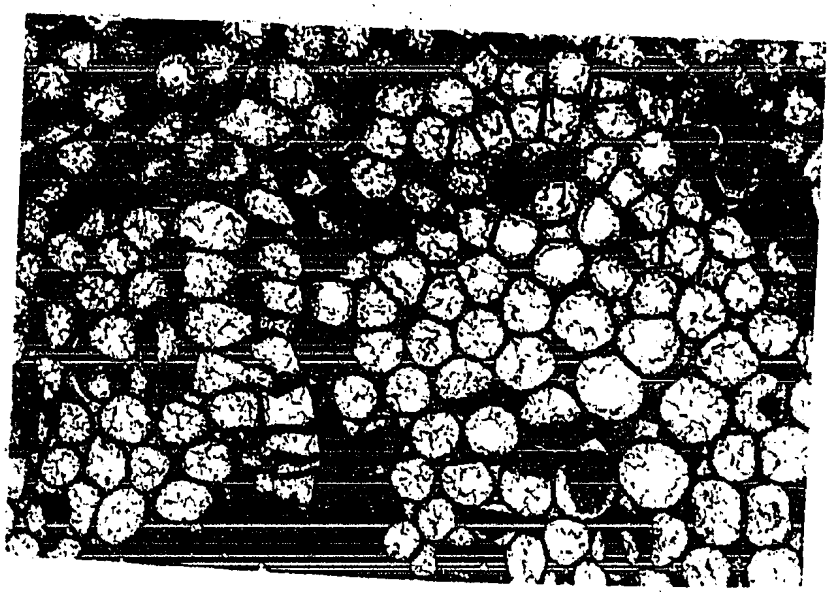


Fig.2

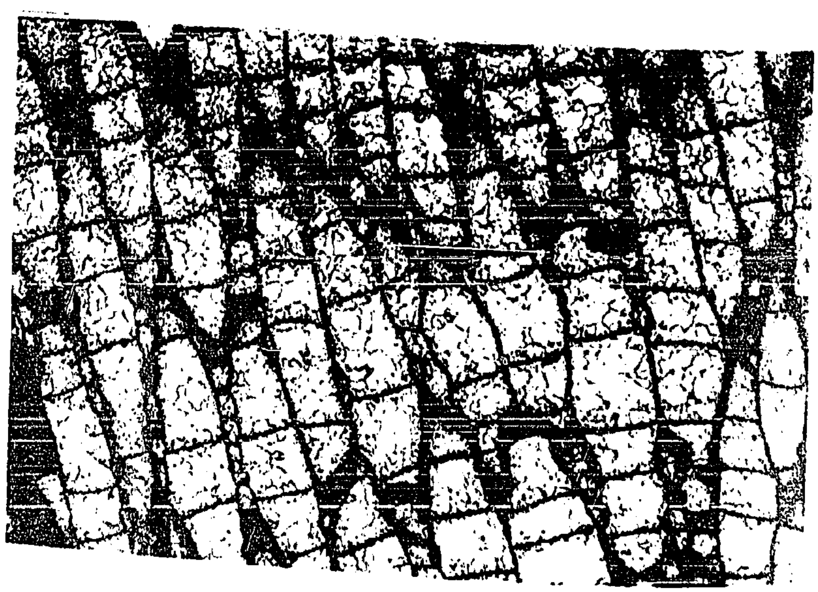


Fig.3

PLATE 37

SCOLECODONTS: Specimens AWSL

figure

1 Œnonites aff. Œ.crepitus

Maxilla I, X 60.

2 & 3 Œnonites aff. Œ.cogg shalli

Maxilla II, X 60.

4 Œnonites aff. Œ.adversus

Maxilla II, X 60.

5 Leodicites aff. L.absolutus

Maxilla II, X 60.

PLATE 37

Fig. 1

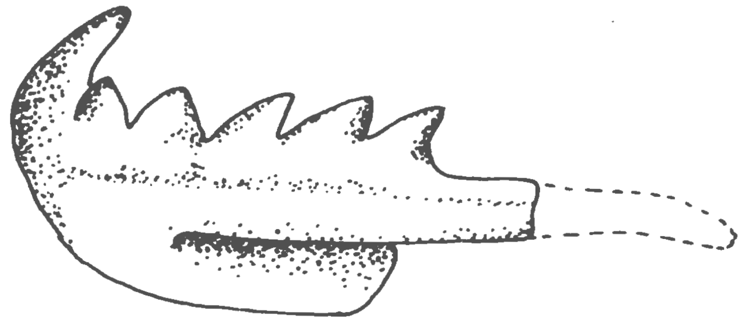


Fig. 2

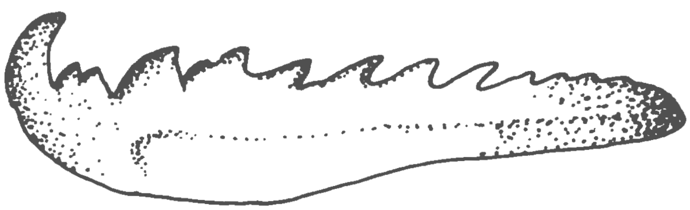


Fig. 3

Fig. 4

Fig. 5

PLATE 38

(Feather-stitch Trail)

Figure

1 Specimen AWU :

Showing feather-stitch pattern trail. Note rounded impressions of possible muscle pads at left and right oblique lines.

X 3.

2 Drawing of a reconstruction of the same specimen as fig. 1.

PLATE 38

Fig. 1

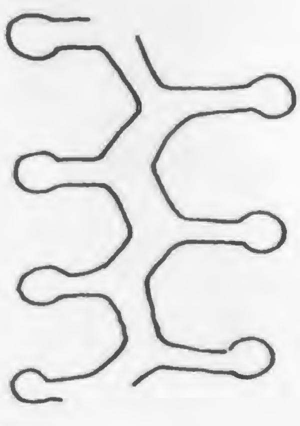


Fig. 2

CHAPTER VI

ASPECTS, MAINLY ECOLOGICAL OF THE LONG POINT FORMATION FAUNA

Aspects, mainly ecological, of the Long Point fauna

Included in this chapter are six separate sections, each of which deals with a particular aspect of the Long Point Formation fauna. The aspects treated are as follows:

1. Way of Life of the brachiopods
2. Way of life of the cephalopods
3. Way of life of the trilobites
4. *Gonioceras*-*Labyrinthites*-*Maclurites* association
5. *Climacograptus* - *Scolecodont* association
6. Reefs of the tabulate coral *Labyrinthites*

1. Way of Life of the brachiopods

The dominant brachiopods in the Black Duck and Leroy Members are the Strophomenids *Sowerbyella*, *Rafinesquina* and *Oepikina*. The characteristic shell modifications of strophomenids have been described by Rudwick (*in* Moore, 1965). The small size of the foramen in *Sowerbyella* may reflect the loss of the functional pedicle. Whether the pedicle atrophied early in life or was never functional is not known. The mature shell, however, must have lain free on the substratum. The shell of *Sowerbyella* is characterized by a low convex pedicle valve which is wider than long and it may have been an adaptation that enabled it to resist shifting by bottom currents. *Rafinesquina* and *Oepikina* also lost their pedicles early in life and their shells lay with the convex pedicle valve resting on, or partly buried in, the bottom sediment. The pedicle valve of Oepikina is geniculate and according to Rudwick (in Moore, 1965) this probably represents a reversion to a sessile or immobile mode of life.

Sedimentation must have been slow at the times brachiopods established themselves because an abundance of sediment would (a) have clogged the delicate feeding mechanism of these organisms and (b) have buried their shells unless they were able in some way to raise their shells above the surface of the sediment accumulating round them.

Plaesiomys lived in a vertical or inclined position supported on a short stout pedicle and from its abundance in the beds of the Misty Cove member this Orthid must have been crowded together in 'banks'.

Camerella was also supported by a fairly stout pedicle but the shell in this brachiopod was held in a horizontal position. The trilobation of the shell was probably an adaptation for separating the water that circulates in the shell into distinct inhalent and exhalent streams. The zig-zag commisure which reduced the distance between the sensitive mantle edges of valves without any corresponding reduction in the area of the aperture (Rudwick in Moore, 1965), may also have acted as a seive for keeping out larger particles of sediment.

Bilobia, in the Misty Cove Member, apparently preferred a muddy substrate as this form occurs in abundance in the shaly beds of this member. Bilobia probably lost its functional pedicle early in life as it possesses only a small constricted pedicle foramen. The significantly tumid pedicle valve was perhaps an adaptation for resting on, or lying partly buried in, the silty or muddy sediment of the sea floor. The convexity of the pedicle valve raised the plane of the commissure above the surrounding sediment.

The only inarticulate brachiopod collected from the Long Point Formation is also found in the shaly beds of the Misty Cove member. The shell was probably held in a horizontal position by a short, relatively thin pedicle since the pedicle opening is quite small in relation to the size of the valves.

The brachiopods of the Long Point Formation must have been buried either where they lived or not far from where they were living because their shells show little or no signs of wear and, although valves have in some cases become separated from one another, they are unbroken and retain their ornamentation.

2. Way of life of the Cephalopods from the Long Point Formation

Consideration of the form of fossil nautiloid conchs is generally regarded as the most productive approach in interpreting the life habits of these fossils (Furnish and Glenister in Moore, 1964).

Different criteria have been used by different authors to designate the ventral side of a nautiloid conch. Conventionally however, it is regarded as the side on which the hyponomic sinus is present. In Gonioceras this is the flattened side of the shell (see Pl. 29) and there is little doubt that it was, in fact, the undersurface of the shell because many of the early straight-shelled nautiloids like Gonioceras lived in a horizontal or inclined position. This is indicated in some cases by colour markings that have been found on the upper half of their shells and by the greater thickness of cameral deposits on the non-camouflaged side. Such nautiloids during life, as they increased in size, deposited shell material within the siphuncle and on the walls of the camerae in order to maintain a balance between the weight of the shell and the weight of the body so that the organism as a whole could retain a horizontal position. A horizontal attitude enabled them to crawl about on the bottom using their tentacles and they could also swim from one place to another in search of food. In addition they could rest on the bottom. Gonioceras ~~[illegible]~~ is particularly well adapted for bottom life and the presence of a flat undersurface probably indicates that it did little or no swimming but lay on the bottom waiting for food, which it captured with its arms, only occasionally moving from place to place. Other features of Gonioceras indicative of its bottom living habits are 1) the narrowness of the camerae and the close spacing of the septa which would result in a shell with little or no buoyancy, 2) the general flatness and streamlining of the cone that would reduce the shell-shifting effect of bottom currents and 3) the development of flanges that increased the width of the shell so enabling it to lie on soft surfaces without sinking in. It is possible, that the closure of the flanks anteriorly was another adaptation to benthonic life in that it prevented or reduced entry of sediment into the mantle cavity which the animal was facing up-current waiting for prey to be carried within reach of its tentacles.

Endoceras was another benthonic nautiloid with an elongated unmodified cone that lived in a horizontal position. This form was probably an active swimmer in the waters overlying the sea floor although it could, like Gonioceras, crawl over the bottom using its tentacles. Endoceras grew to a considerable size and specimens up to two feet in length were observed in the Long Point Formation.

The nautiloids were predators, and trilobites because of their size, abundance and a lack of a calcareous shell may have been their main food as the nautiloids would, with their stout jaws, have had no difficulty in breaking up the chitinous exoskeleton of trilobites.

3. Way of life of the trilobites

The trilobites of the Long Point Formation are, with the probable exception of Sphaerocoryphe, benthonic forms. Although some trilobites became adapted for a planktonic mode of life, few appear to have been modified for active swimming and little is known about the ability of trilobites to swim. They may have used their endopodites, for this purpose, normally used for respiratory function. However, since the exopodites remained unmodified it is unlikely that they were able to make more than brief excursion into the waters above the bottom, possibly only doing so to escape their enemies. Sphaerocoryphe, however, may have been a swimmer or possibly mainly a floater as it has a bulbous frontal glabellar lobe which is thought to have contained gas or fat that gave the animal buoyancy, and its subglobose eyes are placed laterally where they would have provided a wide field of vision. The presence of long genal spines may also have been an adaptation to retard sinking.

Calyptaulax with its upturned cephalic margin and large schizochroal eyes may have ploughed through soft sediment with its eyes just above the surface.

Isotelus with its wedge-shaped cephalon, its streamlined form and eyes that are raised well above the rest of the cephalon was also well adapted for ploughing through soft sediment with its eyes above the surface.

The rounded exoskeletons of *Anataphrus*, *Illaenus* and *Bumastus* may have been an adaptation for crawling in rough seas, and also very likely for clinging on to rock surfaces like the Chitons.

4. *Gonioceras-Labyrinthites-Maclurites Association*

In the Black Duck member the large gastropod *Maclurites* is present in abundance and it is associated with the nautiloid *Gonioceras* and the tabulate coral *Labyrinthites*. The same association has been found in east-central Ellesmere Island in the Canadian Arctic Archipelago (Bolton, 1965) and Bolton regards it as characteristic of the Middle Ordovician Wilderness Stage because of the limited range of *Gonioceras*.

Gonioceras has been found associated with *Labyrinthites* at other localities in beds also considered to belong to the Wilderness Stage and *Maclurites* may well prove to be present in these beds when their faunas are studied in more detail. Thus Troedsson (1929) collected *Gonioceras* and *Labyrinthites* from the Gonioceras Bay Formation of Gonioceras Bay, northern Greenland, and Troelsen (1950) found the same forms in the Cape Webster Formation of Washington Land.

In the Wilderness Stage fauna collected by Berard (1962) from the Ordovician beds underlying a long peninsula in the west-central part of Lake Manicouagan, Quebec Province, Maclurites and Labyrinthites are associated with an unidentified cephalopod fragment and there is clearly a likelihood of Gonioceras being discovered at this locality since Lake Manicouagan lies in the intervening area between Newfoundland and the Canadian Arctic Archipelago.

5. Climacograptus-Scolecodont association

The scandent biserial graptolite Climacograptus and the horny jaw parts of annelid worms, known individually as Scolecodonts, are abundant and commonly associated in the sandy shales of the Misty Cove member. The worms crawled and burrowed in the soft sediments on the sea floor and on death their soft bodies decayed and the several elements of the jaw apparatus became separated from one another. The rhabdosomes of Climacograptus associated with scolecodonts are frequently fragmented and this may well have resulted from the feeding and burrowing activities of the worms.

Graptolites are generally regarded as having either floated freely in the sea or as having been attached to floating weed. Recently Kirk (1969) has questioned these concepts and she suggests that graptolites were freely moving and that the so called 'scandent' forms like Climacograptus were actually 'pendent'. The zooids housed in the thecae were then able to produce downward feeding currents that resulted in an upward movement for the colony as a whole. However, several species of Climacograptus, including the form present in the beds of the Misty Cove Member, bear a pair of spines, sometimes of considerable size, at the proximal end of the rhabdosome (basal spines) and they are believed by Sobolevskaya (1969) to have anchored these graptolites in soft sediment. Such Climacograptids would thus have been benthonic forms. If the basal spines were, in fact, apical, as Kirk (1969) believes, it is difficult to imagine what purpose they served and her ideas therefore seem unacceptable as far as these Climacograptids are concerned.

6. Reefs of the tabulate coral Labyrinthites

In Middle Ordovician times the growth, in close association, of colonies of the tabulate coral Labyrinthites chidlensis in the sea that occupied what is now the northern part of the Port au Port Peninsula, resulted in the development of small, isolated reefs. These elevated, wave-resistant structures presently occur in the Black Duck Member of the Long Point Formation.

The reefs are present as a series of irregular, columnar growths, six to thirty-nine feet high and four to seven feet across along the strike (Pl. 24; Fig. 3). Each consists of domed colonies of Labyrinthites, that have grown one upon another and, packed between them, the skeletal remains of other invertebrates, notably crinoid fragments. The crinoid fragments are dominantly columnals and, judging from their abundance in the reefs and in the associated limestones of the Black Duck member, crinoids must, in places, have carpeted the sea floor. Between the reefs and banked up around them are beds of biomicrite. Associated with some of the reefs are laterally expanded sheet-like stromatoporoids (not identified) but they do not constitute a major element in the reef structure and are equally common in the intervening limestones.

Along the east coast of Long Point, three miles north-east of Black Duck Brook post-office, twenty reefs are exposed in the cliffs over a distance of 2,159 feet. They are thus, relatively common. At the time of their formation the sea floor must have been studded with these coral bodies. Since sediments accumulated around them as they grow upward they would have had the appearance of numerous mounds. The reefs grew towards the north-east so that they now lie at an oblique angle to the strike of the enclosing beds.

The most vigorous growth of reef-building organisms takes place in water shallower than wave base because the vast number of closely associated individual organisms at the reef surface require a well-oxygenated environment and a plentiful supply of nutrients to maintain their life processes. The tops of reefs grow up close to sea level but not above low-tide level as the corals would die soon after exposure to the atmosphere. Reefs require not only shallow water for their development but also warm, sediment free water of normal salinity. Reef building corals today are unable to survive temperatures lower than 18.5°C and they are, therefore, restricted to tropical seas. Modern reef-building corals must also live close to the surface because of their symbiotic relationship with unicellular algae that require sunlight in order to carry out photosynthesis. Ancient corals are believed, from faunal and environmental evidence, to have lived under similar conditions so that it seems likely that tropical conditions prevailed during the development of the reefs in the Port au Port Peninsula area during Middle Ordovician times. Whittington (1966), from his study of Ordovician trilobite faunas, also came to the conclusion that tropical conditions prevailed in this area (part of his northern geographic region, see page 53) during Middle Ordovician times.

If sea level remain stationary, reefs grow laterally with maximum growth along the seaward face of the reef where the greatest agitation of surface waters occurs. On the other hand if sea level rises, reefs grow upwards in order to keep pace with the upward shift of wave-agitated waters. The columnar form of the Long Point reefs thus appears to have been a response to rising sea-level. The rise of sea level must have been very gradual as lateral growth seawards taking place at the same time as upward growth accounts for the gradual shift of the reef towards the northwest with time.

The Long Point reefs are, as far as the author is aware, the first record of reef building dominated by the tabulate coral Labyrinthites although other tabulates were responsible for the formation of extensive reefs during Ordovician time, generally in association with hydrocorallines, stromatoporoids and lime secreting algae.

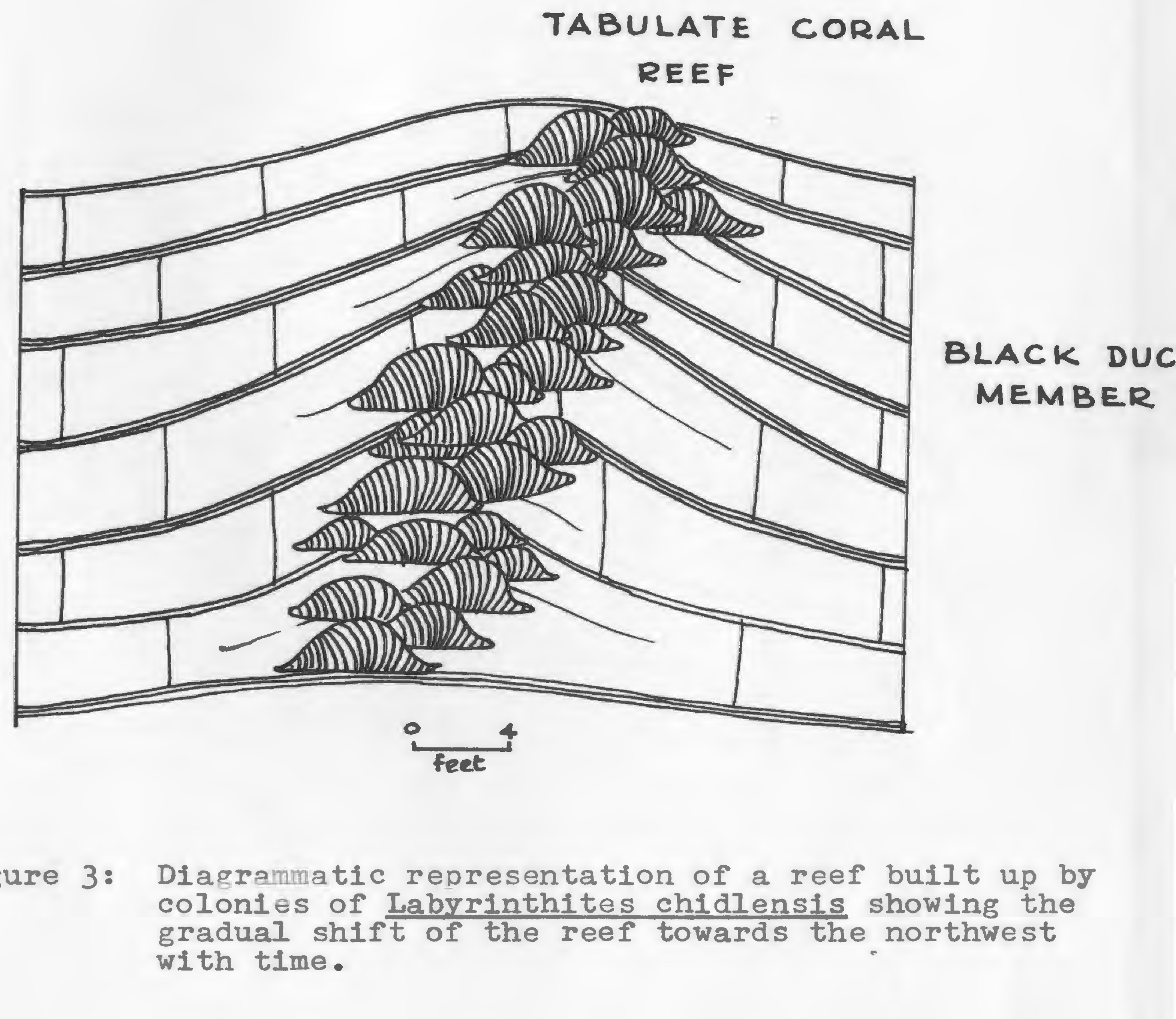


Figure 3: Diagrammatic representation of a reef built up by colonies of Labyrinthites chidlensis showing the gradual shift of the reef towards the northwest with time.

Chapter VII

STRATIGRAPHY AND AGE CORRELATION

Ordovician rocks of the west side of Newfoundland (Western geologic province or Western Platform, Kay, 1966) are mainly carbonate rocks that accumulated on wide shoal banks (Rodgers and Neale, 1963). The Taconian orogeny brought this accumulation to an end except in the southern part of the Western Platform in the Port au Port area where neo-autochthonous strata of the Long Point Formation rest unconformably on the allochthonous Humber Arm Group (Williams, 1969); the Humber Arm Terrain is considered to be a klippe by Rodgers and Neale (1963).

The Ordovician Long Point Formation includes sandstones, calcareous sandstones, limestones and shales. The main part of the formation was deposited on a gradually subsiding platform but the uppermost strata in the succession indicate that subsidence ceased or gave way to uplift as deltaic and terrestrial deposits (a red-bed sequence) overlie the marine strata forming the bulk of the Long Point Formation. The relationship between the two sequences appears to be conformable. Hitherto the red-beds have been regarded as belonging to the Clam Bank Formation which is considered to be close to the Silurian-Devonian boundary in age.

The lower part of the Long Point Formation, the Tea Cove and Shorepoint Members, is composed mainly of quartz sandstones and sandstones with a calcareous matrix. The sandy nature of the Tea Cove member and the presence of beds with mud-cracks indicate very shallow water conditions and the close proximity of the shoreline because these sediments were periodically exposed to the atmosphere, allowing sufficiently long periods of exposure for dessication of the sediment to occur.

The change in the nature of the sediments from dominantly sandy to calcareous in the Portage Member, which consists of nodular limestones with some shaly interbeds, resulted from a gradual deepening of the sea as transgression continued and the shoreline receded from the Long Point area. Occasional influxes of clay were responsible for the shale beds intercalated in the limestone sequence. In the succeeding Black Duck Member, limestone is the dominant rock type and little terrigenous material is present. Fairly vigorous current activity is indicated in the lower part of the member by the absence of fine material from the limestone beds and the presence of current bedding and large-ripples (Pl. 39). The wave length of the large-ripples ranges from 1 foot 6 inches to 2 feet 6 inches.

The upper part of the Black Duck Member is characterized by an abundance of domed coralla of the tabulate coral Labyrinthites, mat-like Stromatoporoid growths and innumerable crinoid fragments. The growth, in close association, of colonies of Labyrinthites gave rise to numerous small columnar reefs that have already been described in chapter 6. The reefs acted as baffles to the bottom currents and much organic debris, notably crinoid ossicles, was trapped between the coral colonies. Reefs thrive in high-energy environments in shallow water and their presence in the Black Duck Member shows that the sea was shallow and agitated by waves and currents at the time of their formation.

The upward growth of the coral reefs was brought to a close by a regression of the sea which resulted in exposure of the reef crests, the death of the polyps, and the subsequent destruction of the reefs by marine erosion. This regression is indicated in the Long Point Formation succession by an erosion surface truncating the tops of the reefs that were still actively growing at the time the regression began. The erosion surface is taken as the boundary between the Black Duck Member and the overlying LeRoy Member.

Regression was, however, only temporary, as the sea soon resumed its transgression and the shoreline once again receded from the area. The basal beds of the LeRoy Member are sandy and the first sediment to be deposited filled in the hollows on the gently undulating erosion surface. These beds include occasional rounded pebbles of limestone and coral heads derived from the underlying Black Duck Member.

The sandy and shaly beds of the LeRoy Member, calcareous to a greater or lesser extent and generally fossiliferous, were succeeded by the fossiliferous nodular limestones of the Beachpoint Member as transgression continued and less and less sediment reached the Long Point area. Environmental conditions during the deposition of the LeRoy and Beachpoint Members were thus similar to those that existed during the time that the Shorepoint and the Portage Members were being laid down. Reefs, however, are absent from the Beachpoint Member and their absence was probably due to the fact that the tabulate corals failed to reestablish themselves after their destruction by the temporary regression mentioned above.

The Beachpoint Member is succeeded conformably by the Misty Cove Member of sandstones and shales. The change from limestone accumulation to clastic sedimentation was accompanied by a disappearance of the shallow water benthonic fauna of the limestones and its place being taken by a fauna dominated by graptolites and annelid worms. The graptolites collected by the writer are exclusively climacograptids and they may have been benthonic (see chapter 6). Graptolites are generally regarded as having been deeper-water forms but neither the nature of the original sediments nor the faunal elements provide any satisfactory evidence regarding water-depth at the time of sedimentation. Deepening alone would not have led to the arrival of sediments in an area already relatively free of sediments but an increase in the amount of sediment available for distribution would probably do so. It is, therefore, believed that uplift of the neighbouring land area led to greater erosional activity and eventually to greater quantities of sediment being carried into the sea. Consequently the accumulation of limestones over sediment-free area of the sea floor (limestones of the Beachpoint Member) ceased when sands, silts and muds reached the area (sandstones and shales of the Misty Cove Member). The transitional nature of the boundary between the Beachpoint and Misty Cove Members supports such an interpretation. Only the lower and upper parts of the Misty Cove

Member are exposed in the Long Point area as the intervening beds are hidden beneath Pleistocene to Recent deposits.

The upper part of the Misty Cove Member was not studied since the outcrops of these beds lie outside the thesis area. However, the writer has visited the locality at the northern end of Clam Bank Cove where the uppermost strata of the Misty Cove Member are succeeded by a red-bed sequence which suggests that deltaic and terrestrial sediments gradually advanced seawards over the marine sediments of the Long Point Formation.

AGE CORRELATION

The affinities of the various faunal elements of the Long Point Formation with similar elements in other formations outside Newfoundland are discussed below.

Fossils from the Black Duck and LeRoy Members, that are regarded as diagnostic, have been correlated with similar fossils in faunas from other parts of North America that have been formally considered as belonging to the upper part of the Wilderness and the lower part of the Barneveld Stages of the upper Middle Ordovician. The association, discussed earlier (chapter 6), of the tabulate coral Labyrinthites chidlensis with species of the nautiloid Gonioceras and the gastropod Maclurites in the Black Duck Member is regarded by Bolton (1965) and others as typical of the upper part of the Wilderness Stage. The association has been found in Ordovician beds in the Canadian Arctic Archipelago and north-west Greenland, and may also be present in the Ordovician of Quebec Province, which indicates that this fauna had a wide distribution. The bryozoan Diplotrypa schucherti, which is also abundant in the Black Duck Member, is similarly regarded as being of upper Wilderness age (Fritz, 1966).

Three brachiopods from the LeRoy Member, Rafinesquina, Oepikina and Sowerbyella, have been related to species of these genera typical of the upper part of the Wilderness Stage or the lower part of the Barneveld Stage. Rafinesquina praecursor is known from the Hull and Sherman Fall Members of the Ottawa Formation of the Ottawa - St.Lawrence Lowland, upper Wilderness to lower

Barneveld Stages in age, Oepikina septata from the Lebanon Formation of the Wilderness Stage of Tennessee and Sowerbyella eximia from the Oranda Formation of the Wilderness Stage of Virginia.

Amongst the trilobites from the limestone beds of the LeRoy Member, the species of Sphaerocoryphe and Isotelus appear to be closely related to species of these genera collected from the Hull and Sherman Fall limestone beds of the Ottawa Formation of the Ottawa - St.Lawrence Lowland. The Hull and Sherman Fall Members, as noted above, belong to the upper part of the Wilderness Stage and the lower part of the Barneveld Stage of the Middle Ordovician. Anataphrus from the LeRoy Member is similar to A.borraeus from Silliman's Fossil Mount in southern Baffin Island, which is thought to include fossils of both Trenton and Richmondian ages (Whittington, 1954).

The crinoid Daedalocrinus from the LeRoy Member, is like D.kirki from the Kirkfield Formation of the Trenton Group of New York and undoubtedly of upper Wilderness age.

Some of the fossils present in the Misty Cove Member have been correlated with members of the fauna of the Cobourg Member of the Ottawa Formation and others with elements of the fauna of the Cobourg Formation of the Trenton Group. The Cobourg Member and the Cobourg Formation are associated with the upper part of the Barneveld Stage of upper Middle and lower Upper Ordovician age. Thus the species of the graptolite Climacograptus and the inarticulate brachiopod Orbiculoidea appear to be similar to species from the Ottawa - St.Lawrence Lowland where they are present in the Cobourg Member of the Ottawa Formation (Wilson, 1946, 1948), and the scolecodonts are like the scolecodonts in the Cobourg Formation of the Trenton Group of Ontario (Eller, 1942, 1945).

On the basis of the faunal affinities outlined above, it seems likely that the strata of the Long Point Formation range from upper Middle Ordovician (upper Wilderness Stage) to lower Upper Ordovician (upper Barneveld Stage) in age.

A correlation chart comparing the Long Point Formation of the thesis area with the Ottawa Formation of the Ottawa - St.Lawrence Lowland and with the Trenton Group of New York is shown in Table 7.

		BRITISH		AMERICAN	BLACK RIVER, NEW YORK			OTTAWA-ST. LAWRENCE LOWLAND		LONG POINT PENINSULA	
		SERIES	GRAPTOLITE ZONE	STAGE	GROUP	FORMATION	MEMBER	FORMATION	MEMBER	FORMATION	MEMBER
ORDOVICIAN	UPPER	ASHGILL	*Dicellograptus complanatus*	? BARNEVELD	TRENTON	COBOURG	HILLIER	OTTAWA	COBOURG	?	
		CARADOC	*Pleurograptus linearis*				HALLOWELL			LONG POINT	? MISTY COVE
	MIDDLE		*Dicranograptus clingani*			DENMARK			SHERMAN FALL		BEACHPOINT
						SHOREHAM					LEROY
			Diplograptus multidens	WILDERNESS late		KIRKFIELD			HULL		
						ROCKLAND			ROCKLAND		BLACK DUCK
			Nemagraptus gracilis	early ↓	BLACK RIVER ↓	CHAUMONT			LERAY		

Table 7 : Correlation of the Long Point Formation of the thesis area with the Ottawa Formation (after A.C.Wilson), and the Trenton Group (after T.J.M.Schoff).

PLATE 39

Large Ripples

Figure	
1 and 2	Large ripples in the Black Duck Member.
3	Symmetrical large ripples with a wave length of about two feet. Note the coin used for scale.

PLATE 39

FIG. 1

FIG. 2

FIG. 3

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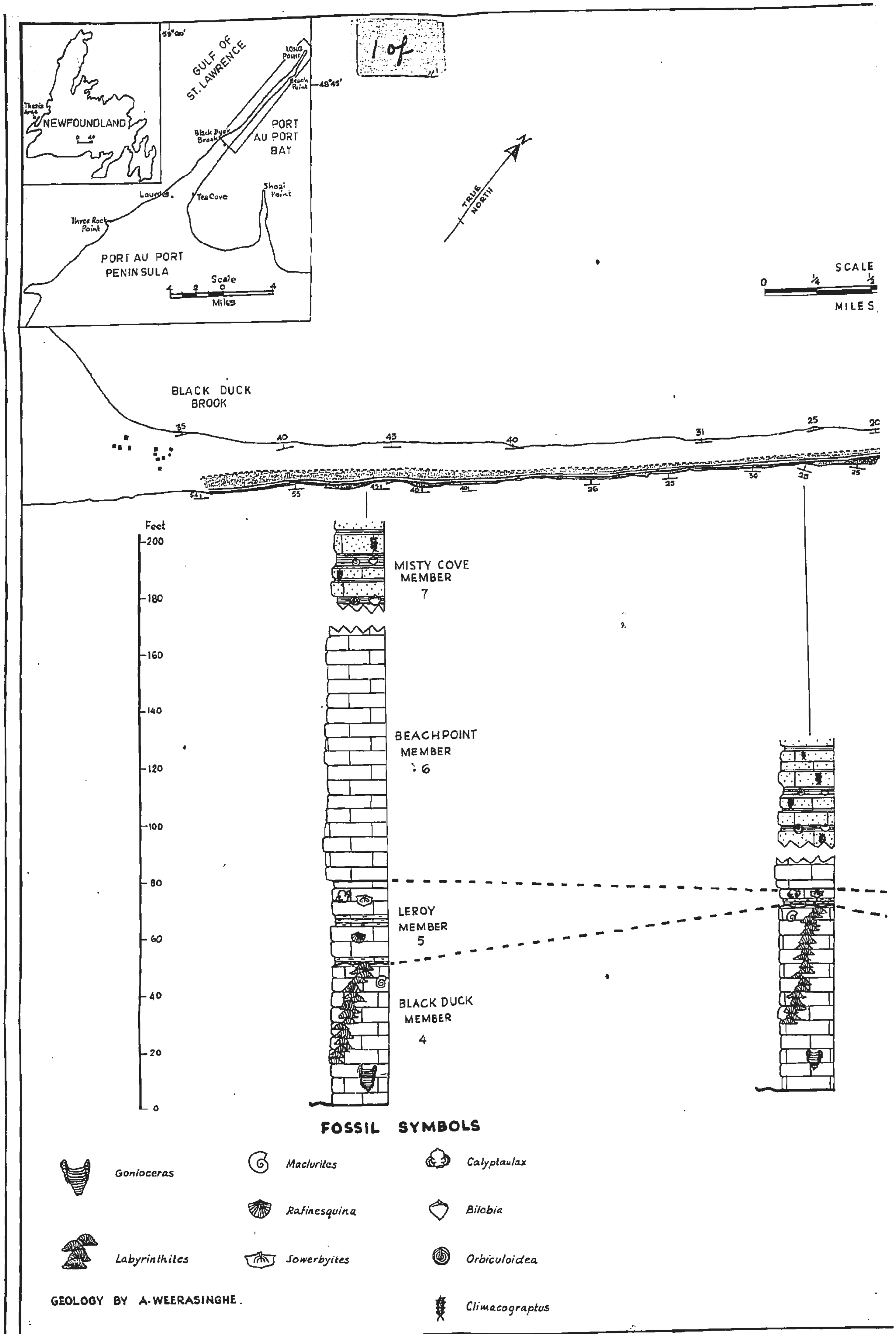
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Thesis Area
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Lourdes
Tea Cove
Shoal Point
Three Rock Point
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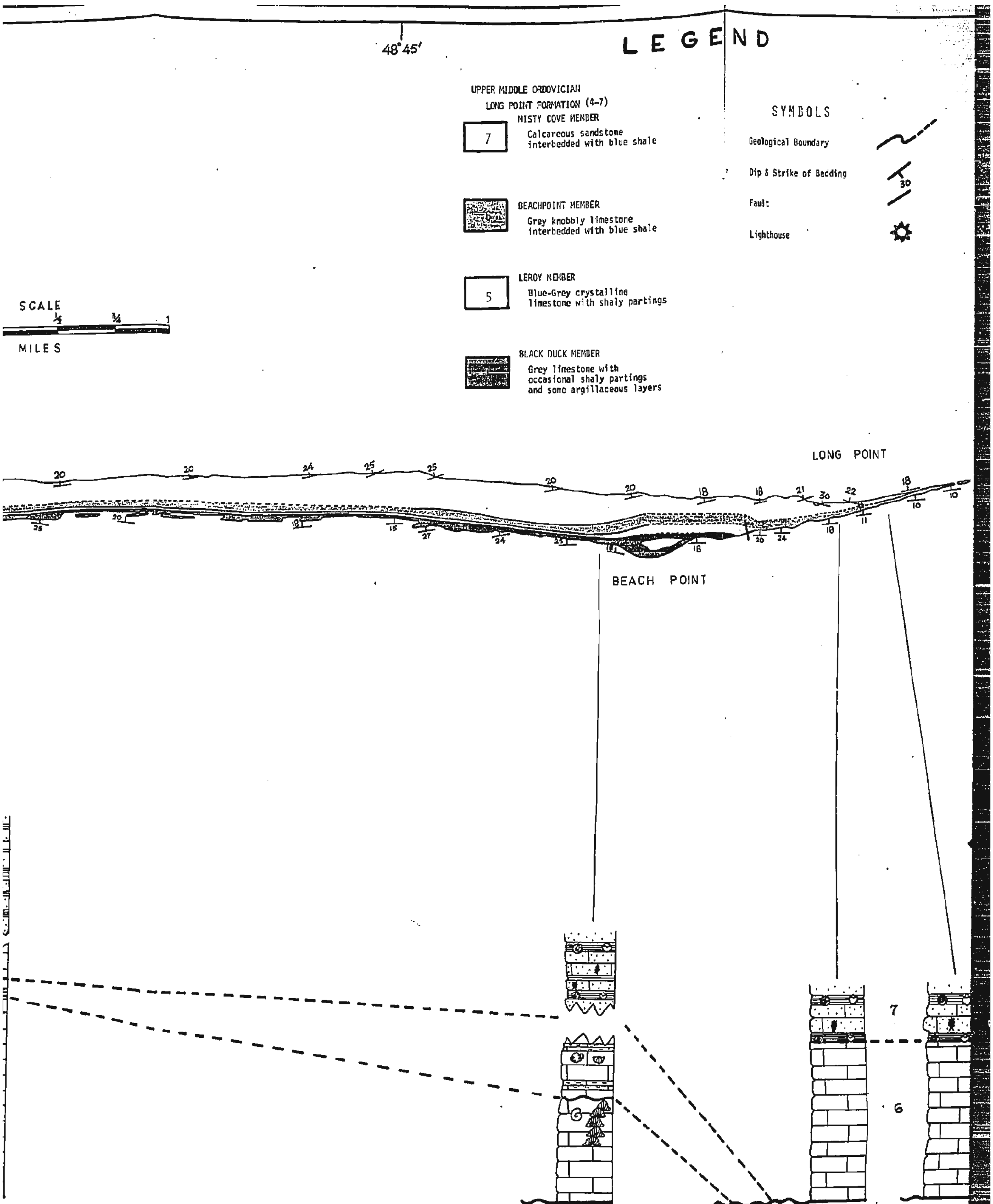
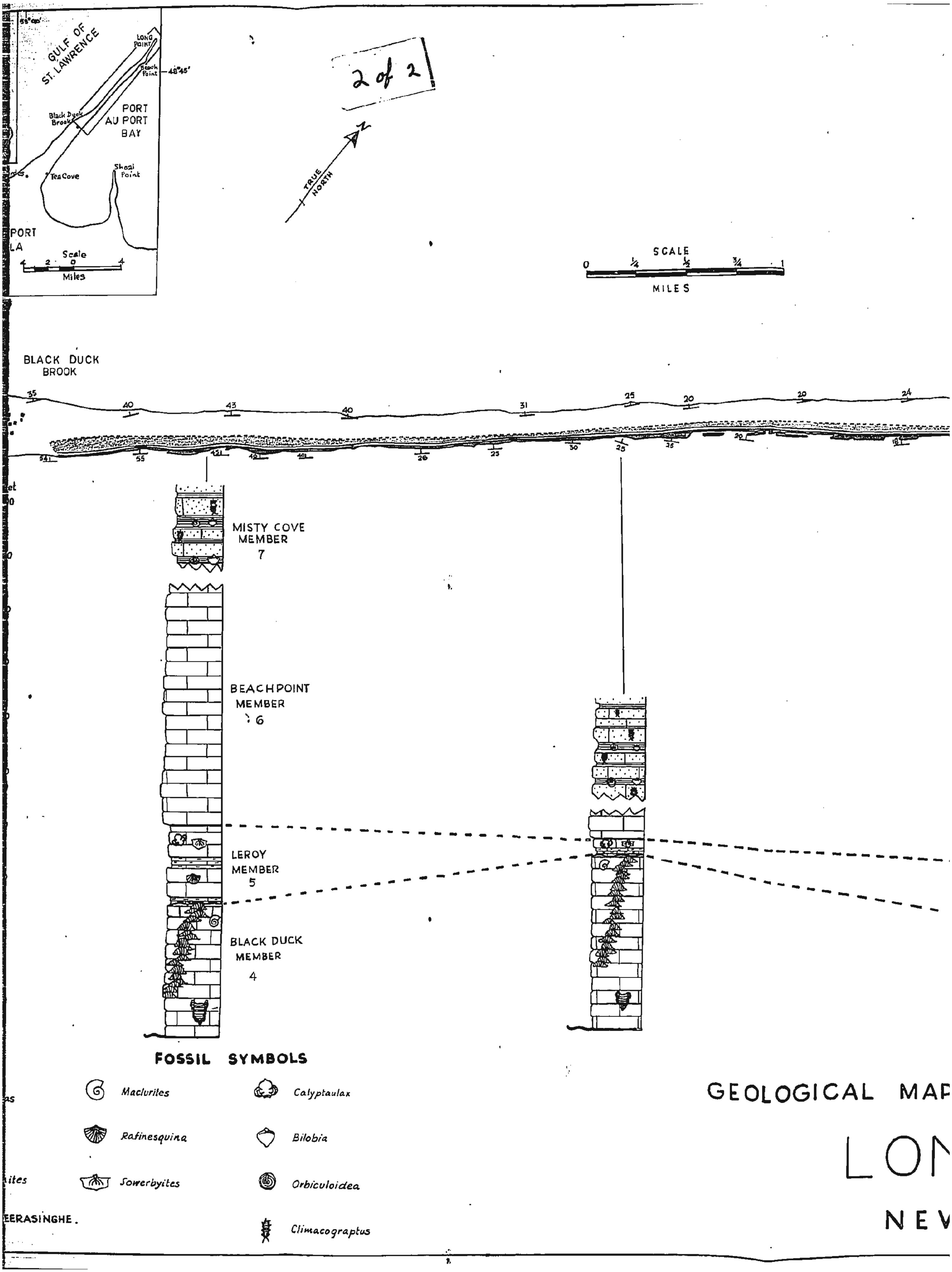
MILES
BLACK DUCK BROOK
Feet
MISTY COVE MEMBER
7
BEACHPOINT MEMBER
6
LEROY MEMBER
5
BLACK DUCK MEMBER
4
FOSSIL SYMBOLS
Gonioceras
Labyrinthites
Maclurites
Rafinesquina
Sowerbyites
Calyptaulax
Bilobia
Orbiculoidea
Climacograptus
GEOLOGY BY A. WEERASINGHE.



GEOLOGICAL MAP AND STRATIGRAPHIC SECTIONS

LONG POINT

NEWFOUNDLAND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FOSSIL SYMBOLS
Maclurites
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Rafinesquina
Bilobia
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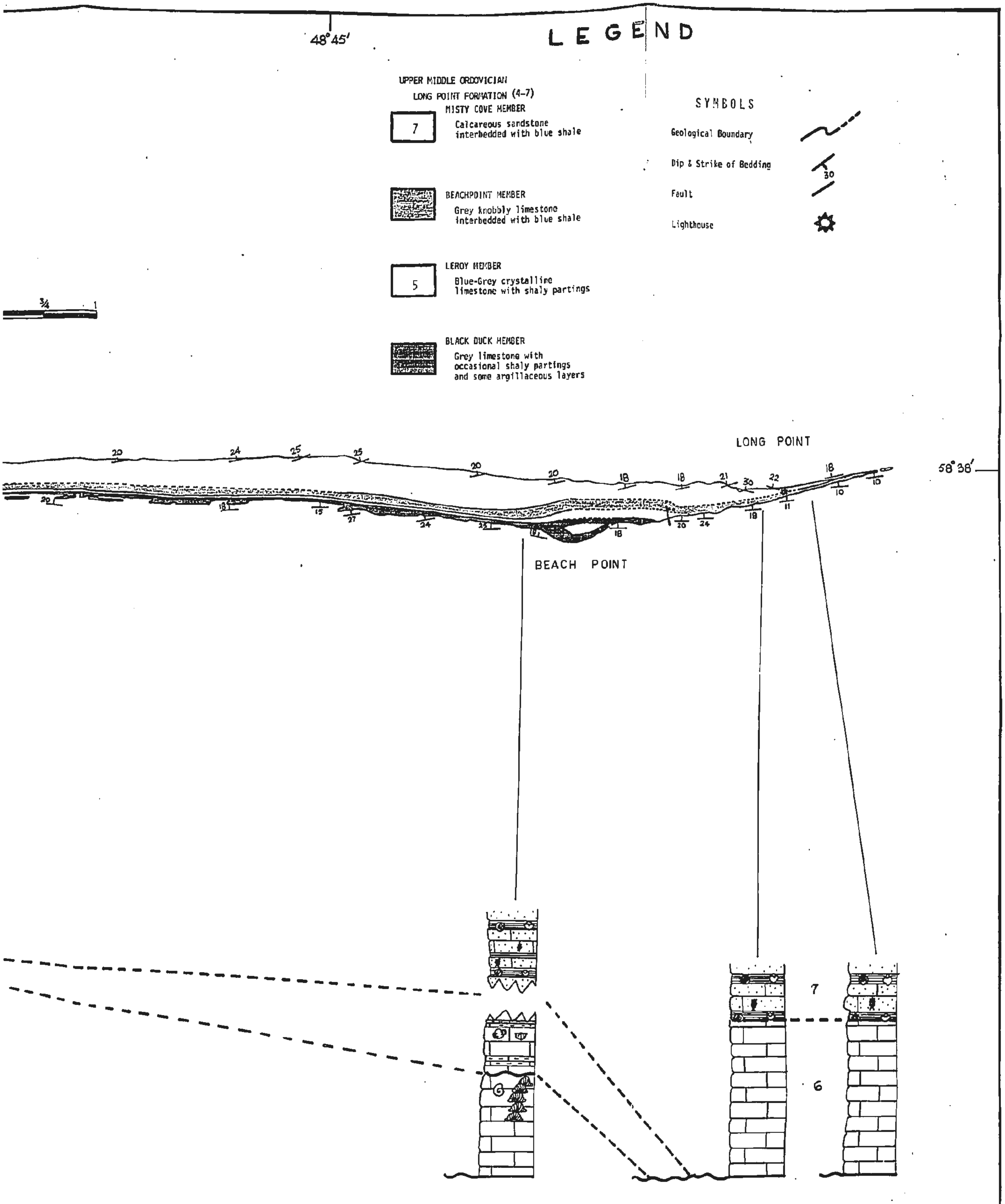

GEOLOGICAL MAP AND STRATIGRAPHIC SECTIONS

LONG POINT

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