# THE STRATIGRAPHY AND PALAEONTOLOGY OF THE CLAM BANK FORMATION, AND THE UPPER PART OF THE LONG POINT FORMATION OF THE PORT AU PORT PENINSULA, ON THE WEST COAST OF NEWFOUNDLAND



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by

Felicity H.C. O'Brien

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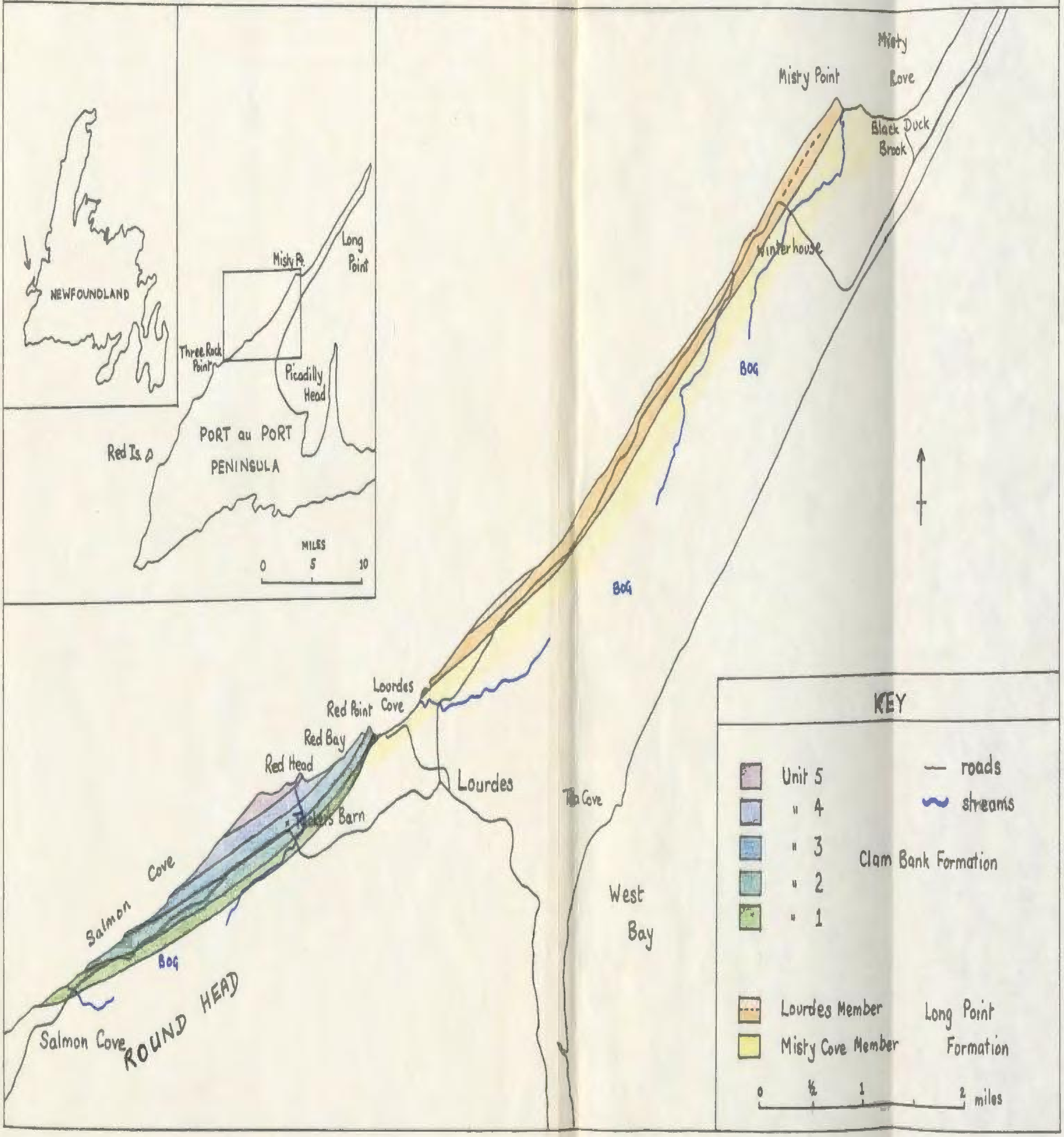
Fig.1 Geology of thesis area between Misty Point and Salmon Cove.



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# ABSTRACT

This thesis is a study of the palaeontology of the Long Point and Clam Bank Formations exposed between Misty Cove and Salmon Cove on the west coast of the Port au Port Peninsula of Western Newfoundland.

The red-beds which outcrop along the coast north of Lourdes Cove, have previously been thought to be part of the red sandstones and conglomerates of the Clam Bank Formation. A detailed study of the rocks in thin section and of the palaeontology of these beds and those immediately below them, showed that these beds are conformable with, and of similar age to, the Long Point Formation. They have, therefore, been named the Lourdes Member of the Long Point Formation.

The fauna of the upper part of the Misty Cove Member and the Lourdes Member of the Long Point Formation, and the fauna of the total exposed Clam Bank Formation is described. The age of the upper part of the Long Point Formation deduced from the fauna, is thought to be at the boundary between the Middle and Upper Ordovician, and that of the Clam Bank Formation to be Pridolian in age.

# CHAPTER 1

# INTRODUCTION

## Location and Area

The thesis area, in which the Clam Bank Formation and part of the Long Point Formation are exposed, is on the northwest coast of the Port au Port Peninsula of Western Newfoundland; it lies between North Latitude 48°37' and 48°42' and West Longitude 58°55' and 59°10' (Fig. 1).

The nearest town of any size is Stephenville which has an airport serviced by Air Canada. The Trans Canada Highway passes about ten miles to the east of Stephenville. Good roads connect Stephenville with the Trans Canada Highway to the east, and with the Port au Port Peninsula to the west as far as Campbell's Creek. A dirt road leads from Campbell's Creek to Lourdes, and from there other dirt roads provide ready access to all parts of the thesis area.

Farming and fishing are the occupations of most of the people living in the area who do not commute to Stephenville. Much of the area has been cleared for farming and the remainder is either wooded or bogland. Inland, except in wooded areas on higher ground, bedrock is largely hidden beneath glacial deposits, and outcrops are infrequent and isolated from one another. Along the shore, however, the strata are well exposed in coastal cliffs.

## Purpose of the Study

The present study of the Clam Bank Formation and of the upper part of the Long Point Formation was undertaken in order to 1) establish their stratigraphy and structural relationship, and 2) determine the nature of their contained fossils. It is based on field investigations carried out in the summers of 1968 and 1969.

## Topography

The relief of the northern part of the Port au Port Peninsula has been essentially controlled by the structure of the underlying rocks and their lithology. The area is underlain by shales, sandstones and limestones; the thicker sequences of the latter, being relatively more resistant, stand up as the hills of Round Head and the Long Point Peninsula. These northerly trending hills have been carved, rounded and smoothed by the passage of ice of the Wisconsin which was the last stage of the Quaternary glaciation to affect Newfoundland. Glacial drift covers much of the lower land. Irregularities in the surface of the drift are filled with water to give small ponds. Vegetative matter has completely filled many of these ponds in post-glacial times leaving thick deposits of peat inland south of Black Duck Brook and in the valley to the north of Round Head. The ponds which still remain, lie within marshy areas where the formation of peat, which started after the retreat of the ice cover under periglacial conditions, is still taking place (Plate 1). In front of Round Head massive screes have developed in the past which now protect the cliffs from frost action so that scree development has virtually ceased along most of the cliff face. Where frost action is no longer active, the screes are covered with vegetation.

Stream courses follow fault zones, the strike of the beds, or they are controlled by the distribution of glacial deposits.

The east side of Long Point is bounded along most of its length by steep cliffs 150 feet or more in height but towards its northern end they gradually become lower until at the tip of Long Point they are insignificant and only a few feet high. Such low cliffs are also typical of the west side of Long Point from its northern tip almost as far south as Black Duck Brook, where the coast curves west to Misty Point and gives rise to the sandy embayment of Misty Cove. Cliffs are absent around the cove where wind blown sand has accumulated above peat deposits.

At Misty Point the shoreline turns sharply southward, and the beach is again backed by low cliffs that developed here in an old peat deposit (Plate 2) with an exposed thickness of about 10 feet. Southward, towards Winterhouse, the peat wedges out against bedded gravels of fluvio-glacial origin that dip gently northwards beneath the peat.

Nearer to Winterhouse the gravels overlie, and are gradually succeeded by, bedrock so that at Winterhouse the cliffs are entirely in bedrock. From Winterhouse southwards to Salmon Cove there is a gradual increase in the height of the cliffs, and in front of Round Head they are over 200 feet high.

South of Red Head the cliffs are still being actively eroded by the sea but northward, except around the headlands, the cliffs are no longer under wave attack and are now subjected only to subaerial weathering. As weathering proceeds, the rocks crumble, and grass and other vegetation establishes itself, which clearly indicates that marine erosion no longer plays a role in the development of the cliffs along these sections of the coast. A well developed beach, through which bedrock projects in places, extends from Misty Point to Salmon Cove except in front of the more rugged headlands where the base of the cliffs is only exposed for a short period at low tide. At these headlands, as for example in front of Round Head in Salmon Cove where the cliffs are very high, and also in Lourdes Cove, a wave-cut platform adjusted to present sea level extends a considerable distance out to sea. Some distance off-shore there are resistant ridges of sandstone forming reefs. The presence of the wave-cut platform and reefs made it possible to measure a more complete sequence of the higher beds of the underlying Clam Bank Formation than would otherwise have been possible from coastal sections alone.

The unusual dagger-shaped headlands of the northern side of the Port au Port Peninsula were carved into their present outline as a result of glacial erosion during the Pleistocene. The final advance and retreat of the ice obliterated nearly all evidence of earlier glacial activity. Geomorphic and depositional evidence of the waning of the ice, and of eustatic readjustment of sea level, is found at several places on the coast of the Port au Port Peninsula.

## Previous Geological Work

Richardson (1861-63) made the first stratigraphical study of Western Newfoundland. His findings were published by Sir William Logan in 'Geology of Canada' (Logan, 1863). Richardson numbered the formations in the region 1-16, but these numbers were subsequently changed by Logan (1863) to the letters A to Q. The Long Point Formation, as presently recognized, is included in his division O (Table 1). The Clam Bank Formation was not distinguished as a separate unit at that time.

TABLE 1

MIDDLE ORDOVICIAN - DEVONIAN FORMATIONS OF WESTERN NEWFOUNDLAND (AFTER SCHUCHERT AND DUNBAR, 1934)

| | | | |
|---|---|---|---|
| Dev. | Lwr. | | Clam Bank Series 1,700' |
| Sil. | | | No record known. |
| | | Logan's divisions. | |
| | | Q much extended | Humber Arm series at least 5,000' |
| | | P | Cow Head thrust breccia. |
| | | O much extended | Faulting and elevation. Long Point series. 1,530' |
| | Chazyan | N to K | Table Head series 1,380' |
| | Canadian | I to D | St. George's series 1,570' - 2,080' + |
| | | Q in part | Green Point series, 1,700' - |

Murray (1866) was the first geologist to describe the Clam Bank strata and he referred them to the Carboniferous. In his later work with Howley (1881), the Clam Bank strata and the red beds at the top of the Long Point succession were regarded as a continuation of the flat lying Carboniferous red beds of Red Island (Fig. 1) which "abutt against the Lower Silurian strata of Round Head" thus "indicating a fault which would run in a nearly straight line from the cliffs nearly opposite Red Island . . . on a bearing about NE towards Long Point." They estimated the thickness of the Long Point sequence as approximately 800 feet. Fossils collected from the sequence were identified by Billings who concluded that they are of Black River age (Murray and Howley, 1881).

Schuchert and Dunbar worked in this area between 1910 and 1933. In their "Stratigraphy of western Newfoundland" (1934), the strata from Three Rock Point to Lourdes, and of Long Point, are called, respectively, the Clam Bank Series, and the Long Point Series, the former being described for the first time in any detail. They found the Long Point Series to be about 1,500 feet thick, almost twice the thickness estimated earlier by Murray and Howley (1881), and divided it into five beds with the youngest strata exposed at Misty Point "where the red basal sandstones of the Devonian rest upon the Long Point shales". Their section of the upper part of the Long Point Series is shown in Table 2.

The Long Point Series is described by Schuchert and Dunbar (1934) as being faulted against the Clam Bank Series, and they claimed that this fault contact can be seen "near the waterfall of the brook half a mile to the north of Clam Bank (Lourdes) Cove." Cooper (<u>in</u> Schuchert and Dunbar, 1934) identified the fossils collected by Schuchert and Dunbar, and he correlated the fauna with that of the Decorah Shale of the Black River Valley, New York.

TABLE 2

SECTION OF THE UPPER PART OF THE LONG POINT SERIES (AFTER SCHUCHERT AND DUNBAR, 1934)

| Bed | | Thickness (ft.) |
|---|---|---|
| 5 | Greenish thin-bedded rippled calcareous sandstones, with some blue limestones and zones of greenish shale, containing, in the upper part, Dinorthis aff. D. iphigenia, Hesperorthis aff. H. tricenaria, Plectorthis sp., Valcourea sp., Dalmanella rogata, Sowerbyella services (large), Rafinesquina aff. R. minnesotensis, and in the lower part, in brick-red sandstone, Rafinesquina near R. deltoidea (dip 25°N. 45°W.) | 536 |
| 4 | Unstudied strata from Black Duck Cove to near the lighthouse, 7 miles north along the west shore, estimated | 667 |
| 3 | Greenish-gray, somewhat rippled, calcareous shales interbedded with three layers of fine-grained limy sandstone and some sandy limestone, the harder beds in the upper part replete with three species of Buthotrephis . . . (Dip 20°N.54°W.) | 150 |

Schuchert and Dunbar (1934) also measured and described the Clam Bank Series (Table 3) and assigned it to the Lower Devonian because the fossils they collected included "a Spirifer more like a Devonian than a Silurian form" and "a single specimen of the characteristic Camarocrinus (the "root" of Scyphocrinus), a peculiar chambered crinoid root not previously known in the lower Devonian of America north of central New York but also occurring in the Lower Devonian of Bohemia." They thought that the conglomerates at the base of their section resembled the continental Connecticut Valley Triassic sandstone.

TABLE 3

LOWER DEVONIAN CLAM BANK SERIES (AFTER SCHUCHERT AND DUNBAR (1934) BEDS 1 AND 2 MEASURED BETWEEN LOURDES AND MISTY POINT

| Bed | Top covered by the sea | Thickness (ft.) |
|---|---|---|
| 10 | Interbedded red shale and sandstone. | 210 |
| 9 | Variegated shale and sandstone with ostracods near base. | 100 |
| 8 | Variegated sandy shale with some sandstone and limy shale. | 365 |
| 7 | Gray thin-bedded rippled sandy and muddy limestone with abundant *Spirifer*. | 35 |
| 6 | Variegated rippled shale and sandstone. | 90 |
| 5 | Gray rippled limy sandstone with layers of *Spirifer*. | 25 |
| 4 | Red sandy shale above, below thinly bedded muddy limestone with *Leperditia*, *Camarocrinus*, *Favosites*. | 40 |
| 3 | Variegated shaley sandstone with small pelecypods. | 135 |
| 2 | Variegated shale and sandstone. | 425 |
| 1 | Dark-red cross-bedded conglomerates, sandstones and some sandy shale. | 265 |
| | Total | 1,690 |

Sullivan (1940) in his study of the rocks of the Long Point and Clam Bank Series, changed the status of each of these stratigraphic units from Series to Group. He was the first to recognise that the beds of the Long Point Group at Lourdes and at Three Rock Point are overturned, and to establish that the Group contains the youngest Ordovician fauna known from the west coast of Newfoundland; he thought this fauna might represent an offshore facies of the Humber Arm Group which had been brought into closer relationship with the Humber Arm terrain by thrusting. He also considered the Long Point Group to be faulted against the massive limestone-breccia of Round Head and believed some of the large fragments in the breccia included fossils like those of the Group.

The Long Point Group was divided by Sullivan (1940) into seven beds of which beds 5, 6 and 7 represent the upper part of the Group (Table 4). Beds 6 and 7 together are approximately equivalent to bed 5 of the section described by Schuchert and Dunbar (1934), and bed 5 is their bed 4. However, a brick-red sandstone noted by Schuchert and Dunbar (1934) at the base of their bed 5 (Table 2), was apparently not found by Sullivan as there is no mention of this sandstone in his description of bed 6 (Table 4).

TABLE 4

UPPER PART OF THE LONG POINT GROUP
(AFTER SULLIVAN, 1940)

| Bed | Section measured from contact with Clam Bank Group at Misty Point | Thickness (ft.) |
|---|---|---|
| 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, sparsley fossiliferous. Exposed near inner part of cove at Black Duck Brook. | 90 |
| 5 | Thin-bedded knobbly limestone, light grey, interbedded with greenish-grey shaley layers. A few sandstone layers. Almost entirely unfossiliferous. Exposed along west shore of Long Point between Black Duck Brook and lighthouse. | 443 |

Sullivan's (1940) section of the Clam Bank Group is shown in Table 5, where his beds are correlated with the appropriate beds of the section established by Schuchert and Dunbar (1934). Beds 1 and 2 of Schuchert and Dunbar (1934) do not belong to the Clam Bank Group as they were measured between Lourdes and Misty Point, and they are, therefore, not comparable with beds 1 and 2 of Sullivan.

TABLE 5

SULLIVAN'S (1940) SECTION OF THE CLAM BANK GROUP SHOWING ITS RELATIONSHIP TO THE SEQUENCE OF SCHUCHERT AND DUNBAR (1934) FROM BED 3-7. BEDS 1 & 2 OF SULLIVAN ARE NOT COMPARABLE WITH BEDS 1 & 2 OF SCHUCHERT AND DUNBAR (SEE TEXT)

| S&D 1934 | S 1940 | | Thickness (ft.) |
|---|---|---|---|
| 9&10 | 7 | Interbedded red and green thinbedded sandstone, cross-bedded and ripplemarked. | 370' |
| 7&8 | 6 | Arenaceous and argillaceous lst. interbedded with sandy shale. Limestone layers replete with brachiopods _Spirifer modestus_ var. _plicatus_ Maynard and _Leptaena rhomboidalis_ (Wilkens). | 409 |
| 6 | 5 | Reddish crossbedded sandstone and shale. | 93 |
| 4&5 | 4 | Grey-green mud cracked sandy lst. | 87 |
| 3 | 3 | Greyish-green, sandy lst. and shale. Ripplemarked and mud cracked. Very fossiliferous including the following: _Platyceras_ sp., _Sanguinolites_ sp., _Dalmanella_ cf. _concinna_ (Hall), _Leptaena rhomboidalis_ (Wilkens), _Spirifer modestus_ var. _plicatus_ Maynard _Strophonella_ cf. _S. geniculata_ (Hall), _Favosites_ sp. and _Zaphrentis_ sp. | 125 |
| | 2 | Reddish shale and micaceous sandstone. | 450 |
| | 1 | Brick-red, thinly laminated and crossbedded sandstone and interbedded conglomerate. Mud cracked and ripplemarked. | 345 |
| | | | 1,879 |

Sullivan (1940) considered that the fossils he collected from the Clam Bank Group represented a fauna similar to that of the Helderberg Limestone of the central Hudson Valley of New York, now regarded as Gedinnian to early Siegenian (Boucot et al., 1969).

Cooper (1942) suggested correlation of the Clam Bank Group with the Keyser Limestone of the central Appalachians, thus giving the formation a basal Devonian age. Several years later, Cooper (1956) restudied the brachiopods from the Long Point Group and correlated them with his Upper Wilderness Stage, the equivalent of the lowest Trenton of Kay (1948).

In Geological Survey of Canada Memoir 323, Riley (1962) reviewed all previous work carried out in the Stephenville Map-Area, but he did not provide any new information relevant to the thesis area.

Rodgers and Neale (1963) accounted for the complexity of the stratigraphy and structure of the Palaeozoic rocks of the west coast of Newfoundland, by proposing the existence of two klippen, one at the northern tip of the Great Northern Peninsula and the other extending from the Port au Port Peninsula north to Daniels Harbour. Part of the latter is shown in Figure 2. They thought the klippen moved into place during the Middle Ordovician: a deep water greywacke sequence (Humber Arm Series) to the east was uplifted and slid westwards under the influence of gravity, assisted by lubrication from shales being

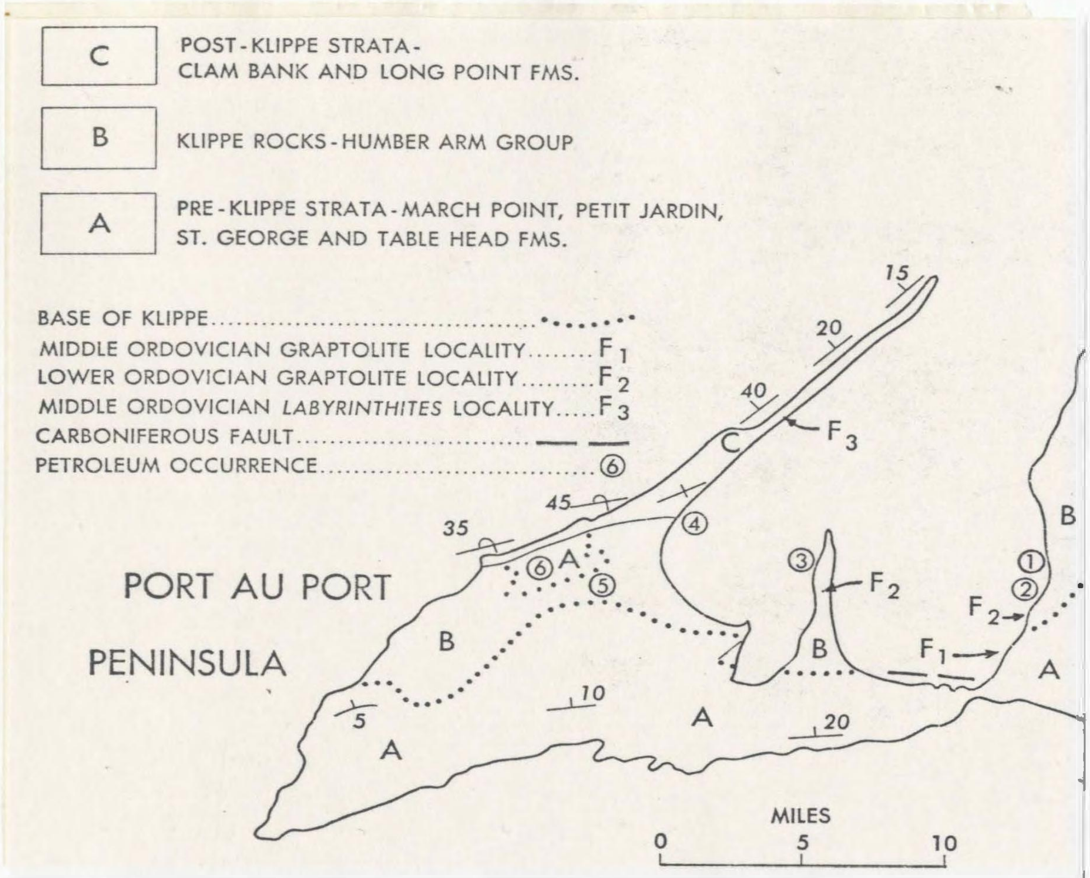



FIGURE 2

GEOLOGY OF THE PORT AU PORT PENINSULA SHOWING PART OF THE SOUTHERN KLIPPE OF RODGERS AND NEALE (AFTER CUMMING 1967)

deposited on the shallow water carbonate sequence (the Table Head and St. George's Groups), to overlie the rocks of the carbonate sequence as far west as the Port au Port Peninsula. The Humber Arm Series moved in slices so that older rocks came to overlie younger rocks and, in places, part of the carbonate sequence itself was involved and became intercalated in the greywacke sequence. This interpretation of the structure also accounts for the presence of fossils of the same age in both sequences.

The younger Ordovician age of the Long Point Group suggested to them that the Long Point Group and the Clam Bank Group were deposited after the arrival of the klippe, thus giving an upper limit to the time of its emplacement.

The fossils collected by Rodgers and Neale from the Clam Bank Group in 1961 were identified by Cumming (in Rodgers and Neale, 1963) who considered their age to be latest Silurian to earliest Devonian.

Rodgers (1965) studied both the Long Point and the Clam Bank strata, and he reduced the stratigraphic status of both sequences from Group to Formation. He considered that an unconformity separates the Long Point Formation from Humber Arm terrain and this relationship was subsequently confirmed by Utting and Brueckner when they dug out the contact on the east coast of Long Point (in Rodgers, 1965). In the northeast corner of Clam Bank (Lourdes) Cove, Rodgers (1965) described the top beds of the Long Point Formation and, like Schuchert and Dunbar (1934), noted the maroon cast of the higher beds, which he stated "still resemble the beds in the Long Point more than those in the Clam Bank." He recorded that Middle Ordovician fossils were found in this locality in 1961, both by Kindle and Whittington and by Rodgers and Neale. Although Rodgers (1965) did not observe the contact between the Long Point and Clam Bank Formations, he believed that the maroon cast of the highest beds of the former, "hints at a gradation" and also that if the Long Point Formation grades up into the Clam Bank Formation, the lowest 700 feet of the Clam Bank Formation must represent the time interval from Upper Ordovician to the end of the Silurian. Previous authors had regarded this contact as a fault because they thought that the highest beds of the Long Point Formation lie against the highest Clam Bank Strata.

Rodgers (1965) studied the outcrop of the Clam Bank Formation from Misty Point to Three Rock Point and found the highest beds exposed on a point a little more than a mile southwest of Clam Bank (Lourdes) Cove at Red Head (for this name see Figure 1), with the same stratigraphic sequence appearing "below them in both directions along the shore, to Clam Bank (Lourdes) Cove on the one side and to Salmon Cove on the other . . . the top and bottom of this stratigraphic sequence are thick units of red beds, the upper one especially coarse." He had difficulty in fitting the red beds exposed along the shore northeast of Clam Bank (Lourdes) Cove into this sequence but suggested that if a single large cross-fault (shown in Figure 3) were present just north of the brook at the northeast corner of Clam Bank (Lourdes) Cove, then the entire section beyond could be explained as a redder and coarser version of the sequence southwest of the cove.

Rodgers (1965) noted that north of the community of Lourdes, both the Long Point Formation and the Clam

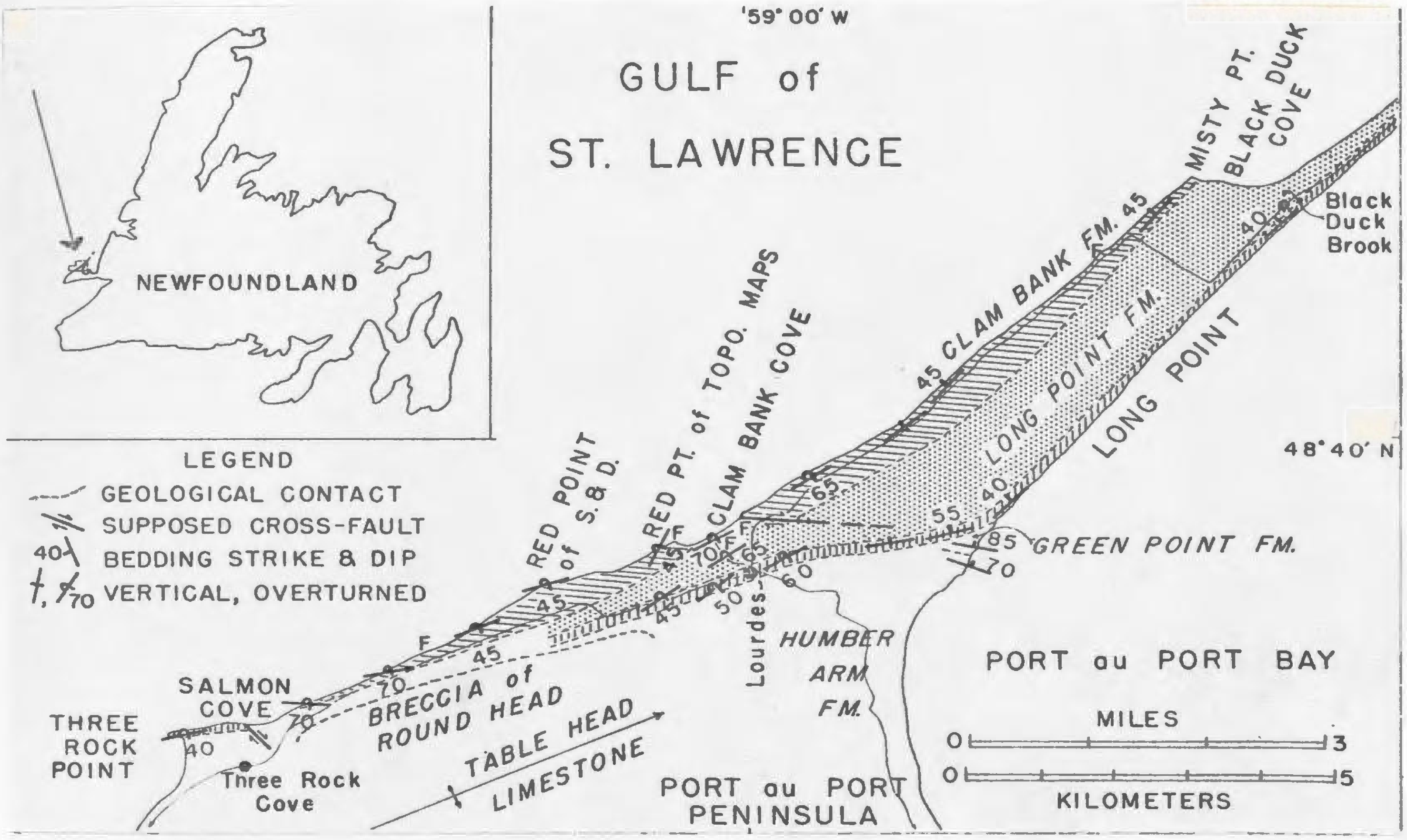



Figure 3

Geological map of the outcrop belt of the Long Point and Clam Bank Formations (after Rodgers, 1965).

Bank Formation strike northeast and dip northwest, whereas in the vicinity of Lourdes, both formations change from this dip through vertical to overturned so that they dip to the southeast between Lourdes and Three Rock Point. He states "therefore all strata face or young to the northwest, whatever their dip; they evidently form a single homocline extending the length of the outcrop belt."

Lilly (1966) examined outcrops occurring as shoals in coastal waters approximately 130 miles north of Port au Port Bay. He found the beds little disturbed and thought they represented a northerly continuation of the Clam Bank Formation which, in that area, has an overall structure of a very gently folded anticline plunging to the north. Further south, just west of the Port au Port Peninsula, Lilly (1966) found that the rocks are dipping at 20° to the northwest, whereas eight miles offshore the beds are almost horizontal; he also discovered that the junction between the undeformed Clam Bank Formation and the intensely deformed strata of the Humber Arm Group is present about six miles from the coast.

Bruecknen (1966), in a review of the geology of Western Newfoundland, suggested that the Long Point Formation is an "older neo-autochthonous sequence" of Late Middle Ordovician age.

Cumming (1967) drew a cross-section through Anticosti Island to the northern part of the Port au Port

Peninsula (Figure 4) which shows the Long Point Formation above the allochthonous rocks of the klippe (Humber Arm Group), the Clam Bank in depositional contact with the Long Point Formation, and a complete absence of Silurian strata in the latter area. The strata of the Port au Port area are also shown as continuing beneath the Gulf of St. Lawrence so that to the west they are present beneath Anticosti Island. Cumming (1967) also noted that the klippe rocks acted as a cap rock to trap petroleum in the underlying platform carbonates.

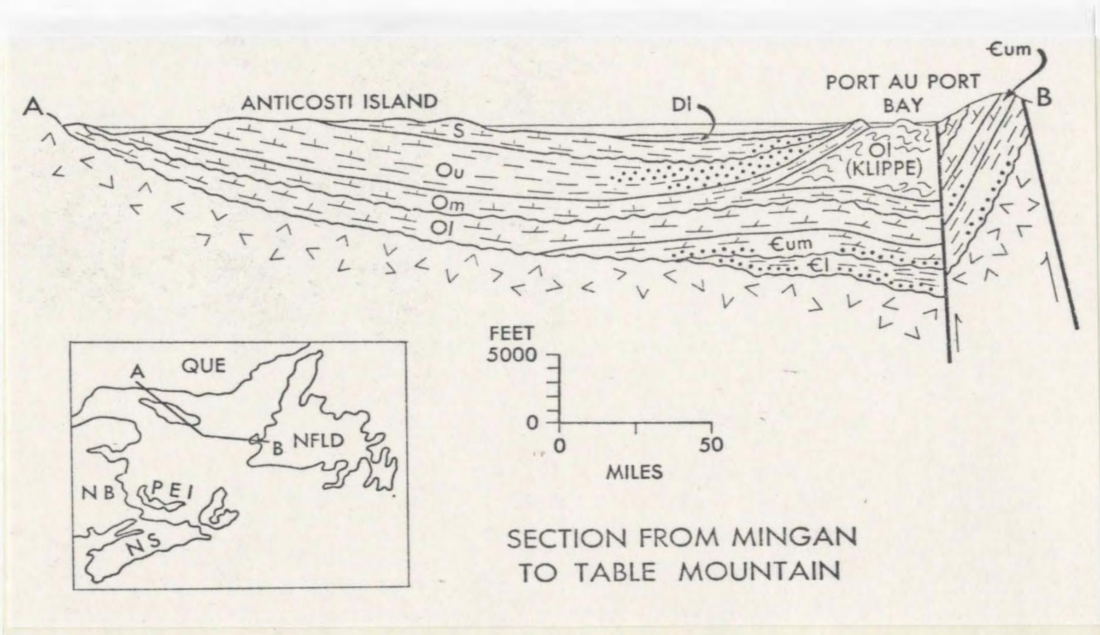



FIGURE 4

SECTION FROM MINGAN TO TABLE MOUNTAIN. (CUMMING, 1967)

Williams (1969), like Rodgers (1965), discussed the possibility of the 700 feet of strata beneath the fossiliferous limestone in the Clam Bank Formation representing the total sedimentation of the Silurian Period on the west coast of Newfoundland.

Kay (1969) divided the Long Point Formation into four unnamed 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 limestone with reefs and the coral _Labyrinthites_ (25 m).

1 Sandstone and mudcracked calcilutite (20 m).

He suggested that the Long Point Formation may be a continuation of the Mingan Limestone of the Mingan and Anticosti Islands, and placed it in the Valcourian-Ashbyan and Porterfieldian Stages of the Chazyan and Bolarian Series of the Appalachian region.

Weerasinghe (1970) and Shaikh (1971) studied the Long Point Formation of the northern and southern parts respectively of Long Point. As they were working in an adjoining area of significance to the present study, it was mutually agreed that, to facilitate description of the Long Point Formation, it was necessary to divide it into members (Table 6).

TABLE 6

MEMBERS OF THE LONG POINT FORMATION (FROM WEERASINGHE 1970)

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

Members 1, 2 and 3 were named by Shaikh, 4, 5 and 6 by Weerasinghe, and 7 and 8 by Weerasinghe in conjunction with the writer.

Weerasinghe (1970) correlated the Long Point Formation with British, American and Canadian formations of Middle to Upper Ordovician age (Table 7), and suggested that the fauna is most closely related to that of the Ottawa Formation of Central Ontario. He also noted that there is only a slight age difference between the fauna from the uppermost and lowermost beds respectively of the Long Point Formation.

Shaikh (1971) found no evidence of a fault contact between the Clam Bank Formation and the Long Point

Formation in the northeast corner of Clam Bank (Lourdes) Cove; he did, however, describe a fault contact between the red beds at the top of the Long Point Formation and the lowest beds of the Clam Bank Formation in the southwest corner of the cove.

TABLE 7

CORRELATION OF LONG POINT FORMATION OF THESIS AREA WITH THE OTTAWA FORMATION (AFTER A. C. WILSON) AND THE TRENTON GROUP (AFTER T. J. M. SCHOPF) AFTER A. WEERASINGHE 1970

| | | British | | American Stage | Black River, New York | | | Ottawa-St.Lawrence Lowland | | Long Point Peninsula | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Series | Graptolite Zone | | Group | Formation | Member | Formation | Member | Formation | Member |
| ORDOVICIAN | UPPER | Ashgill | Dicellograptus complanatus | ? | TRENTON | Cobourg | Hillier | OTTAWA | Cobourg | | |
| | | CARADOC | Pleurograptus linearis | BARNEVELD | | | Hallowell | | | ----?---- | ? |
| | | | | | | | | | | LONG POINT | Misty Cove |
| | MIDDLE | | Dicranograptus clingani | | | Denmark | | | Sherman Fall | | Beach Point |
| | | | | | | Shoreham | | | | | Leroy |
| | | | Diplograptus multidens | WILDERNESS | | Kirkfield | | | Hull | | |
| | | | | | late | Rockland | | | Rockland | | Black Duck |
| | | | Nemagraptus gracilis | | Black River early | Chaumont | | | Leray | | |

Plate 1.

Fig. 1

PLATE 2

Fig. 1. Cliff, four feet high, developed in the peat near Misty Point showing two tree layers, and a layer of carbon just above the pebbles of the existing beach in the foreground.

Fig. 2. Cross-bedding in the coarse sandstones of the Lourdes Member at Misty Point.

Fig. 1

Fig. 2

PLATE 3

Fig. 1. View northeastward across Lourdes Cove looking along the top of the red sandstones which strike N 50° E. The men are standing on an outcrop of the same beds on the beach.

Fig. 2. View, from the road turning at Winterhouse, looking northeast towards Misty Point, showing the beds along the shore striking N 40° E, and dipping 36° to the NW.

Fig. 1

Fig. 2

# CHAPTER 2

## LONG POINT FORMATION

Rocks of the Long Point Formation underlie the thesis area between Misty Cove, at the southern end of Long Point, and Lourdes Cove (Fig. 1); only the upper part of the Misty Cove Member and the Lourdes Member are represented (Table 8).

The beds of the Misty Cove Member crop out below low tide level in Misty Cove, in the stream bed and the waterfall close to the northeast corner of Lourdes Cove, and also in the low cliffs between the waterfall and the fishermen's huts, toward the southwestern end of the same cove. They are best exposed at the waterfall and behind the huts, as the cliffs between these localities are largely grass covered.

The upper 358 feet of the Misty Cove Member crop out in the thesis area. The lower part of this sequence is made up of an alternation of grey-green sandstones and shales, the middle part comprises shales, calcareous sandstones and thin interbeds of limestone, and the upper part consists of sandstones containing little calcareous material. The colour of the beds changes from grey-green at the bottom of the sequence to maroon at the top.

The rocks of the Misty Cove Member are overlain

TABLE 8

DIVISION OF THE LONG POINT FORMATION
INTO MEMBERS AND BEDS

Composite section measured in Lourdes Cove, and along the shore from Misty Point to Lourdes Cove.

| Member | Bed | Lithology | Thickness |
|---|---|---|---|
| Lourdes | 3 | Brown fissile shales and flagstones | 38' |
| | 2 | Maroon shales with limy lenses, some containing fossils | 64' |
| | 1 | Red, current-bedded conglomerates and sandstones with red-brown shales at base ripple marked, in places a mud-breccia, graded bedding, bitumen in joints | 115' |
| Misty Cove | 4 | Alternating reddish-pink and brown sandstones and shales. Sandstones flaggy showing some current bedding. Red sandstone at base very fossiliferous. Top beds browner, less fossiliferous | 46' |
| | 3 | Sandstone and limestone beds alternating with grey-green shale. Limestone more crystalline 2"-6" thick. Browner and more sandy towards top. Very fossiliferous | 95' |
| | 2 | Fine-grained calcareous sandstone, some grey limestone beds. Layer of brachiopods 79' from top of waterfall, otherwise sparsely fossiliferous | 162' |
| | 1 | Coarse, grey calcareous sandstone with green-grey shaly layers. Weathers brown. Sparse brachiopods and graptolites | 55' |

conformably by 217 feet of red beds of the Lourdes Member (Table 8). The latter underlie the coast between Misty Point and the northeast corner of Lourdes Cove, and they are also present in the southwest corner of the same cove. At Misty Point the lowest beds exposed are coarse, trough-bedded red sandstones with numerous pale-green reduction spots. They grade upwards into more shaly beds which include calcareous lenses. Most of the iron in the calcareous lenses, and in the shales immediately surrounding them, has been reduced, so that the lenses and the shales around them are bright green. These red and green beds are overlain in the coastal cliffs to the south, between Winterhouse and Lourdes, by an alternation of dark brownish-red shales and fine-grained flaggy sandstones which are the highest beds of the Long Point Formation exposed on the Port au Port Peninsula.

Beds 1 and 2 of the Misty Cove Member (Table 8) are present on the eastern side of Misty Cove, and in the stream section above the waterfall in the northeast corner of Lourdes Cove. Both consist dominantly of calcareous sandstone, but those of Bed 1 are coarser-grained than those of Bed 2, and they are interbedded with shales, whereas the sandstones of Bed 2 contain intercalations of limestone.

Bed 3, which crops out in the waterfall in the northeast corner of Lourdes Cove and also behind the fishermen's huts, comprises sandstones, shales, and both sandy and crystalline limestones. The more sandy beds are not as fossiliferous as the calcareous beds, and they are generally cross-bedded. Mica and chlorite are particularly abundant in the sandstones and the shales.

Bed 4 is exposed in the cliffs between the waterfall and the small headland in the northeast corner of Lourdes Cove which is partly covered by Pleistocene marine clay. It consists of an alternation of reddish-pink and brown sandstones and shales that form a transitional sequence between the calcareous rocks of the Misty Cove Member and the predominantly noncalcareous rocks of the Lourdes Member.

The red beds above the Misty Cove Member (Table 8), that are here regarded as forming the Lourdes Member of the Long Point Formation, have previously been considered as Clam Bank strata. Thus, the beds between Misty Cove and Lourdes Cove, and also those in the southwestern part of Lourdes Cove, were thought to represent, respectively, the uppermost and lowermost portions of the Clam Bank Formation. The reasons for the assignment of these red beds to the Long Point Formation are discussed in Chapter 7.

Bed 1 of the Lourdes Member is exposed in the southwestern and northeastern corners of Lourdes Cove, and it is again exposed along strike, in a small headland in Lourdes Cove between these two other outcrops. Both in the exposure in the southwest corner of Lourdes Cove and in this small headland, Bed 1 shows some trough-bedding within the beds and a considerable degree of graded bedding, with each graded bed reaching a thickness of up to 18 inches. Along strike to the north of Lourdes Cove this Bed becomes progressively more trough-bedded until it is covered by Bed 2. From Winterhouse, at the point where the Lourdes-Black Duck Brook road turns east across the Long Point Peninsula, northward to Misty Point, Bed 1 reappears showing extensive cross- and trough-bedding. The cross- and trough-bedding indicate that, at the time of deposition of the sediments, the currents came from 10° to 20° E of N. showing that their source was in that direction. Bed 1 becomes increasingly more arkosic towards its top. The cement of the sandstone and the arkose is limonitic and haematitic.

The maroon sandy shales of Bed 2, above the coarse sandstones of Bed 1, are much darker in colour, and they contain reduction spots which, in places, form large patches where the iron has been reduced to give the rock a bright green colour. Most reduction spots have small particles of organic material centrally, and in the more widely reduced limy lenses there are poorly preserved gastropods and thick-shelled brachiopods. At the top of Bed 2, the colour changes from maroon to dark-brown.

The shales of Bed 3 are dark-brown and very fissile. They grade upward into thinly-bedded, dark-brown flagstones. Bed 3 contains no calcite, and it is unfossiliferous.

The overall mineral composition of the beds of the upper portion of the Long Point Formation changes quite gradually up the section. However, changes in the mode of occurrence of a particular mineral, especially calcite and the iron minerals, give rise to quite sudden visible changes in the rock types.

Beds 1 and 2 of the Misty Cove Member are mostly grey-green in colour but typically weather a bright rusty colour as a result of the weathering of chlorite and possibly biotite. Both these Beds have a calcite cement.

Bed 3 contains more calcite-rich beds than the previous Beds; the average composition of the sandy limestones, which make up much of this Bed, being 33% calcite, 33% chlorite and biotite, and 33% quartz, bitumen and heavy minerals. Biotite flakes are found, curved and distorted along the curve of the cross-bedding, with their long axes parallel to the current direction. Most of the biotite has altered to chlorite, some crystals completely and others partially, and some appear to be bleached. The last may, however, include muscovite. Bitumen occurs as grains and flakes in all the rock types of Bed 3.

In Bed 4 the percentage of chlorite and mica in the red sandstones is similar to that of Bed 3. Quartz is more abundant, and small amounts of feldspar are present. The proportion of calcite is much less than in Bed 3; excluding the shell fragments, the rock is virtually free of calcite as it does not occur as grains or cement. The amount of limonite and haematite increases upward in Bed 4 until, in the brown beds at the top of the sequence, these minerals form the cement.

Bed 1 of the Lourdes Member lies conformably on top of Bed 4 of the Misty Cove Member. The proportion of one mineral to another is similar in the sandstones, conglomerates and shales in Bed 1 but these proportions change gradually from the base to the top of the Bed with calcite decreasing and feldspar increasing towards the top. Feldspar occurs as fresh plagioclase, altered orthoclase or graphically intergrown with quartz; limonite and haematite are present as a skin round the grains and also as cement. The joints of Bed 1, just north of Lourdes Cove, are filled with bitumen which has seeped in at some time after consolidation of the sediments.

In Bed 2 limonite becomes more important and makes up 20% of the total rock in the shales; it is present as grains or as a cement, but not as a skin around the grains. The quartz content is higher, and the plagioclase content lower, than in Bed 1. Epidote is present in small quantities. Calcite occurs in lenses but is not distributed throughout the rock.

Bed 3 of the Lourdes Member contains no calcite, and the iron content reaches a maximum for the Long Point Formation.

All the red beds of the Lourdes Member contain little or no calcite, and most of the iron present is limonite or haematite.

On Long Point, the rocks of the Long Point Formation strike northeast, almost parallel to the coast line between Misty Cove and Lourdes Cove. At Misty Cove the beds dip at 34° to the northwest whereas half a mile to the south they are vertical, and in the waterfall in the northeast corner of Lourdes Cove they are overturned and dipping steeply to the southeast (65°). In the southwest corner of Lourdes Cove, graded red beds striking at N 50°E, and dipping to the southeast at 47°, can be traced across the bay (Plate 3) into the northern corner of Lourdes Cove. These are the highest beds of the Long Point Formation represented on the southern side of the cove. A covered interval south of the red beds, representing about 130 feet in section, separates them from round-grained 'sugary' well sorted, evenly-bedded calcareous sandstones and red shales of the Clam Bank Formation striking N 30°E into the bay. The covered interval thus conceals the boundary between the Clam Bank Formation and the Long Point Formation. The sudden change in strike of the beds from N 50°E on one side of the covered interval to N 30°E on the other, indicates the presence of a fault contact between the two formations. Topographic expression of this fault can be seen as a valley which extends, in a southwesterly direction, from just behind the top of the cliffs above the covered interval in Lourdes Cove to the point where it joins the larger valley in front of Round Head.

Minor faults are present in the Long Point rocks in Lourdes Cove, and the rocks of Bed 3 of the Misty Cove Member are very shattered and slickensided.

Two sets of more or less vertical joints are distinguished in most localities, one set cuts the beds at N 113°E and the other set cuts them at N 57°E.

Fossils are found in all the Beds of the Misty Cove Member; Bed 3 is very fossiliferous, Bed 2 and most of Bed 4 are fairly fossiliferous, and Bed 1, and the top of Bed 4 are sparsely fossiliferous. The distribution of the various fossils in the Beds of the Long Point Formation is shown in Table 9.

TABLE 9

DISTRIBUTION OF IDENTIFIABLE FOSSILS WITHIN THE LONG POINT FORMATION

| Fossil | Member | | | | | | |
|---|---|---|---|---|---|---|---|
| | Misty Cove | | | | Lourdes | | |
| | Bed | | | | | | |
| | 1 | 2 | 3 | 4 | 1 | 2 | 3 |
| *Rafinesquina esmondensis* | | x | x | | | | |
| *Rafinesquina deltoidea* | | | x | x | | | |
| *Rafinesquina miodeltoidea* | | | x | x | | | |
| *Rafinesquina laurentina* | | | x | x | | | |
| *Sowerbyella sericea* | | x | x | | | | |
| *Sowerbyella subovalis* | | x | x | | | | |
| *Rafinesquina* cf. *R. hermitagensis* | x | | | | | | |
| *Rafinesquina* cf. *R. planulata* | | x | | | | | |
| *Paucicrura* cf. *P. rogata* | x | x | x | x | | | |
| *Hesperorthis* cf. *H. tricenaria* | | | x | x | | | |
| *Climacograptus spiniferous* | x | | x | | | | |
| *Hormotoma trentonensis* | | | x | | | | |
| *Euconia* cf. *E. etna* | | | | | | x | |
| *Ischadites iowensis* | | | | x | | | |

# CHAPTER 3

# PALAEONTOLOGY OF THE LONG POINT FORMATION

## Brachiopoda

Brachiopods were collected from two outcrops within the upper 300 feet of the Long Point Formation, one at the waterfall in the northeast corner of Lourdes Cove, and the other behind the fishermen's huts near the southern end of the same cove. Those collected from the lower beds in this part of the succession, grey-green sandstones, generally have quite well preserved shell material present, whilst the brachiopods in the succeeding red beds at the top of the formation are represented mainly by internal moulds; some external and internal casts were also found.

The specimens have been classified to genus, and, in most cases, to species level. Where diagnosis of the species is uncertain, the designation 'cf.' is used to indicate a comparable, possibly conspecific form and 'aff.' is used for a related but possibly different species.

The brachiopods collected from the top of the Long Point Formation are entirely articulate forms belonging to the orders Orthida and Strophomenida.

ORDER STROPHOMENIDA Öpik, 1934

This order is represented by two genera, Rafinesquina and Sowerbyella. The rafinesquinids generally occur alone in the redder, more sandy beds, while the sowerbyellids are usually associated with orthids in the finer-grained beds (see Plate 4, Fig. 1).

Family STROPHOMENIDAE King, 1846

Subfamily RAFINESQUININAE Schuchert, 1893

Genus RAFINESQUINA Hall & Clarke, 1892

Generic description (from Muir-Wood & Williams, 1965).

The shell is concavo-convex with a vestigial pseudodeltidium. The ornamentation is unequally parvicostellate with feeble posterolateral rugae. In the pedicle valve the muscle scar is small, subcircular and weakly impressed, without bounding ridges except for extensions of divergent dental plates. In the brachial valve the notothyrial platform is weak and transmuscle septa are not preserved.

Rafinesquina cf. R. hermitagensis Bassler, 1932
(Plate 4, Fig. 2).

Material

The single specimen collected from the grey-green shaly sandstone of the Misty Cove Member, halfway between the top of the waterfall in Lourdes Cove and the road from Lourdes to Winterhouse, is an internal mould of a pedicle valve.

Description

The shell is broadly U-shaped in outline, and it is slightly wider than it is long. The cardinal angle measures about 90°. The greatest width occurs behind the hinge line. Where the true lateral margins can be seen, they are approximately parallel. The anterior and lateral margins follow a smooth, almost semicircular curve. The valve is generally very flat round the margins but shows considerable convexity in the median region behind the umbo. Ornamentation consists of costae of two sizes although all except the median costa, which is thickened, are very fine. The angle between the dental ridges is about 100°.

Discussion

This description is very similar to that of Salmon (1942) for Rafinesquina trentonensis (Conrad) except with regard to size, as the Long Point specimen is larger. In this respect it is similar to the plastotype of R. hermitagensis Bassler figured by Salmon (1942). Cooper (1956) suggests that because R. hermitagensis Bassler is consistently slightly different in shape and ornamentation, it is probably a valid species. If this is so, then the Long Point specimen is probably Rafinesquina hermitagensis Bassler. Bassler (1932) described this species from beds of the same age as the Upper Sherman Fall beds of the Ottawa Formation.

*Rafinesquina* cf. *R. planulata* Cooper 1956.

(Plate 4, Fig. 3).

*Material*

A very poorly preserved external mould of a pedicle valve was collected from the grey-green sandstone above the waterfall in the northeast corner of Lourdes Cove.

*Description*

This is the smallest of the species of *Rafinesquina* collected from the Misty Cove Member of the Long Point Formation. It has a U-shaped outline, with the greatest width reached at the hinge line, and nearly parallel lateral margins so that the cardinal angles are practically right angles. The anterior margin is broadly rounded. The valve is flat around the margins with greatest convexity occurring at, and just anterior to, the umbo.

Ornamentation consists of a thickened median costa and coarser lateral costae with finer costae between. Faint growth lines can also be seen.

The greatest width is 14 mm. and the valve is 11 mm. long.

*Discussion*

Cooper (1956) states that *R. planulata* can be distinguished from *R. trentonensis* by its smaller size, plano-convex profile and delicate cardinalia. The Long Point specimen is slightly smaller than those described by Cooper as *R. planulata*, but otherwise appears to correspond

PLATE 4

RAFINESQUINA

Fig. 1. Hand specimen of red sandstone of the Misty Cove Member of the Long Point Formation, showing shells at three levels. Lowest level rafinesquinids only; middle level rafinesquinids with sowerbyellids; upper level mostly sowerbyellids. The majority of the small shells are filled with mud and thus show almost perfect internal moulds.

Fig. 2. OLB 2. Internal mould, with external features superimposed, of the pedicle valve of a large specimen of *R.* cf. *R. hermitagensis* Bassler, 1932.

Fig. 3. OLB 3. Modelling clay cast of an external mould of the pedicle valve of a small specimen of *R.* cf. *R. planulata* Cooper, 1956.

Fig. 4. OLB 4. Internal mould of the pedicle valve of *R. esmondensis* Salmon, 1942.

OLB 1

Plate 4

Fig.1

0 10 20 30 mm

OLB 2

Fig.2

x 2

OLB 3

Fig.3

x 2

OLB 4

Fig.4

x 2

in outline, convexity and ornamentation. As it is much smaller and has coarser costae than R. trentonensis, the Long Point specimen is more likely to be R. planulata than a youthful specimen of R. trentonensis. R. planulata is present in the Oranda Formation of Virginia (Cooper, 1956), but the range of this species is unknown because no upper limit has yet been determined.

Rafinesquina esmondensis Salmon, 1942
var. borealis Wilson, 1946.
(Plate 4, Fig. 4)

Material

Three specimens were collected from the sandstone of the Misty Cove Member just below the red beds at the base of the waterfall in the northeast corner of Lourdes Cove. Only internal moulds of pedicle valves were found.

Description

The outline is U-shaped and the valve is widest at the hinge line. The pedicle valve is moderately convex but as the greatest convexity is very close to the anterior margin, the valve appears to be almost flat posteriorly. The angle between the dental ridges is narrow, about 90°. The ratio thickness : width : length is 1 : 5.3 : 3.6; the greatest width is 25 mm.

Discussion

This species is characterized by its very narrow strip of shell along the anterior margin which makes the valve look much wider than long, and flat, when the convexity of the shell is quite high. The specimens from the Long Point Formation are smaller than those described by Salmon (1942) but they are otherwise similar, and the ratio of their length to width is the same. They are also smaller than those described by Wilson (1946), although only slightly, and likewise correspond in the ratio of their length to width. Wilson (1946) used the smaller size of her specimens from the upper part of the Cobourg beds of the Ottawa Formation as a sufficiently important characteristic to erect the variety borealis to distinguish the Cobourg specimens from the original Mohawkian species of Salmon (1942). If this distinction is valid then the specimens from the Long Point Formation belong to this variety.

Rafinesquina deltoidea (Conrad, 1839) emended Conrad, 1839.

(Plate 5, Figs. 1 to 3)

Material

Five specimens were collected from the red sandstone at the top of the Misty Cove Member at the foot of the waterfall in the northeast corner of Lourdes Cove. They are internal moulds of pedicle valves which show

# PLATE 5

## RAFINESQUINA DELTOIDEA

Three specimens of pedicle valve showing variations in shape.

All figures X 2.

Fig. 1. OLB 5. Internal mould, with external features superimposed, of pedicle valve of *R. deltoidea* showing typical deltoid shape with smooth lateral margins and angular anterior margin.

Fig. 2. OLB 6. Internal mould of pedicle valve of *R. deltoidea* showing pentagonal outline with sinuous lateral margins.

Fig. 3. OLB 7. Internal mould of pedicle valve, with external features superimposed, showing pentagonal outline with smooth lateral margins.

OLB 5

Fig. 1.

OLB 6

Fig. 2.

OLB 7

Fig. 3

R. deltoidea

outline, superimposed external ornamentation and, in specimen OLB 7, weakly preserved muscle scars. No brachial valves were found.

Description

The specimens range from deltoid to subpentagonal in outline, all with small ears and very small umbos. The shells are convex with angular geniculation about 18 mm. from the umbo. The posterior part of the shell is rather flat, and specimens OLB 6 and OLB 7 show slight wrinkling which could be postlateral rugae. The angle between the dental ridges is about 100°. Specimens OLB 5 and OLB 7 exhibit very fine costellae, and specimen OLB 6 shows slight thickening of the median costa. The ratio of thickness : width : length of the figured specimens is 1 : 2.7 : 2.3. The greatest width is 25 mm and the greatest length is 21 mm.

Discussion

The Long Point specimens are similar in size and outline to R. deltoidea from the Ottawa Formation as described by both Wilson (1944) and Salmon (1942). However, they differ in being less convex, i.e., the thickness of their shells is about 8 mm as against a thickness of some 10 mm for the Ottawa specimens. Some of the more subpentagonal Long Point specimens are also similar in shape and outline to R. praecursor, but R. praecursor is highly convex, while the Long Point specimens are all geniculate, and this clearly distinguishes them from that species.

Rafinesquina miodeltoidea Wilson 1944.

(Plate 6, Figs. 1 - 6)

Material

Six well preserved and several eroded specimens of internal moulds of pedicle valves were collected from the red sandstone at the top of the Misty Cove Member of the Long Point Formation at the foot of the waterfall in the northeast corner of Lourdes Cove. No brachial valves were found.

Description

The outline is deltoid to subpentagonal with slightly auriculate cardinal angles. The greatest width is at the hinge line. The posterior portion of the shell is flat. Geniculation occurs about 12 mm from the umbo where is is sudden and angular, 100 - 110° between the anterior and posterior portion of the shell. Specimen OLB 10 (Plate 6, Fig. 6) is probably an older shell as the length of the anterior portion of the shell from the geniculation to the anterior edge is greater than in the other specimens. There are two sizes of costae, and the central costa is slightly thickened. The angle between the dental ridges is about 110°. The ratio of thickness : width : length is 1 : 3.1 : 2.6 and the maximum width is 20 mm.

## PLATE 6

## <u>RAFINESQUINA MIODELTOIDEA</u>

All figures X 2.

Three specimens of pedicle valve showing variation in shape.

Fig. 1. <u>OLB 8a</u>. Internal mould of pedicle valve, with superimposed external features, showing a pentagonal outline.

Fig. 2. <u>OLB 8b</u>. Profile showing geniculation and the flat posterior portion of the shell just behind the umbo.

Fig. 3. <u>OLB 9a</u>. Internal mould of a pedicle valve of a rather rounded pentagonal outline.

Fig. 4. <u>OLB 9b</u>. Profile showing angular geniculation and a broader, more gently sloping anterior margin than that of specimen OLB 8 above.

Fig. 5. <u>OLB 10a</u>. Internal mould of a pedicle valve with a more deltoid outline than shown by specimens OLB 8 and 9.

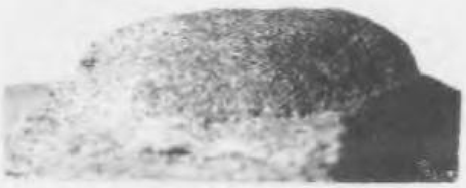
Fig. 6. <u>OLB 10b</u>. Profile showing angular geniculation. Possibly a rather senile specimen is indicated by the greater length between geniculation and the anterior margin.

OLB 8

Fig. 1.

OLB 8

Fig. 2



OLB 9

Fig. 3

OLB 10

Fig. 5

Fig. 4 OLB 9

OLB 10

Fig. 6

R. miodeltoidea

Discussion

The specimens are very uniform in outline and size and correspond exactly to those described by Wilson (1944) from the Ottawa Formation as R. miodeltoidea. R. miodeltoidea is found throughout the Coberg beds, where it is associated with R. deltoidea, and also in the topmost Sherman Fall beds.

Rafinesquina laurentina Wilson 1944.

(Plate 7, Figs. 1 - 4 and

Plate 8, Figs. 1 - 3 )

Material

Six specimens are figured from a total of fifteen specimens which were collected from the red sandstone of the Misty Cove Member in the northeast corner of Lourdes Cove, and from the grey beds behind the fishermen's huts in the same cove. They are external and internal moulds of both pedicle and brachial valves. The dental ridges of the vales collected from the grey beds still consist of shell material.

Description

The specimens are U-shaped or subpentagonal in outline. The greatest width occurs at, or just in front of the hinge line. The shells are highly convex with a maximum convexity half way between the anterior and posterior margins. The part of the shell posterior to the

PLATE 7

RAFINESQUINA LAURENTINA

All figures X 2.

Fig. 1. OLB 11. Internal mould of pedicle valve, with external features superimposed, showing typical U-shaped outline. Some wrinkling of the surface is apparent and there are faint impressions of muscle scars. The cardinal extremities are damaged in this specimen which has its greatest width in front of the hinge line.

Fig. 2. OLB 12. Internal mould of pedicle valve that differs in possessing sinuous lateral and slightly alate cardinal angles.

Fig. 3. OLB 13a. Internal mould of pedicle valve with greatest width at the hinge line.

Fig. 4. OLB 13b. Profile showing high convexity and continuous curvature of the pedicle valve from umbo to anterior margin.

Plate 7

OLB 11

Fig. 1

OLB 12

Fig. 2

OLB 13

Fig. 3

OLB 13

Fig. 4

# PLATE 8

## RAFINESQUINA LAURENTINA

All figures X 2.

Fig. 1. OLB 14a. Internal mould in plaster of paris of pedicle valve showing muscle scars.

Fig. 2. OLB 14b. This internal mould of a pedicle valve looks much wider than long because of the great convexity of the shell.

Fig. 3. OLB 15. Pedicle valve exterior. This damaged valve has a U-shaped outline, and is ornamented with two sizes of costae, 3 to 5 finer ones between coarser ones.

## R. DELTOIDEA or R. LAURENTINA

Fig. 4. OLB 16 a. Plaster of paris mould of brachial valve interior showing flatness of valve and shape of muscle scars. The median septum is slightly off-centre. Angle between dental ridges about 90°.

Fig. 5. OLB 16b. Diagram of interior of specimen OLB 16b, an example of R. trentonensis type brachial interior (Salmon, 1942).

OLB 14a

Fig. 1

OLB 14b

Fig. 2

OLB 15

Fig. 3

OLB 16a

Fig. 4

OLB 16b

Fig. 5

level of maximum convexity is wider than long giving some specimens an appearance of much greater width than length. The ratio of thickness : width : length is 1 : 3.8 : 3.0.

Interiors of both pedicle and brachial valves are found (see OLB 14a and 16a). The muscle scars of the very flat brachial valve are of the simple R. trentonensis type as described by Salmon (1942) (see Plate 8 Fig. 5). The cardinal process is very small. The angle between the dental ridges is generally wide, about 120°. The dorsal median ridge is about one half to one third the length of the shell.

The pedicle muscle scar is almost circular, slightly elongated and narrowing anteriorly; it shows radial ridges. The adductor scar is elongated and distinctly separated from the diductor scars. The border of the anterior end of the scar is faintly impressed. Simple teeth are present on the hinge margin.

Ornamentation consists of coarse costae separated by finer costae, the number of the latter is rather variable, especially in the central part of the shell (Plate 8, Fig. 3).

Discussion

Specimens from the Long Point Formation are generally slightly smaller than those of R. laurentina described by Wilson (1944) from the Ottawa Formation. Some of the specimens with a subpentagonal outline (see

OLB 12, Plate 7, Fig. 2) resemble *R. deltoidea* but they have been included with *R. laurentina* because they are highly convex, without geniculation, and have a slightly less angular outline.

In the Ottawa Formation Wilson (1944) found specimens of *Rafinesquina* whose characteristics of outline and geniculation or convexity fall between those of *R. deltoidea* and *R. laurentina*. This is also true of some of the specimens of this genus collected from the Long Point Formation. *R. laurentina* is found associated with *R. deltoidea* and *R. miodeltoidea* throughout the Coberg beds of the Ottawa Formation.

| | | | |
|---|---|---|---|
| Family | SOWERBYELLIDAE | Öpik | 1930 |
| Subfamily | SOWERBYELLINAE | Öpik | 1930 |
| Genus | SOWERBYELLA | Jones | 1928 |

Generic Description (from Wilson, 1946 and from Muir-Wood and Williams, 1965).

The outline of the shell is oval or semicircular. The shell is concavo-convex with the greatest width at or near the hinge line. The cardinal angles are acute and extended in some cases. The cardinal area is low, usually striated, and occasionally crossed by transverse wrinkles. The delthyrium is triangular and partly closed by the deltidium.

The ornamentation is parvicostellate, either smooth or slightly beaded and variably segregated.

The pedicle muscle scar is small and bilobed, bounded posterolaterally by short dental plates and anteromedianly by a pair of divergent ridges which bifurcate from a short median ridge and bear the adductor scars. The brachial valve muscle scar has a pair of strong median septa flanked by raised suboval areas. The median ridge is variably developed.

In S. (Sowerbyella) the parvicostellae are segregated into narrow segments by many accentuated costellae. The median ridge in the brachial valve is weak or absent.

Sowerbyella sericea (Sowerby, 1839) Jones, 1928.
(Plate 9, Figs. 1 - 5)

Material

Numerous specimens were collected from the grey-green sandy limestones at the top of the Misty Cove Member of the Long Point Formation in the waterfall at the northeast corner of Lourdes Cove, and also from the beds in the cliffs behind the fishermen's huts near the southern side of the same cove. They are well preserved, with shell material still present, and include exteriors and interiors of both pedicle and brachial valves.

Other, additional specimens of pedicle and brachial valves were collected from the red sandstone at the base of

PLATE 9

SOWERBYELLA SERICEA

All figures X 4.

Fig. 1. OLB 17a. Pedicle valve exteriors and, top right, an internal mould of a brachial valve. The former shows two sizes of costae and the punctate nature of the shell, and the latter, the cardinal area.

Fig. 2. OLB 17b. Interior of a small brachial valve with muscle scars of a more circular form than is typical of this species; possibly a specimen of *S. subovalis*.

Fig. 3. OLB 17c. Internal mould of pedicle valve showing muscle scars and lemniscate mantle canal pattern.

Fig. 4. OLB 18. Internal mould of poorly preserved brachial valve of quadrate form.

Fig. 5. OLB 19. Exterior of small brachial valve of quadrate form showing two sizes of costae.

OLB 17a

Fig.1

OLB 17b

Fig.2

OLB 17c

Fig.3

OLB 18

Fig.4

OLB 19

Fig.5

the waterfall in the northeast corner at Lourdes Cove. Most of these are poorly preserved as internal moulds but where shell material is still present it is in a weathered, very friable state and shows the punctate nature of the shell. Many of the shells are mud filled and they yield very detailed internal moulds when the rotten shell material is removed or scraped away.

Description

The outline of the valves is a variable feature and specimens range from semi-circular to subrectangular (Plate 9). Nearly all specimens show the greatest width at the hinge line, but some of the smaller brachial valves have their greatest width just in front of the hinge line as their cardinal angles exceed 90°. The width of the valves varies from 8 mm to 18 mm, and the length from 5 mm to 9 mm. Curvature of the pedicle valve is moderate, occurring in the median part of the valve.

Ornamentation consists of two sets of obviously different sized costellae, the thicker ones dividing the shell into segments (Plate 9). This separation into segments is especially well developed on the pedicle valves but not so noticeable on the brachial valves. The shell is highly punctate (Plate 9).

On all the brachial interiors, the two submedian septa are conspicuous, and on most specimens a small median ridge can also be seen between the anterior ends of the median septa (Plate 9, Fig. 3). In the better preserved smaller specimens, the raised suboval areas which supported the adductor muscles are distinct (Plate 9).

The interior of the pedicle valve (OLB 17c) shows bilobed muscle scars separated by a short median ridge which bifurcates about halfway down the length of the muscle scar lobe. Submedian septa occur on each of the two lobes. The punctate nature of the shell is evident beyond the muscle scars towards the anterior margin of the shell, and the impression of a lemniscate mantle canal pattern can also be distinguished.

The cardinalia are small and are only well preserved in a few specimens. (Plate 9, Fig. 1).

Discussion

Wilson's (1946) description of S. sericea from the Ottawa Formation is applicable to the Long Point specimens which similarly exhibit a great range in the size of the valves, the smallest brachial valve measuring 8 mm in width and the widest 18 mm. Variation in size is thus characteristic of this species. However, the brachial valve of S. subovalis is described by Wilson (1946) as being indistinguishable from small specimens of S. sericea, and it is thus possible that some of the smaller specimens included here represent the brachial valve of S. subovalis rather than S. sericea. In the Ottawa Formation, S. sericea is found throughout the Sherman Fall and Coberg beds.

Sowerbyella subovalis Wilson 1932.

(Plate 10, Figs. 1 - 3).

## Material

Several specimens were collected from the sandstones just below the red beds of the Misty Cove Member in the northeast corner of Lourdes Cove. Most of them retain some shell material but it is weathered and friable. The rotten shell material is quite easily removed to reveal the internal moulds present within these shells. Only pedicle valves were positively identified.

## Description

The outline of the pedicle valves is almost oval. The lateral margins, almost parallel to each other, curve smoothly into the anterior margin. The length is two thirds to three quarters the width. The pedicle valves are convex with the greatest convexity just in front of the umbo, and the sides curve down suddenly to give the shell a short thick appearance (Plate 10, Fig. 2).

The brachial valve was originally described by Wilson (1932) as being indistinguishable from that of S. sericea. The smaller specimens of brachial valves, especially those with the more oval outline and rather narrower width (OLB 17b), are probably, therefore, the brachial valves of S. subovalis.

Costae of three sizes occur, the largest dividing the shell into segments which are then filled with costae

## PLATE 10

### SOWERBYELLA SUBOVALIS

All figures x 4.

Fig. 1. OLB 20. Pedicle valve exterior showing typical outline and the punctate nature of the shell.

Fig. 2. OLB 21. Internal mould of highly convex pedicle valve with right-angled cardinal extremities.

Fig. 3. OLB 22. Small brachial valve exterior showing two sizes of costae.

### PAUCICRURA CF. P. ROGATA (SARDESON).

Fig. 4. OLB 23. Pedicle valve exterior showing the curvature of the striae towards the umbo in the apical region.

Fig. 5. OLB 24. Brachial valve exterior showing the flatness of the valve and the slight sulcus centrally in the posterior part of the valve.

OLB 20

Fig. 1

OLB 21

Fig. 2

OLB 22

Fig. 3

OLB 23

Fig. 4

OLB 24

Fig. 5

of two smaller sizes that alternate with one another.

Discussion

It is difficult to distinguish between this species and S. sericea. However two different forms are present. The more rectangular form has been included with S. sericea and the oval form with a more convex pedicle valve with S. subovalis.

The latter species occurs throughout the Upper Coberg beds of the Ottawa Formation.

Order ORTHIDA Schuchert and Cooper 1923.

This order is represented by two genera, Paucicrura and Hesperorthis. The paucicrurids are reasonably abundant and quite easily recognised whereas the hesperorthids are broken, badly preserved and very difficult to identify,

Family DALMANELLIDAE Schuchert 1929

Genus PAUCICRURA Cooper 1956

Paucicrura cf. P. rogata (Sardeson) 1892.

(Plate 10, Figs. 4, 5)

Material

Several whole, and a number of broken, specimens were collected from the sandstone beds, both grey and red, at the bottom of the waterfall and also above the waterfall in the northeast corner of Lourdes Cove. An external cast of a pedicle valve and of a brachial valve are figured. Most specimens are casts or moulds but those from the red beds still have some shell material present. Many of the specimens are crushed or broken and no interiors were found with complete cardinalia or showing muscle scars.

Generic description (exterior only, from Cooper, 1956)

The outline is quadrate to subcircular and the profile is convexo-concave to plano-convex. The brachial valve is gently sulcate. The hinge line is shorter than the greatest width. The cardinal area is very small with the delthyrium and notothyrium open. Ornamentation is coarsely fascicostellate to finely costellate, with the costellae grouped in bundles which curve slightly on the wings and along the cardinal region. The costellae are occasionally hollow. The shell is punctate.

Description

The pedicle valve has a convex profile and is subquadrate in outline. The greatest convexity develops in front of the umbo to give an almost triangular posterior view. The hinge line is shorter than the greatest width of the valve. The cardinal angles are rounded. The umbo is very small but only the exterior is seen. The ornamentation is fascicostellate with the costellae curving up towards the hinge on the cardinal angles.

The brachial valve is shorter than the pedicle valve, and it is almost flat, with a slight sulcus on the posterior part of the valve; the sulcus is deeper on the smaller specimens. The costellae again curve towards the hinge line.

The specimens vary in size but all are small; the average width is 10 mm and the average length 8 mm.

Discussion

The external characteristics of these specimens resemble those of Paucicrura rogata (Sardeson), but without any interiors to help confirm this diagnosis, only the designation cf. can be given.

P. rogata (Sardeson) is described from Missouri, Minnesota, and Wisconsin from rocks of Wilderness to Trenton age, and as Dalmanella rogata Sardeson it is described from all exposures of the Sherman Fall beds, and the Cobourg beds of the Ottawa Limestone (Cooper, 1956; Wilson, 1946).

Family DOLERORTHIDAE Öpik, 1934

Subfamily HESPERORTHINAE Schuchert & Cooper, 1931

Genus HESPERORTHIS Schuchert & Cooper, 1931

Hesperorthis cf. H. tricenaria (Conrad, 1843)

(Plate 11, Figs. 1 to 3)

Material

A few fragmentary valves and two internal moulds of pedicle valves were collected from the grey-green sandstone of the Misty Cove Member, halfway up the waterfall in the northeast corner of Lourdes Cove.

Plate 11

HESPERORTHIS CF. H. TRICENARIA (CONRAD, 1843)

All figures x 4.

Fig. 1. OLB 25. Internal mould of pedicle valve, slightly crushed and distorted, showing cardinal area and simple, strong costae.

Fig. 2. OLB 26. Internal mould of a broken pedicle valve showing outline of the shell, the simple costae, and the interior of the cardinal area.

Fig. 3. OLB 27. Plasticine mould of broken valve taken to show the internal structure of the ribs. Note that each rib has a slight median cleft.

OLB25

Fig. 1

OLB 26

Fig. 2.

OLB 27

Fig. 3

Generic description (from Wilson, 1946).

Semicircular or semi-elliptical in outline. Plano-convex or concavo-convex in profile. The hinge line is straight. The cardinal angles are acute or form a right angle. The anterior margin is straight or broadly convex. The pedicle interarea is long, plane, or gently curved, and the brachial interarea is plane and shorter.

The pedicle valve is convex with a gently curving beak. The delthyrium is long and narrow covered by a partial or complete deltydium. The pedicle interior has a deep cavity with small teeth and shallow, oblique crural fossettes.

The costae are simple and strong with a few finer ones between them. Internally each rib has a median cleft. The shell substance is impunctate.

Description

Two complete but poorly preserved internal moulds of pedicle valves were found. The outline is semicircular and the hinge line is straight. As both specimens are damaged on one side this description is based on the undamaged side of each specimen. Both specimens are convex in profile. The costae are strong and simple and, internally, there is a slight cleft down the centre of each ridge near the anterior margin. The beak is gently curved and long, but the delthyrium cannot be seen; on either side there is a mould of a deep cavity with small oblique dental ridges.

Some shell material removed in cleaning one of the specimens was impunctate.

The valves average 22 mm wide, and 19 mm long in their undamaged state.

Discussion

It is difficult to make a positive identification on the basis of two badly weathered specimens. Those characteristics still preserved indicate that they belong to the genus Hesperorthis and possibly to the species H. tricenaria. The stratigraphic range of the genus is from Lower Ordovician to Upper Silurian but H. tricenaria is normally restricted to the lower end of this range although it has also been collected from the Cobourg beds of the Ottawa Limestone by Wilson (1946).

Other fossils of the Long Point Formation

In addition to brachiopods, other fossils were collected from the upper part of the Misty Cove Member and from the Lourdes Member of the Long Point Formation. These include graptolites, gastropods, crinoids, a trilobite and an alga. Apart from the graptolites, which are locally abundant, the other groups are less widespread, and they are represented by only a few specimens belonging to a limited number of species or even to a single species.

Class GASTROPODA Cuvier, 1797

Family RAPHISTOMATIDAE Koken, 1896

Subfamily OPHILETINAE Knight, 1956

Genus EUCONIA Ulrich & Scofield, 1897

*Euconia* cf. *Euconia etna* Billings, 1865

(Plate 12, Fig. 1)

Material

One broken internal mould was collected together with a few thick-shelled brachiopods and another small gastropod (Plate 12, Fig. 2) from a limy lens in the Lourdes Member in the cliffs on the small headland just before the road turns across Long Point at Winterhouse.

Generic description (from Twenhofel, 1938)

The shell is trochiform, acutely conical with shallow sutures. The sinus culminates at the angular periphery just above the upper suture in a short notch.

Description

Only the two middle whorls of the shell are present, with both the apex and the aperture missing. The shell is slightly compressed laterally but not sufficiently to obscure its main characteristics. The form of the shell is a flat cone with a projected apical angle of 65°. The sutures are shallow, accentuating the flat sides of the cone. There are wrinkles on the surface of the lower whorl curving in an abapical direction towards the aperture. The base of the lower whorl is very flat at an angle of

PLATE 12

FOSSILS FROM THE LOURDES MEMBER

Fig. 1. OLM 12. X 2 Internal mould of *Euconia* cf. *E. etna* showing trochiform outline, very shallow sutures and subrhomboidal cross-section of lower whorl.

Fig. 2. Three thick shelled, indeterminate brachiopods and an internal mould of a small compressed roundly trochiform gastropod. Some shell structure remains in the brachiopod shells.

OLM 12

Fig. 1 ×2

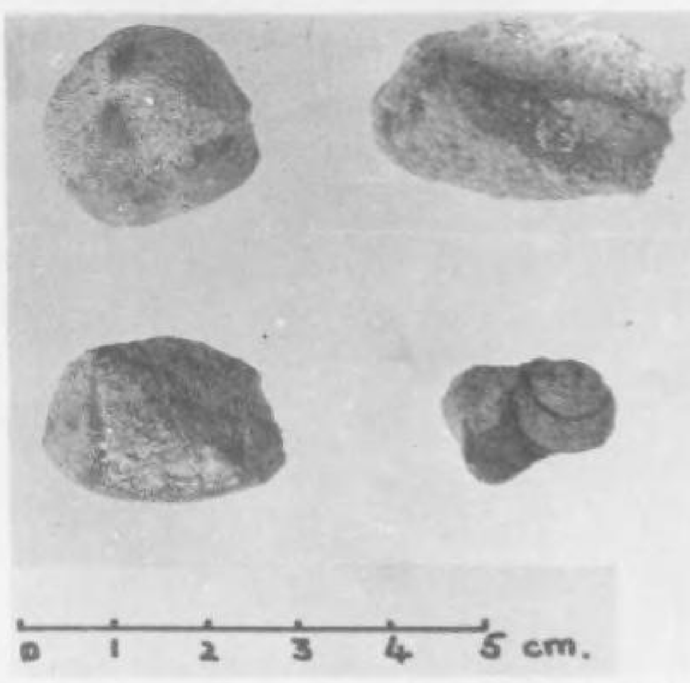



Fig. 2

70° to the side and then curves gently to a small umbilicus in the centre of the concave area. Although the aperture is missing, the exposed crcss-section of the lower whorl shows it to be subrhomboidal.

The specimen is 3.6 cm wide across the base and its reconstructed height is 2.8 cm.

Discussion

The specimen is very similar to both *Euconia ramseyi* (Billings) and *E. etna* (Billings). It is apparently larger than *E. ramseyi*, but exactly the same size (if reconstructed) as specimens of *E. etna* illustrated by Billings (1865) and by Knight (1941).

The genus *Euconia* appears to be the only acutely conical trochiform genus present in the Ordovician, but so far has only been found in rocks of Lower Ordovician age. *E. ramseyi*, of which only one specimen has been described, was collected from the Romaine Formation in the Mingan Islands (Billings 1859, Twenhofel, 1938) while *E. etna* was described by Billings (1865) from Western Newfoundland and by Knight (1941) from Division G of the St. George's Group as well as from the Table Head Group of Western Newfoundland. The Lourdes Member, however, lies at the top of the Long Point Formation which is dated as youngest Trenton age and, therefore, since *Euconia* has only been found as high as the Beekmantown in the past, either the range of *Euconia* has to be extended, at least to the bottom of the Upper Ordovician, or this specimen must be regarded as a derived fossil from the St. George's Group or the Table Head Group. The specimen was found closely associated with other internal moulds of a turreted form as well as with a small, roundly trochiform gastropod and thick shelled brachiopods which are very worn (Plate 12, Fig. 2).

| | | | |
|---|---|---|---|
| Superfamily | MURCHISONIACEA | Koken | 1896 |
| Family | MURCHISONIIDAE | Koken | 1896 |
| Genus | MURCHISONIA | Salter | 1859 |

Hormotoma trentonensis (Hall, 1847) Ulrich and Scofield, 1897

(Plate 13, Figs. 1 - 2)

Material

Several broken or incomplete specimens, all internal moulds, were collected from the red sandstone in the banks of the stream below the waterfall in the northeast corner of Lourdes Cove.

Generic description (from Wilson, 1951)

Large, high-spired, practically imperforate shells up to 75 mm in length with an apical angle of 38-40°. There are seven or eight volutions which are rounded on the exterior and enlarge rapidly. Aperture with a broad deep notch in the outer lip.

Description

Specimen OLM 7 (Plate 13, Fig. 1a) is a partial

## PLATE 13

<u>HORMOTOMA</u> <u>TRENTONENSIS</u> (HALL, 1847) ULRICH AND SCOFIELD, 1897

Fig. 1a. <u>OLM 7</u>. Partially eroded specimen showing exterior of two complete whorls and two poorly preserved whorls below. The apical whorls are missing.

Fig. 1b. Composite diagram of OLM 7 taken from tracing of photograph and by inspection of specimen. Continuous lines indicate features present, and dotted lines represent inferred structure.

Fig. 2. <u>OLM 8</u>. Three apical whorls of small broken specimen which is crushed so that the width of the specimen is exaggerated.

OLM 7 × 1½

Fig. 1a

Fig. 1b

OLM 8 × 3

Fig. 2

specimen with two, or probably three, apical whorls missing. Of the remaining whorls, two are complete and, below them, two others can be distinguished together with the aperture of the body whorl and the central columella. The whorls are rounded and expand very rapidly towards the aperture. No shell material remains and there is, thus, no evidence of growth lines or of a notch or selenizone.

Discussion

Hormotoma trentonensis (Hall, 1847), typical of the Trenton Group, is rarely found in Minnesota where the type specimens were collected, but it is common in the Trenton Limestone of Canada and New York (Ulrich and Scofield, 1897). Wilson (1951) restricts this species to New York, and considers that a smaller variety, Hormotoma trentonensis crassa is the typical Canadian form. This variety is found throughout the Ottawa Limestone with the exception of the lowest Pamelia beds (Wilson, 1951). The Long-Point specimens are generally smaller than those reported from the New York area but due to the incompleteness of the Long-Point specimens it is not possible to decide whether or not they belong to the smaller variety recognized by Wilson.

| | |
|---|---|
| Class | GRAPTOLITHINA Bronn, 1846 |
| Order | GRAPTOLOIDEA Lapworth, 1875 |
| Family | DIPLOGRAPTIDAE Lapworth, 1873 |
| Subfamily | CLIMACOGRAPTINAE Frech, 1897 |
| Genus | CLIMACOGRAPTUS Hall, 1865 |

Climacograptus spiniferous Ruedemann, 1912

(Plates 14 and 15)

Material

Twelve more or less complete specimens as well as many fragments were collected from the Misty Cove Member of the Long Point Formation in the cliffs behind the fishermen's huts near the southern end of Lourdes Cove. A number of poorly preserved specimens was also collected from the same horizon in the beds exposed in the waterfall in the northeast corner of Lourdes Cove.

In spite of the coarse texture of the rock some of the graptolites are well preserved as a thin carbon film, particularly those collected from the locality behind the fishermen's huts, which are generally more or less complete with the sicula still present.

Generic description (from Elles & Wood, 1906, and from Ruedemann in Treatise on Invertebrate Paleontology, Part V, 1955)

The rhabdosome is biserial throughout with bilateral symmetry. No synrhabdosomes have been found. The thecae are tubular with the ventral wall of each showing sigmoid curvature. The apertural margins are typically horizontal in a well defined excavation, occasionally introverted. The upper

PLATE 14

CLIMACOGRAPTUS SPINIFEROUS

Fig. 1. OLM 3. Small specimen showing slight narrowing of rhabdosome at theca $2^1$ at the top of the sicula and two fine straight spines.

Fig. 2. OLM 4. Enlargement X 40 of part of rhabdosome of a broken specimen showing the thickened rim of the thecae and the typical biconcave free wall of the Long Point specimens.

Fig. 3. OLM 5. Larger specimen showing typical delicate straight spines with an angle of 110° between them.

Fig. 4. OLM 6. Small specimen with nema extending twice the length of the rhabdosome.

Plate 14

OLM 3

Fig. 1 x 10

OLM 4

Fig. 2 x 40

OLM 5

Fig. 3 x 8

OLM 6

Fig. 4 x 8

C. spiniferous

PLATE 15

CLIMACOGRAPTUS SPINIFEROUS RUEDEMANN 1912

Fig. 1. OLM 2a. X 6. The largest specimen collected showing the narrow rhabdosome and the long, thin basal spines.

Fig. 2. OLM 2b. X 40. Enlargement of a part of the rhabdosome of specimen OLM 2 to show the characteristic features of a single theca: shape, thickened apertural rim, small mesial spines, biconcave form of the free ventral wall. These features have been emphasised by erosion of the surface leaving only the thecal outline.

Fig. 3. Diagramatic representation of Fig. 2.

Plate 15

OLM 2b

Fig. 2 × 40

OLM 2a

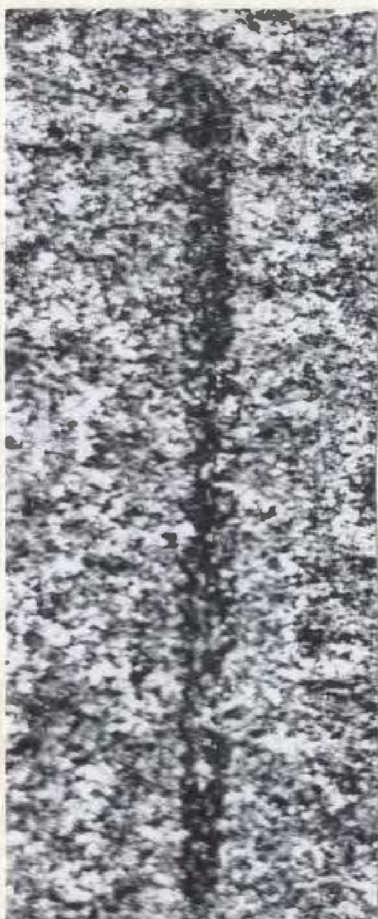


Fig. 1 × 6

Fig. 3

part of the ventral wall is approximately vertical and free, the middle part has an impressed edge which curves sharply inward to form the so-called excavation whilst the lower part resumes the vertical position and is in contact with the theca next below. Thecal spines are ventral and medial in position. The aperture may be bordered by a rim. A virgula is present expanded at the antisicula end in some species. A sicula groove is sometimes present beginning near the sicula end.

Description

The straight, scandent, biserial rhabdosomes are small, between 0.5 cm and 1.0 cm long although three specimens exceed this and reach 2.0 cm in length. The rhabdosome widens very rapidly over a distance of about 2 mm from the sicula end (theca $3^1$) to a maximum width of 1.2 mm in the three larger specimens, and to approximately 1.0 mm in the smaller ones. Just before maximum width is reached there is a slight narrowing on two of the specimens at about the level of theca $2^2$.

The thecae are small and close, averaging 20-24 in 10 mm; 20 in 10 mm in the larger specimens. In the larger specimens the sigmoidal thecae are about 1.0 mm long. The free ventral wall overlaps one third of the total theca Plate 15, Figs. 2, 3). The horizontal apertural edge, situated in an elliptical excavation, is thickened into a rim which extends outwards as a small spine. There is also a small mesial spine at the top of each excavation. The free wall between these two spines is not concave but rather biconcave (Plate 15, Figs. 2, 3).

Discussion

Only one species of Climacograptus appears to be represented by the Long Point specimens which superficially resemble C. bicornis. However, they are smaller, narrower, have straight spines and neither theca $1^1$ nor theca $1^2$ is ever modified to the extent of being only a spine. Elles and Wood (1906) suggested that small forms similar to C. bicornis are a dwarfed survival of that species and they placed them in a separate species, C. supernus. C. supernus differs from C. bicornis in being smaller and narrower, and it also shows a slight narrowing of the rhabdosome about the level of theca $2^1$ and theca $2^2$ at the top of the sicula. Furthermore, the basal spines of C. supernus are smaller and finer and are only enlargements of the mesial spines of theca $1^1$ and $1^2$. The Long Point species is very similar to C. supernus, even to the extent of the two specimens showing a slight narrowing above the sicula at the level of theca $2^2$, but its straight and slender basal spines are never curved as is frequently the case with the basal spines of C. bicornis and C. supernus. Two other, smaller climacograptids with straight spines that also resemble the Long Point specimens are C. pygmaeus (Ruedemann, 1925) and C. spiniferous (Ruedemann, 1912, 1947) but the spines of the former are distinctly smaller while those of the latter are slightly larger and thicker. Apart from this minor difference, C. spiniferous and the Long Point form are otherwise remarkably similar, and although the latter is generally slightly smaller, and has its thecae more closely arranged, they are considered to be conspecific.

Both C. spiniferous and C. pygmaeus are index fossils of the highest graptolite zones of rocks of Middle Ordovician age in Eastern Canada (Riva, 1969). C. supernus is found at an equivalent level in the British P. linearis zone, similarly at the boundary between the Middle and Upper Ordovician.

Weerasinghe (1970) and Shaikh (1971) both describe climacograptids from the Misty Cove Member of the Long Point Formation. In both cases these fossils have been identified as Climacograptus aff. C. inuiti similis Wilson. Inspection of these specimens indicate that they are in fact the same as those described above. The apertural rim is thickened and extended into a slight spine and there is a mesial spine on each theca but between these spines the free ventral wall is biconcave rather than concave. The thecae are smaller and more closely arranged than those of C. inuiti similis and the sicula end shows two spines developed from the mesial spines of thecae $1^1$ and $1^2$. The spines are straight, relatively long and slender like those of C. spiniferous. Like the specimens described above, those of Shaikh (1970) were also found associated with fragments of diplograptids.

### Class CRINOIDEA

(Plate 16, Figs. 1, 2)

One thecal plate, possibly from a cystoid, and long crinoid stems were found in the Misty Cove Member, both in the waterfall in the northeast corner of Lourdes Cove and behind the fishermen's huts in the same cove.

Behind the fishermen's huts, crinoid stems are found in a thin muddy band above the shell banks of sowerbyellids. The segments are very long, although no complete specimen was found, so they cannot have travelled far from their growing position. In the northeast corner of the cove a crinoid layer occurs at the same level but in this locality the branches and stems are broken up into small segments or even individual columnals. The possible cystoid plate was found amongst these.

PLATE 16

Fig. 1. OLM 9. Slab from crinoid bed in southwest corner of Lourdes Cove showing external moulds of long sections of stems.

Fig. 2. OLM 10. Single calyx plate, possibly from a cystoid, from same site as above.

ENCRINURUS SP.

Fig. 3. OLM 11. Pygidium of very small specimen showing triangular outline, ten distinct annulations and more vague ones in the narrow axial lobe, and backwardly curved pleurae with their distal ends separated from one another.

| | |
|---|---|
| Class | TRILOBITA Walch, 1771 |
| Family | ENCRINURIDAE Angelin, 1854 |
| Subfamily | ENCRINURINAE Angelin, 1854 |
| Genus | ENCRINURUS Emmrich, 1844 |

Encrinurus sp. Emmrich, 1844

(Plate 16, Fig. 3)

Material

One very small internal mould of a pygidium was collected from the crinoid bed beneath the red sandstone at the top of the Misty Cove Member in the waterfall at the northeast corner of Lourdes Cove.

Description

The specimen is very small (3.4 mm long, 3.8 mm wide anteriorly) and sharply triangular with an acute posterior angle. The axial lobe is narrow and reaches to the posterior extremity with 10 visible annulations and 7 ring furrows. Eight pleurae can be distinguished which are curved backward; they diverge from the axis so that they are quite separate from one another at the margin of the pygidium.

Discussion

The specimen is small but well preserved. The numerous axial rings on the very narrow axis, the backward curvature of the pleurae, and the separation of the outer ends of the pleurae, suggest that it belongs to the genus Encrinurus. A larger, but similar, pygidium was collected by Weerasinghe (1970) from a lower level in the Long Point Formation; this specimen is present in his collection but not figured or described in his M.Sc. thesis. Encrinurus ranges from Middle Ordovician to Silurian.

Plate

OLM 9

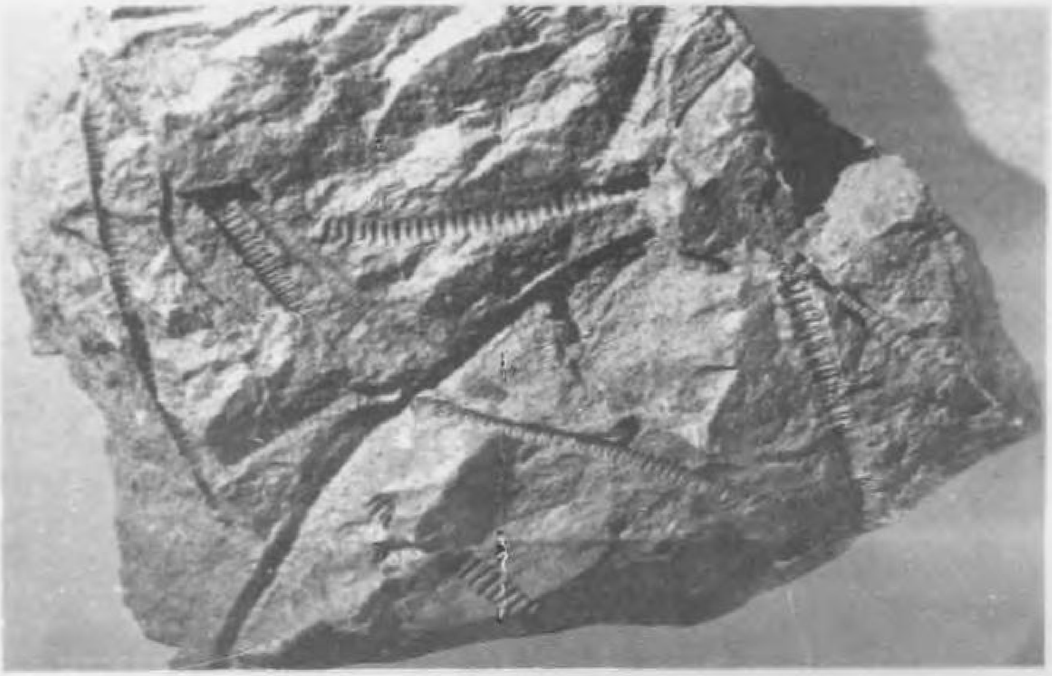


Fig. 1 ×1

OLM 10

Fig. 2 ×4

OLM 11

Fig. 3 ×10

Subkingdom THALLOPHYTA

Phylum CHLOROPHYTA

Class CHLOROPHYCEAE Kutzing, 1843

Family DASYCLADACEAE Kutzing, 1843

Genus ISCHADITES Lonsdale, 1839

Ischadites iowensis (Owen, 1852)

(Plate 17, Figs. 1 & 2)

Material

Three compressed specimens in the form of internal moulds were found closely associated on a single surface in a red mudstone layer at the top of the red beds of the Misty Cove Member below the waterfall in the banks of the stream in the northeast corner of Lourdes Cove.

Generic description (from Kesling & Graham, 1962)

Only the thallus is known. The thallus consists of a group of branches radiating from an apparently uncalcified original central axis. Branches bear distal and subdistal expansions to form two walls, an outer and an inner, between which the gametangia are formed (Fig. 5). The thallus originally grew in a variety of different forms or was deformed in many ways after burial due to lack of calcification of the central acis. Wilson (1948) describes the fossils as subglobular, cone, biscuit or irregularly hornshaped forms. The specimen of Kesling and Graham (1962) is best described as bulbous (see Fig. 5).

The units of the inner wall overlap. On weathered

PLATE 17

ISCHADITES IOWENSIS (OWEN)

Fig. 1. OLM 1. Internal mould. Apical view of saucer-shaped specimen resulting from collapse of apex of thallus, with the impressions of the rhomboidal plates of the inner wall giving the characteristic ornamentation of concentric rings.

Fig. 2. Diagramatic reconstruction of part of the thallus as seen from the side. Outer wall is exfoliated to show the pattern of plates in the inner wall (from Kesling & Graham, 1962).

OLM 1


Fig. 1

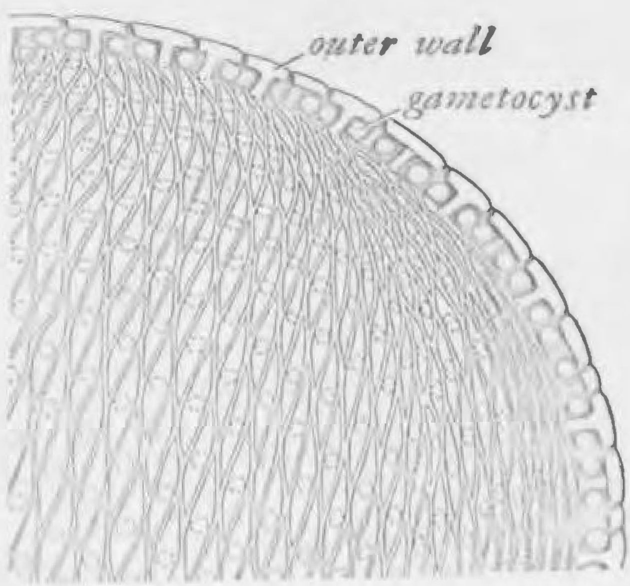



Fig. 2

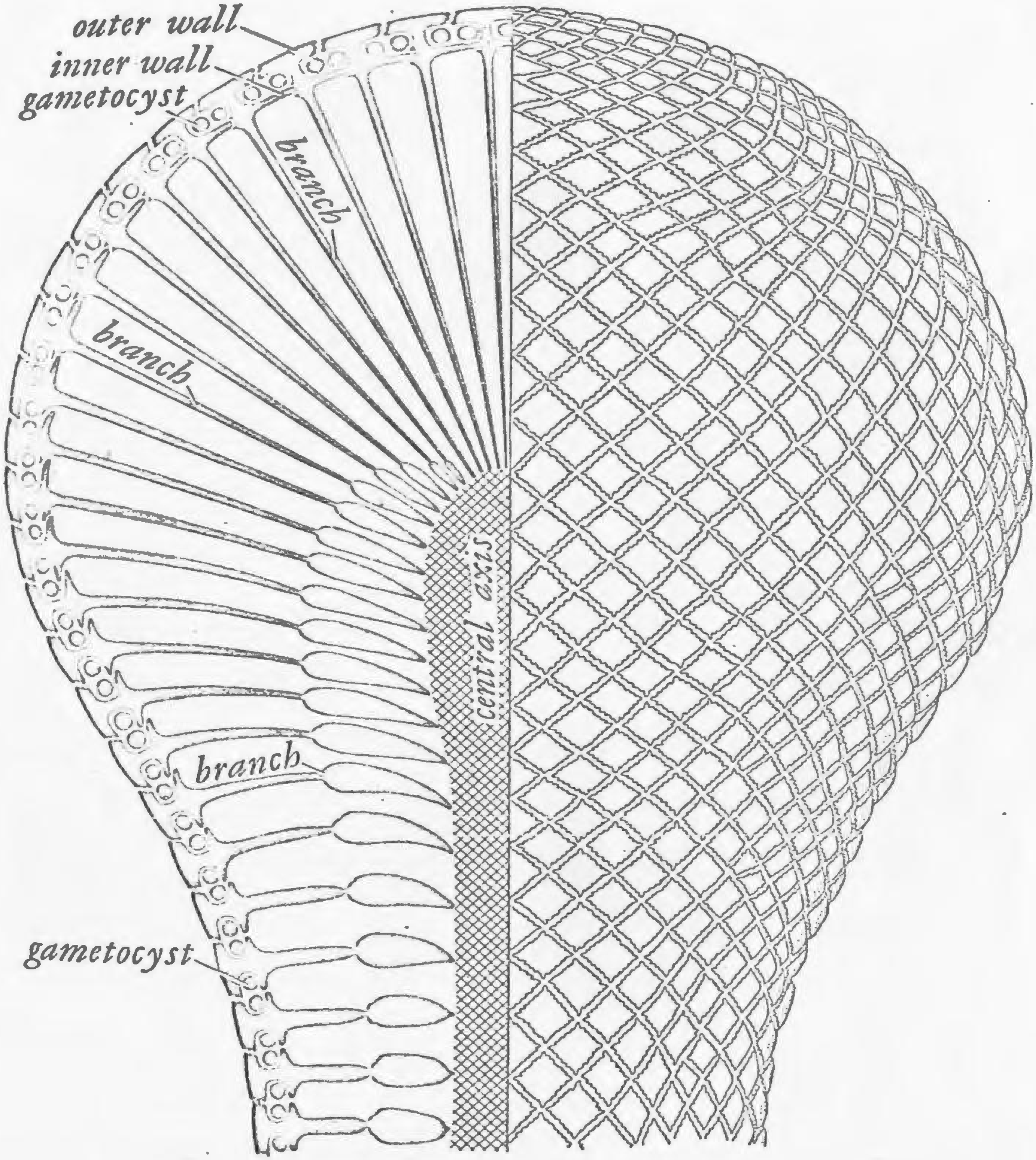



Fig.5. Reconstruction of the thallus of Ischadites iowensis (Owen) as seen from the side. Right half shows exterior of thallus; left half shows longitudinal section. Basal branches have thick proximal calcifications; towards apex the amount of proximal calcification progressively decreases; apical branches are acicular with no thickening. The central axis is not preserved in the known specimens. (from Kesling and Graham,1962).

surfaces the matrix between the plates of the inner wall remains as narrow crests forming a characteristic rhomboidal pattern. The outer wall is rarely found in Ischadites but when present it gives a reticulated pattern at an angle to the rhomboidal network of the inner wall.

Description

Compression of the thallus has resulted in its collapse over the central axis to give a saucer shaped fossil. Ornamentation on the surface is actually that of the inner wall where the subdistal expansions of the branches from the central axis give rise to a rhombohedral pattern which is more or less concentric, exactly as illustrated by Shimer and Shrock (1955) and by Wilson (1948). All the specimens found at the top of the Long Point Formation are between 5 and 6 cm in diameter. None of the original calcite skeleton is preserved.

Discussion

Shimer and Shrock (1955) illustrate a specimen of I. iowensis from the Ordovician of Minnesota that is 4 cm in diameter. Larger specimens of Ischadites with a diameter of 8 cm are known from the Ottawa Formation and their size led Wilson (1948) to erect a new species for these forms, I. ottawaensis. However, Weiss (1954) noted that apart from size they are otherwise identical to specimens of I. iowensis, and he therefore regarded them as conspecific; I. ottawaensis thus becomes a junior synonym of I. iowensis. The specimens from the Long Point Formation, as well as that described by Kesling and Graham (1962) from Iowa, are of indeterminate size, some 6 cm in diameter, and it thus seems likely that specimens of I. iowensis differ in size because they represent different growth stages.

According to Shimer and Schrock (1955), I. iowensis is characteristic of the Middle Ordovician in Eastern Canada and throughout the U.S.A. It appears to be restricted to rocks of Trenton age. In the Ottawa Limestone it occurs in the Coberg beds (Wilson, 1948).

N.B. Although this form is here treated as an alga, the systematic position of the receptaculids is a matter of dispute between authors.

Foster (1973) believes that although the receptaculids have the characteristics of both sponges and algae the preponderance of evidences favors their assignment to the sponges.

# CHAPTER 4

## Clam Bank Formation

The Clam Bank Formation consists of some 1,470 feet of sandstones, shales, and limestones that indicate a cyclical depositional history. These strata underlie the thesis area between the southwest corner of Lourdes Cove and the small community of Salmon Cove at the southwest end of Round Head; exposures are continuous in the cliffs between these two places.

The sequence has been divided, for convenience of description, into five stratigraphic units (Table 10) on the basis of the general characteristics of the beds (colour, sedimentary structures, fossils etc.) because similar rock types occur at different levels in the succession.

The succession of the Clam Bank Formation is from Unit 1 at Lourdes Cove to Unit 5 at Red Head, and then in the succeeding section, Red Head to Salmon Cove, from Unit 5 to Unit 1. This reversal of the sequence is not a a structural reversal indicating the presence of a syncline, but is simply due to the way in which the coast curves seaward across the strike of the beds between the two coves.

Unit 1 crops out in the southwest corner of Lourdes Cove, to the west of a covered interval, and also in Salmon

TABLE 10

DIVISION OF THE CLAM BANK FORMATION INTO UNITS AND BEDS

Section of the Clam Bank Formation measured along the coast from Salmon Cove to Red Head

| Unit | Bed | Lithology | Thickness' |
|---|---|---|---|
| 5 | 14 | Red conglomerate and sandstone with nodular limestone lenses | 340 |
| 4 | 13 | Red and green shales with algal mats | 292 |
| | 12 | White and red sandstone with a 1 foot grey shale at its base | 64 |
| 3 | 11 | Pink limestone and sandstone | 90 |
| | 10 | Red sandstone and pink limestone with *Tentaculites* and crinoid ossicles | 32 |
| | | Nodular pink limestone | 67 |
| | 9 | Pink limestone containing occasional fossils | 7 |
| 2 | 8 | Nodular fossiliferous limestone, mostly grey, with some pink areas | 41 |
| | | Red and grey shales | 157 |
| | 7 | Grey and white, very fossiliferous, laminated, argillaceous limestone | 39 |
| | | Red and greenish-grey shales with ostracods | 46 |
| | 6 | Silty, laminated, and slump-bedded grey and white fossiliferous limestone | 65 |
| 1 | 5 | Red and green shales with ripple-marks and a 2' thick pink limestone band 26' above the base | 180 |
| | 4 | Leached, yellowish-white 'sugary' sandstone | 25 |
| | 3 | Thin, medium-grained, red sandstone with calcareous cement | 2 |
| | 2 | Green and red shale | 16 |
| | 1 | Pink and grey laminated limestone | 2 |
| | | Red shale and sandstone | 5+ |
| | | | 1470+ |

Cove at the southern end of the section. The sandstones of this unit are composed of well-rounded quartz grains of uniform size that are bound by a calcareous cement. The beds within the unit at Salmon Cove differ in thickness from those in Lourdes Cove, but thin, laminated silty limestones provide marker horizons that enable the beds at each end of the section to be correlated with one another.

Unit 2 occurs in the headland of Red Point at the southwest corner of Lourdes Cove, and also more extensively in Salmon Cove. It consists of an alternation of grey limestones and red, purple or green shales. Limestone is the dominant rock type in this unit, and crystalline, very sandy, and muddy varieties are present. Most of the limestones, and some of the shales are fossiliferous. The muddy limestones, which typically contain brachiopods, ostracods and cephalopods, are thinly bedded and characterized by a variety of sedimentary structures, load casts, slumped bedding, ripplemarks, mudcracks, and salt pseudomorphs, which are indicative of the conditions under which the beds were laid down. The crystalline limestones contain a greater variety of fossils than do the sandy or muddy limestones; their fauna includes brachiopods, bryozoans, corals, crinoids and gastropods. Some trace fossils are also present.

Unit 3 is exposed in the northern part of Red Bay, and also on a small headland in Salmon Cove. It is made up of predominantly red, calcareous fine-grained sandstones. They are cross-bedded, and their bedding surfaces are ripplemarked. Load casts also occur. The sandstones are generally unfossiliferous, but one bed contains lamellibranchs, and another, tentaculites and crinoid ossicles. At the top of the unit there is a small algal reef.

Unit 4 has about 65 feet of sandstone at its base. The sandstones crop out close to the southern side of Red Point in Red Bay and also just south of Red Head. At Red Head these sandstones are made up of alternating red and white beds. The white beds contain a higher percentage of calcite than the red beds. At Red Point the sandstones are mostly red with some calcite-rich white lenses. These sandstones contain grains of chromite. Above the sandstone, the remainder of Unit 4 comprises some 300 feet of red shale which includes thin intercalations of siltstone, mud-breccia, and gritstone. Grey-green algal mats are present within the sequence which otherwise appears to be unfossiliferous.

Unit 5 is below sea level except at Red Head where beds of the lower part of the unit underlie the headland. Offshore, at this locality, beds of the upper part of the unit are exposed at low tide, and they were studied from a boat. The unit consists of about 340 feet of red conglomerates interbedded with sandstones. Occasional lenses of nodular limestone are associated with the sandstones.

The beds of conglomerate and sandstone are lenticular, and cross-bedded. The majority of the larger fragments in the conglomerates are pebble size, although some beds contain cobbles up to 6 inches in diameter. The clasts are, in general, well-rounded, and they are set in a matrix of red, arenaceous calcareous mud. Pebbles of soft micritic limestone, similar to the matrix, calcareous mud balls, which look as if they had been rolled in sand, and a fine-grained red sandstone predominate, but some pebbles of vein quartz and serpentine are also present.

In the southern corner of Lourdes Cove, the lowest exposed beds of the Clam Bank Formation strike across the bay at N 30° E. They are overturned, and dip at 45° to 50° to the ESE. South of Red Point, the strike of the beds gradually changes to about N 70° E, and it then remains unchanged almost to Salmon Cove; over this distance there is a slight steepening of the dip (55° to the SSE at Salmon Cove). Ample evidence for the entire Clam Bank sequence being overturned is provided, particularly in Beds 7 and 8, by graded beds, slumped beds, pseudoboudins, ripple marks, load casts, and trough-bedding (Plates 18, 19).

Half a mile east of Salmon Cove, the strike of the rocks changes from N 70° E to S 83° E over a distance of about fifty yards. West of this locality the Clam Bank Formation disappears beneath Pleistocene dune sands and marine clays, and there are no further exposures of the

PLATE 18

Fig. 1. Laminated calcareous claystones and siltstones which show convolutions and pseudoboudins with undisturbed laminae at the base of the picture.

Fig. 2. More intensely deformed laminated beds.

Fig. 1

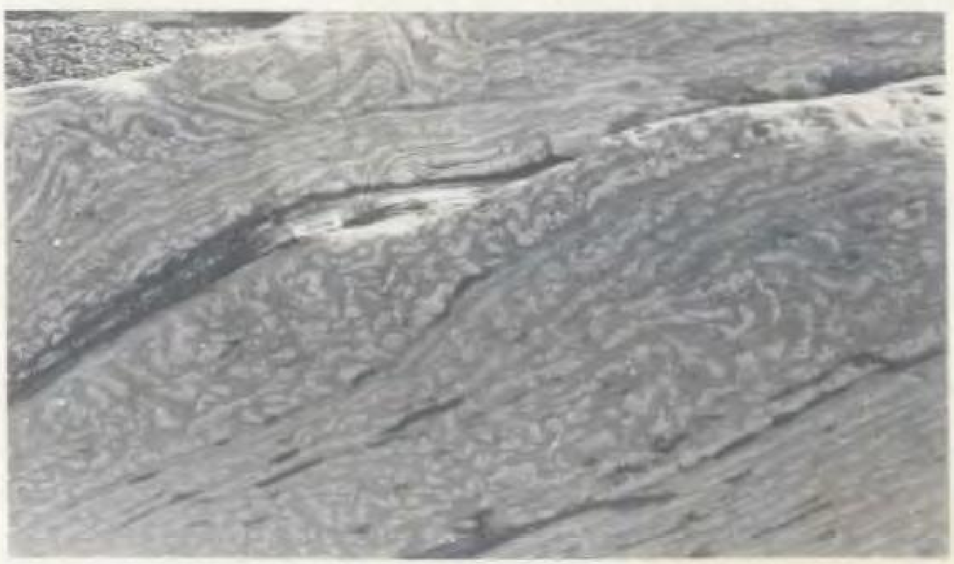


Fig. 2

Clam Bank Formation west of this point. On Three Rock Point, which is separated from the Pleistocene deposits of Salmon Cove by a long covered interval, rocks of the lower members of the Long Point Formation are exposed. The presence of Long Point strata where Clam Bank rocks would be expected (along strike) indicates that a fault lies beneath the covered interval. This fault cuts off the southwestern end of Round Head, and it is probably responsible for the change in strike of the beds at the southwestern end of the outcrop of the Clam Bank Formation.

Minor normal and reverse faults, of limited throw, are present on Red Point and in Salmon Cove. The majority are, however, reverse faults; in some cases slickensiding indicates that movement was oblique. In several places it is possible to observe the throw of a fault decreasing along the fault plane until the fault dies out in a flexure (Plate 19a).

The joint pattern consists of two major sets: one set cuts the beds at S 67° E and another at N 57° E. In Salmon Cove a less well developed set cuts the rocks of the Clam Bank Formation at N 75° E (Plate 19b).

Unit 1 is, in general, unfossiliferous, but Bed 5 at the top of the unit includes ostracods and inarticulate brachiopods. Unit 2 is very fossiliferous, with the grey limestones of Bed 7 containing the most varied fauna. Unit 3 is sparsely fossiliferous, although certain species are

PLATE 19a

Fig. 1. View looking SE in Salmon Cove showing three different types of ripple-marks. Most are parallel symmetrical ripple-marks which run E-W, a few similar ripple-marks run N-S and there are also interference ripple-marks on one large bedding surface.

Fig. 2. Flexure in laminated siltstones and mudstones where a small fault gradually dies out.

Fig. 1

Fig. 2

PLATE 19b

Fig. 1. Small normal fault on the beach in Salmon Cove with a displacement of 8 feet.

Fig. 2. View showing jointing in the flaggier beds of Unit 2 in Salmon Cove. Camera was looking S.W.

Plate 19b

Fig. 1

Fig. 2

locally abundant. Unit 4 contains algal mats associated with shales at several levels, and Unit 5 is totally unfossiliferous. The fauna recognized from each unit is shown in Table 11.

TABLE 11

DISTRIBUTION OF FOSSILS IN CLAM BANK FORMATION

| Fossil | Units | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | | | | 3 | | 4 |
| | Beds | | | | | | | |
| | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Kloedenia deckerensis | x | x | | | | | | |
| Leperditia cf. L. scalaris | x | x | x | | | | | |
| Beyrichia cf. B. tonolowayensis | | | x | | | | | |
| Lingula lewisi | x | x | | | | | | |
| Orbiculoidea cf. O. subplana | | x | | | | | | |
| Protozeuga anticostiana | | | | x | | | | |
| Howellella cf. H. crispa mut. moydartensis | | | | x | | | | |
| Howellella cf. H. angustiplicatus | | | | x | | | | |
| Striispirifer sp. | | | | x | | | | |
| ? Resserella sp. | | | x | | | | | |
| Modiolopsis exilis | | x | | | x | x | | |
| Paleopecten danbyi | | | x | | | | | |
| Leptodesma subrhomboidea | | | x | x | | | | |
| Pteronitella cf. P. venusta var. oblonga | | x | x | x | | | | |
| Hexameroceras cf. H. panderi | | | x | | | | | |
| Ormoceras sp. | | | | x | | | | |
| Tentaculites aff. T. attenuatus | | | x | | | x | | |
| Mesoconularia aff. M. fragilis | | | x | | | | | |
| Pelechypodichnus anticostiana | | x | | | | | | |
| Scolecodonts | | x | | | | | | |
| Worm tracks | x | x | x | | x | | | |
| Crinoid ossicles | | | x | | | x | | |
| Bryozoa | | | x | | | | | |
| Fish remains | | x | | x | | | | |
| Algal reef or mats | | | | | | | x | x |
| Plant remains | | x | | | | | | |

# CHAPTER 5

# PALAEONTOLOGY OF THE CLAM BANK FORMATION

## Brachiopoda

Articulate and inarticulate brachiopods are found in the Clam Bank Formation. The inarticulates are found in Beds 5 and 6, and most of the articulates are found in Bed 8, with one species present in each of Beds 7 and 9.

| | | | |
|---|---|---|---|
| Class | INARTICULATA | Huxley | 1869 |
| Family | LINGULIDAE | Menke | 1828 |
| Genus | LINGULA | Bruguière | 1797 |

*Lingula lewisi* Sowerby 1839.

(Plate 20, Fig. 1)

### Material

Several almost complete specimens and some fragments were collected from Bed 5, and from the lowest grey limestone of Bed 6 of the Clam Bank Formation, both in Salmon Cove and in the southwest corner of Lourdes Cove. Most specimens have shell material preserved.

### Description

The shell is subquadrate, longer than wide and has almost parallel sides. The umbones are obtusely angular. The slightly convex valves have well developed growth lines that are accentuated by erosion. There is an obvious median ridge extending two-thirds the length of the shell on brachial valves.

Discussion

In Beds 5 and 6 of the Clam Bank Formation, Lingula lewisi is found associated with another inarticulate brachiopod, Orbiculoidea, and with numerous ostracods, fish remains and scolecodonts. L. lewisi is also found in the Stonehouse Formation of Arisaig, Nova Scotia, and it is also common in the Wenlock of England (McLearn, 1924).

| | | | |
|---|---|---|---|
| Family | DISCINIDAE | Gray | 1840 |
| Genus | ORBICULOIDEA | D'Orbigny | 1847 |

Orbiculoidea cf. O. subplana (Hall) 1860.

(Plate 20, Fig. 2)

Material

A complete pedicle valve, and part of another valve, were collected from Bed 6, Unit 2 of the Clam Bank Formation in Salmon Cove. Some shell material is still present, particularly apically.

Description

The pedicle valve is almost circular, 14 mm long and 15 mm wide. The apex is situated posteriorly at one-fifth the distance frcm the posterior to the anterior margin. The pedicle furrow begins just behind the apex. The valve is somewhat crushed but still convex. The surface is strongly decorated with growth lines.

Discussion

The Clam Bank specimen closely resembles *Orbiculoidea subplana* described by McLearn (1924) from the Arisaig series (now recognized as a group) of Arisaig, Nova Scotia, although it differs from it in being a little wider. In Arisaig, this species is found in the lower part of the Stonehouse Formation which is thought to be of Pridoli age (Berry and Boucot, 1970).

| | | | |
|---|---|---|---|
| Superfamily | DAYIACEA | Waagen | 1883 |
| Family | DAYIIDAE | Waagen | 1883 |
| Subfamily | DAYIINAE | Waagen | 1883 |
| Genus | PROTOZEUGA | Twenhofel, | 1913 |
| *Protozeuga anticostiana* | | Twenhofel | 1914 |

Material

Numerous tiny specimens were collected from Bed 9, Unit 3 of the Clam Bank Formation in Salmon Cove, and a few from Bed 8, Unit 2. They are nearly all entire shells, and no interiors were found.

Description

The shells are unequally biconvex, subcircular in outline, slightly sulcate ventrally and very small, the larger ones being 5 mm long and 4 mm wide. The hinge line is very short, the ventral beak is sharp, pointed and incurved, and there is no development of an interarea. Growth lines are well developed near the anterior margin and also close to the umbo. The shell is impunctate.

Discussion

No internal features were revealed by sectioning as the interiors of these shells have undergone recrystallization. Assignment to a particular species has, therefore, been based entirely on external features. These have been described above and they correspond most closely to those of Protozeuga anticostiana Twenhofel, 1914. This species was collected by Twenhofel (1914) from rocks of Upper Silurian age on Antocosti Island.

Family DALMANELLIDAE Schuchert, 1913

Genus RESSERELLA Bancroft, 1928

? *Resserella* sp.

(Plate 21, Fig. 3)

Material

Several shell fragments, and two pedicle valves, were collected from limy sandstone bands in the limestones of Bed 7, Unit 2 of the Clam Bank Formation in Lourdes Cove.

Description

The fragments of the brachial valves are slightly convex and costellate. The pedicle valves are deeply convex and costellate. The cardinal process is bilobed and the brachiophore bases are divergent.

Discussion

The specimens are poorly preserved and show few internal features. They are tentatively assigned to the genus *Resserella* which occurs throughout the Silurian.

Superfamily CYRTIACEA Frederiks, 1919 (1924)

Family CYRTIIDAE Frederiks, 1919 (1924)

Subfamily EOSPIRIFERINAE Schuchert & LeVere, 1929

Genus STRIISPIRIFER Cooper & Muir-Wood, 1951

Striispirifer sp.

(Plate 22, Figs. 1 to 4)

Material

Many broken specimens were collected from a shell bank in the rubbly limestone of Bed 8, Unit 2 of the Clam Bank Formation in Salmon Cove. They are found associated with bivalves, ostracodes, and fish remains. Many have retained the original shell material. Removal from the matrix was difficult because the specimens are fragile and crumble readily, but sufficient pieces were removed from the matrix to see the shape of the outline, and some good interiors of brachial valves were found.

Description

The shells are biconvex and weakly transverse with rounded cardinal extremities. The hinge line is slightly shorter than the maximum width. The lateral slopes have three or four weak plications with a smooth fold and sulcus. The interior of the brachial valve has long crural plates. The delthyrium is wide and the interarea is anacline and strongly curved. The pedicle interarea is apacline and the delthyrium encloses an angle of about 60°.

## PLATE 20

### LINGULA LEWISI SOWERBY 1839

Figs. x 3.

Fig. 1. Brachial valve showing subquadrate outline, obtusely angular umbo, a clearly defined median ridge and well developed growth lines.

### ORBICULOIDEA CF. O. SUBPLANA (HALL, 1860)

Fig. 2. Pedicle valve of almost circular outline with prominent apex about one fifth the distance from the posterior margin, and conspicuous growth lines.

OCB 1

Fig. 1

OCB 2

Fig. 2

6

## PLATE 21

### PROTOZEUGA ANTICOSTIANA TWENHOFEL 1914

Fig. 1a. Individual shells (x 3) each showing high beak, tear-drop outline, lack of decoration, and very sharp commissure.

Fig. 1b. Hand specimen showing specimens of Protozeuga anticostiana throughout the rock with isolated shells above showing brachial, pedicle and side views respectively from left to right.

### ? RESSERELLA SP.

Fig. 3. Pedicle valve showing convexity, which is greatest just in front of the umbo, the slight flattening of the valve near the lateral and anterior margins, and the deep costellae; the features of the cardinal area are indistinct.

OCB3

Fig.2 ×3

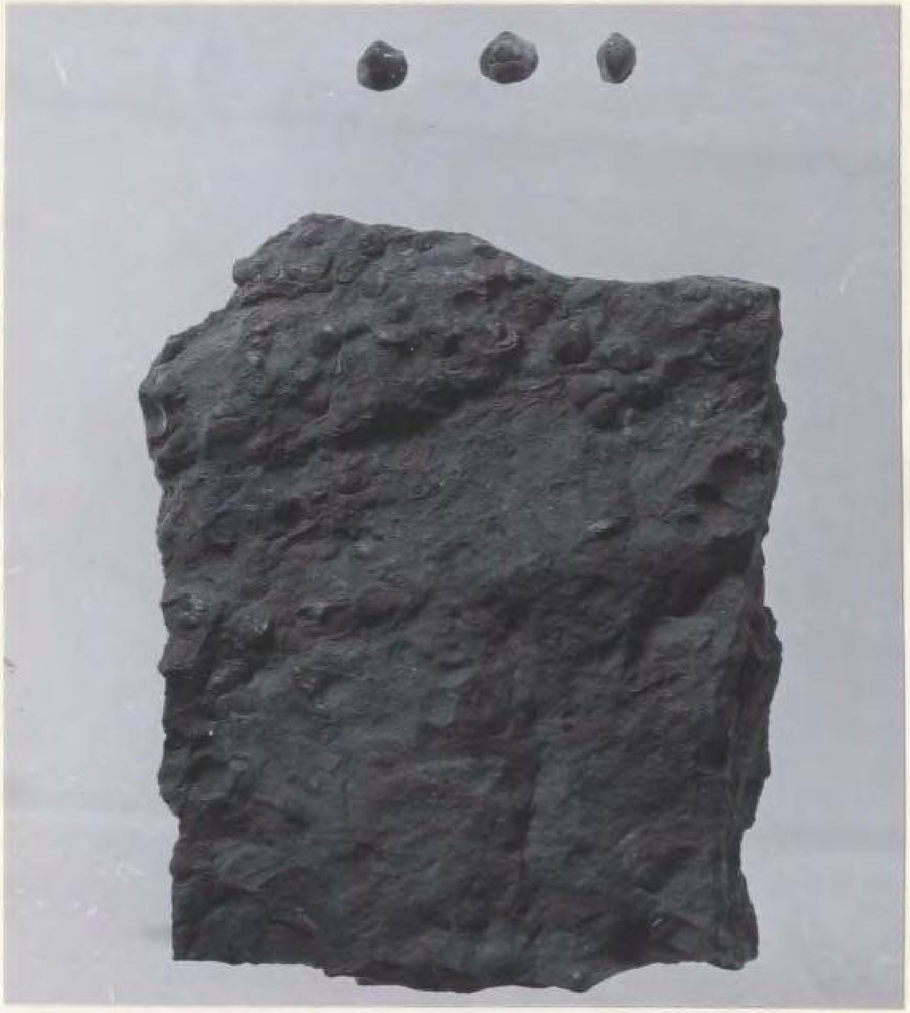


Fig.1 ×1

OCB4

Fig.3 ×2

# PLATE 22

## STRIISPIRIFER SP.

Fig. 1. Hand specimen showing very small specimens of this genus associated with shells of the brachiopod Protozeuga anticostiana and the ostracod Leperditia.

Fig. 2. Pedicle valve with weakly developed plications showing the impunctate shell material.

Fig. 3. Pedicle valve with more strongly developed plications.

Fig. 4. Brachial valve showing long crural plates.

OCB 5

Fig. 1 x $\frac{3}{4}$

OCB 6

Fig. 2

OCB 7

Fig. 3

OCB 8

Fig. 4

Discussion

The Clam Bank specimens closely resemble *Striispirifer stonehousensis* from Arisaig, Nova Scotia, except for their outline which is rounder and less alate. In some specimens the plications on the lateral slopes are poorly developed giving an almost non-plicate specimen. These may belong to the genus *Eospirifer* rather than *Striispirifer*. In other Clam Bank specimens, 3 or 4 plications are well developed on the lateral slopes, and in every way they correspond to the generic description of *Striispirifer* of Cooper and Muir-Wood (*in* Boucot, 1963). It is possible that two or more genera are represented in the Clam Bank specimens but every stage between the very plicate and the non-plicate is represented so that all the specimens have been assigned to the genus *Striispirifer*.

Family DELTHYRIDIDAE Waagen, 1883

Genus HOWELLELLA Kozlowski 1946

*Howellella* cf. *H. crispa* mut. *moydartensis* (McLearn, 1924)

(Plate 23, Fig. 1)

Material

Numerous near perfect specimens of the genus *Howellella* were collected from Bed 8, Unit 2 of the Clam Bank Formation on the second headland in the southwest corner of Lourdes Cove. They were found in pockets of shale, from which they could easily be removed, at the base of large ripples in hard, sandy limestone scattered over a large exposed area of a single bedding surface.

Description

The shells are biconvex and transverse with a smooth fold and sulcus and lateral slopes bearing four strong plications. The pedicle interior has well developed dental plates with no median septum, and the brachial valve interior possesses short crural plates. The sulcus of the pedicle valve is not always central but sometimes swings diagonally across the valve towards the right. The beak on the pedicle valve is high giving an apsacline cardinal area. The dimensions of these specimens are as follows:

| | |
|---|---|
| 1.4 cm wide | 1.1 cm high |
| 1.4 cm " | 1.2 cm " |
| 1.3 cm " | 1.1 cm " |
| 1.3 cm " | 1.2 cm " |

The size is rather larger than those of the Moydart Formation but in all other ways they appear identical. Many of the Clam Bank specimens are crushed and broken, and, therefore, their dimensions can not be measured accurately, so that it was not found possible to determine the ratio of their width to height for comparison with the Moydart material.

Discussion

This species was described by McLearn (1924) under the name of Delthyris crispa mut. moydartensis. Koslowski

(1929) used *Delthyris crispa* (Hisinger) as the type species for his new genus *Crispella* which he renamed *Howellella* in 1946. It is therefore described here by the name *Howellella crispa*. In Arisaig, this species is found in the Moydart Formation which is thought to be of Ludlow age (Berry & Boucot, 1970). The Clam Bank specimens are found associated with another, more quadrate or rectangular form of *Howellella* which is described below.

Family DELTHYRIDIDAE Waagen 1883

Genus HOWELLELLA Kozlowski 1946

*Howellella* cf. *H. angustiplicatus* Kozlowski 1946

(Plate 23, Figs. 1 and 2)

Material

Several nearly perfect as well as some slightly damaged specimens were found associated with *H. crispa* mut. *moydartensis* in Bed 8, Unit 2 of the Clam Bank Formation in the southwest corner of Lourdes Cove.

Description

The species is very similar in form to *H. crispa* mut. *moydartensis* except that the beak is lower and rounder and both valves are slightly more convex. The sulcus is straight down the centre of the pedicle valve. The outline is subelliptical. In all exterior features the Clam Bank specimens correspond exactly with the specimens illustrated in the Treatise on Invertebrate

Paleontology, Part H, Vol. 2, as H. angustiplicatus Kozlowski, except that the sulcus is less deep.

Discussion

H. angustiplicatus is found in beds of Ludlow age in Poland (Boucot et al., 1965). The Clam Bank specimens appear to be closely related to this species.

Phylum MOLLUSCA
Class BIVALVIA
Family MODIOMORPHIDAE Miller, 1877
Genus MODIOLOPSIS Hall, 1847

Modiolopsis exilis Billings, 1874
(Plate 24, Figs 1 & 2)

Material

Bedding surfaces covered with specimens of Modiolopsis, and of Pteronitella, were found in the lower part of Bed 6, Unit 2 of the Clam Bank Formation in Lourdes Cove, and a few isolated specimens were collected from the same level in Salmon Cove. Other specimens were collected from the pink and red sandstones of Beds 9 and 10, Unit 3 in Red Bay and Salmon Cove. All are external moulds, and no interiors or denticulation can be seen.

Description

The shell outlines are subovate and, in some specimens, slightly arcuate. The length is at least twice the height of the shell. The beaks are set in the anterior third of the shell but the position is variable. The hinge line is straight. The anterior margin of the shell is broadly rounded. The posterior margin slopes from the end of the hinge line to about the midheight of the shell and it is then either rounded or subtruncate. From the umbones an obtusely rounded angulation extends to the lower posterior angle. The ventral and dorsal margins of the specimens are subparallel.

Minimum height 0.6 cm   Maximum ht. 1.1 cm

Minimum length 1.4 cm   Maximum lth. 2.7 cm

All sizes between are represented, and the ratio of height to length varies from 1:2.33 to 1:2.45.

Discussion

The original description of *Modiolopsis exilis* by Billings in 1874, is applicable to only about half the specimens collected from the Clam Bank Formation, as he would have placed the remainder in related species. Thus, when McLearn, 1924, discussed the variable characteristics of this genus he included several other of Billings' species and varieties within the species *M. exilis*, pointing out that the great variety in shell outline, variability in the sharpness of the angulation from umbo to the lower posterior angle, and the position of the umbo, are not good enough criteria for separating *M. exilis* Billings from *M. ruda* Billings. He also indicated that *M. leightoni* Williams (1913) from Maine is a generally smaller, closely related, if not overlapping, species in its variations, and that M. solenoides (Sowerby) from the English Upper Ludlow, which has nearly parallel dorsal and ventral margins is also closely related to M. exilis.

The Clam Bank specimens seem to include some of the characteristics of all four species discussed above. They are slightly smaller than the Arisaig specimens, and the dorsal and ventral margins are more nearly parallel than those of any of the North American species, and in this respect they most closely resemble the English Form. However, in view of the known variation in the form of the shells of M. exilis (McLearn, 1924), and the fact that many of the Clam Bank specimens are indistinguishable from that species, it seems likely that only this species is represented in the beds of Unit 2 of the Clam Bank Formation. Both the Pembroke Formation of Maine and the Stonehouse Formation of Arisaig, Nova Scotia, are of Pridoli to early Gedinnian age (Berry and Boucot, 1970).

FAMILY PTERINEIDAE Miller, 1877

GENUS LEPTODESMA Hall, 1883

Leptodesma subrhomboidea McLearn, 1924

Material

Three complete left valves and several fragments were collected from Beds 6, 7 and 8 in Unit 2 of the Clam Bank Formation in Salmon Cove and Lourdes Cove. All specimens are external moulds with no internal features showing, and no original shell material has been retained. In Beds 6 and 7 the specimens are associated with other bivalves whilst in Bed 8 the specimen is found in a shell bank mainly composed of Striispirifer sp., large Pteronitella sp. and the remains of a fish.

Description

The outline of the shell is subrhomboidal with the anterior and posterior margins subparallel. The hinge line is straight and the dorsal margin is extended into a wing on either side of the umbo. The anterior wing is flattened and not auriculate; the posterior wing is moderately well defined and has its posterior border slightly concave but it is not auriculate on the posterior dorsal margin. The ventral margin is smoothly rounded. Decoration consists of widely spaced concentric striae.

Dimensions of the three complete valves are as follows:

2.2 cm high and 2.4 cm long
2.1 cm " " 2.2 cm "
1.9 cm " " 2.0 cm "

Discussion

No interiors are seen, so that the Clam Bank specimens, like those of Arisaig, can only be tentatively assigned to the genus Leptodesma. The Clam Bank specimens show the same relationship of height to length as the Arisaig specimens, and in spite of their slightly larger size, they are assigned to the same species.

In the Arisaig area, L. subrhomboidea is confined to zone d of the Ross Brook Formation and does not appear in higher beds (McLearn, 1924). This zone is of late Llandovery to early Wenlock age, which is older than the age of other specimens that have been described (Berry and Boucot, 1970).

Family PTERINEIDAE Miller 1877

Genus PTERONITELLA Billings 1874

Pteronitella cf. P. venusta var. oblonga Billings 1874

Material

One surface in the shell bank of Bed 8, Unit 2 of the Clam Bank Formation in Salmon Cove is covered with rather eroded external moulds. Four single specimens were also collected from Beds 6 and 7 in the southwest corner of Lourdes Cove. All are left valve exterior moulds, and no internal moulds or right valves were collected.

Description

As the name of the variety indicates, these specimens are almost rectangular in outline. The hinge line is straight, extending only a short distance in front of the umbo but almost to the posterior extremity of the shell behind the umbo. The anterior extremity in front of the umbo is small and triangular, extending down about one quarter of the height of the shell. From there the anterior margin slopes downward and curves backward to the ventral margin of the shell, which continues almost parallel to the hinge line. The posterior margin curves smoothly up to half the height of the shell, and it then curves forwards and finally backwards to give a slight sinus just below the hinge line.

Decoration is limited to concentric striae, which are best developed on the antero-ventral part of the shell and on the posterior wing. The striae are, however, almost entirely absent from the older part of the shell.

Dimensions of the smallest and largest specimens collected are as follows:

3.0 cm long and 2.5 cm high

4.0 cm long and 3.7 cm high

Discussion

The ratio of height to length of the Clam Bank specimens is constant at 1 : 1.2, whilst the figures for two specimens from Arisaig give a ratio of height to length of 1 : 1.4 and 1 : 1.6 respectively. The Arisaig specimens also tend to be rather larger than the Clam Bank specimens. Identification of the Clam Bank specimens is based entirely on external features, and, therefore, the designation of these specimens is only tentative. However, they appear to be very similar in form, and are probably conspecific. In the Arisaig rocks the variety of P. venusta is found in the Silurian formations up to those of Pridoli age.

Family LEIOPECTINIDAE Krailova, 1959

Genus PALEOPECTEN Williams, 1913

<u>Paleopecten</u> <u>danbyi</u> (McCoy, 1851)

(Plate 25, Figs. 1 & 2)

<u>Material</u>

One complete left valve and several fragments of both left and right valves were found closely associated in Bed 7, Unit 2 on the headland at the southwest corner of Lourdes Cove. Unfortunately, owing to the fragile nature of the rock, only fragments could be collected, and the complete valve was in too dark a place to photograph. The shape of the original valve shown in Plate 25, Fig. 2 was constructed from drawings made in the field, and from the fragments collected.

<u>Description</u> (external only)

The left valve is concave, suboval and prosocline, neither wing is well defined and there is no byssal notch. The anterior of the shell is well-rounded, becoming more pointed to the posterior. Growth lines are seen sparsely near the umbo but extensively towards the ventral margin. Several radial ridges extend from the umbo towards the ventral margin. Where shell material is present, these can be seen to be long wrinkles in the shell which fade out ventrally as the growth lines become stronger. On the fragments of the right valve, which is flatter than the left, only growth lines are visible and radial ridges appear to be absent. No interiors were seen. The complete valve measures 4 cm high and about 6 cm wide.

Discussion

The Clam Bank specimen is very similar to those of the Stonehouse Formation of Arisaig, Nova Scotia. This species is also found in the Edmunds and Pembroke Formations of Eastport, Maine, and in the Upper Ludlow of Westmorland, England (McLearn, 1924).

| | |
|---|---|
| Phylum | MOLLUSCA |
| Class | CEPHALOPODA |
| Family | HEMIPHRAGMOCERATIDAE Foerste, 1926 |
| Genus | HEXAMEROCERAS Hyatt, 1884 |

Hexameroceras cf. H. panderi (Barrande, 1867)

(Plate 26, Fig. 1)

Material

A single incomplete specimen was collected from Bed 7, Unit 2 of the Clam Bank Formation in Salmon Cove.

Description

This specimen is a small endogastric brevicone, 6 cm long, with a maximum width of 4.5 cm. The conch is compressed, and has curved dorsal and ventral outlines. The phragmocone is made up of seven camerae, with the intervening horizontal septa equidistantly spaced some 4 mm apart except for the last septum which is much closer to the previous septum to give a narrow camera beneath the body chamber. The body chamber is inflated, and the apperture is contracted and visored, but unfortunately the peristome is not clearly seen as it is partly hidden beneath sediment, and compression of the conch has also distorted the sinuses. However, the pattern of the peristome appears to be as follows: it is produced ventrally into a long narrow hypernomic sinus slightly expanded at its end, with a dorsal salient opposite and three lateral sinuses on either side apically (only fully visible on one side of the specimen). The two dorsal sinuses are short and are directed straight backward, while the ends of the two dorso-lateral sinuses curve slightly backward, and the two antero-lateral sinuses face in the direction indicated by their names.

Discussion

Teichert and Sweet (1962) used the number of lobes of the peristome as a generic distinction and placed the forms with eight lobes into the genus Octamerella and those with six lobes into the genus Hexameroceras.

In shape, the Clam Bank specimen closely resembles Hexameroceras panderi (Barrande) as figured by Foerste (1926). The apperture and shape are distorted as the specimen is flattened. The Clam Bank specimen is, therefore, assigned to the species Hexameroceras panderi (Barrande) because of the six lobes of the peristome and the similarity of its shape to the specimen of this species figured by Foerste (1926).

This genus is quite widespread in North America in rocks of Silurian age although relatively few specimens have been found.

Family ORMOCERATIDAE Saemann, 1853

Genus ORMOCERAS Stokes, 1840

Ormoceras sp.

(Plate 26, Fig. 2)

Material

A single incomplete specimen was collected from Bed 8, Unit 2 of the Clam Bank Formation in Salmon Cove. The specimen is part of a phragmocone that has been laterally compressed, and consequently the septa are broken and crushed. The original outline is distorted both by breakage and by collapse of the structure of the conch.

Description

The specimen represents part of a straight phragmocone that has the upper and lower camerae missing. Longitudinal sectioning reveals that this part consists of about 15 camerae separated by saucer-shaped septa. The siphuncle is well preserved, but the septa and the deposits within the camerae are broken and in a chaotic state due to compression of the conch which now has an elliptical instead of a circular cross-section. The ectosiphuncle consists of cyrtochoanitic septal necks that are joined by connecting rings which entirely surround the septal necks and bulge outwards between succeeding septa to give a nummuloidal siphuncle. The annulosiphonate deposits are hardly more than incipient rings and are not very big, even towards the base of the conch.

Discussion

The size of this specimen is similar to *Ormoceras allumettense* (Billings) but the endosiphuncular deposits are much less extensive than is typical for this Ordovician species. The interior of *Ormoceras* species became progressively less filled by endosiphuncular deposits from the Ordovician to the Devonian (Teichert, 1964). This specimen's deposits fall somewhere between those described for the genus *Ormoceras* and those of the Carboniferous genus *Carbactinoceras*. The Clam Bank specimen is therefore assigned to the genus *Ormoceras* but no species is given as no species is described like this one in the available literature.

# PLATE 23

## HOWELLELLA

Fig. 1. *Howellella* cf. *H. crispa* mut. *moydartensis* (McLearn, 1924).

Top row: view of brachial valves showing high pointed beaks.

Bottom row: view of pedicle valves showing high beaks. Right-hand specimen, side view showing the apsacline cardinal area.

Fig. 2. *Howellella* cf. *H. angustiplicatus* Kozlowski, 1946.

Pedicle and brachial valves showing similar outlines to those in Fig. 1.

Right-hand specimen, side view showing lower, rounder beak and greater convexity of both valves.

OCB 5

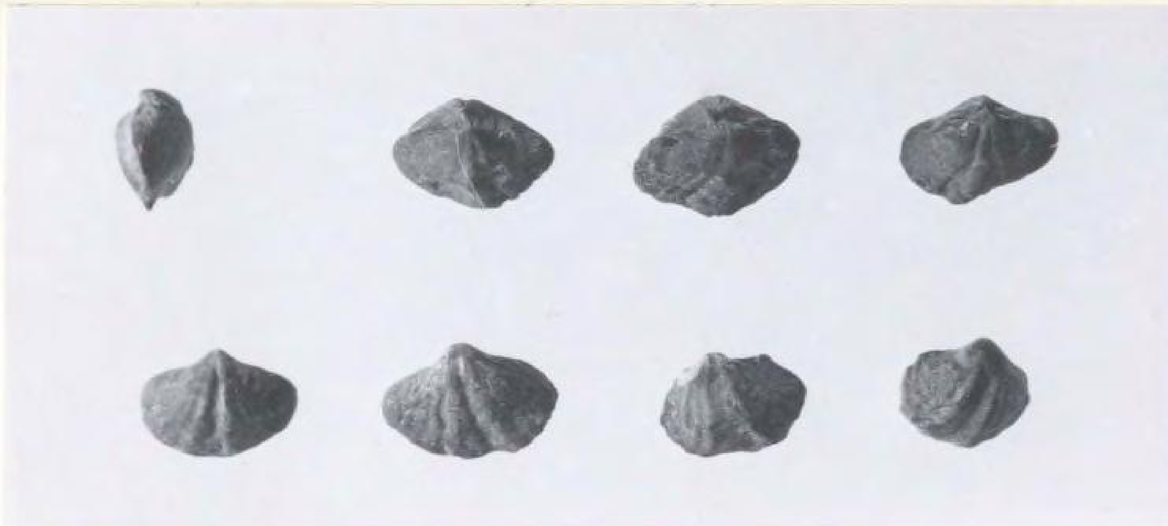


Fig.1

OCB6

Fig.2

PLATE 24

BIVALVES FROM THE CLAM BANK FORMATION

Fig. 1. Left valve of Modiolopsis exilis: internal mould showing outline of shell and growth lines.

Fig. 2. Internal mould of left valve of Modiolopsis exilis showing a rather truncated posterior, and arcuate outline.

Fig. 3. Leptodesma subrhomboidea: internal mould of left valve showing long hinge line, emphasized growth lines, and slight concavity of posterior margin to give a slight wing.

Fig. 4. Pteronitella cf. P. venusta var. oblonga: internal mould of left valve showing almost rectangular outline, long hinge line which extends from just in front of the umbo almost to the posterior margin. This specimen is badly preserved and shows very little decoration of the shell surface.

Fig. 5. Pteronitella cf. P. venusta var. oblonga: internal mould of left valve showing decoration of concentric growth lines which are restricted to the younger, marginal part of the shell, and almost entirely lacking on the older part of the shell near the umbo.

OCL 1

Fig. 1

OCL 2

Fig. 2

OCL 3

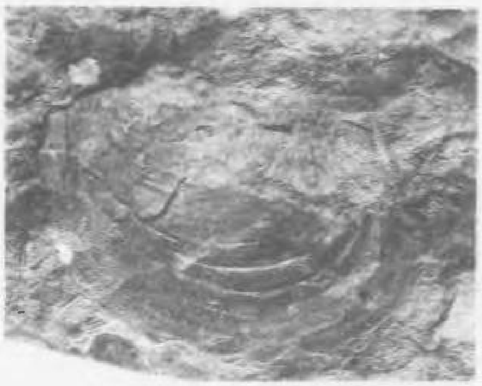


Fig. 3

OCL 4

Fig. 4

OCL 5

Fig. 5

PLATE 25

**PALEOPECTEN DANBYI** (MCCOY, 1851)

Fig. 1a. Two fragments of a left valve. The larger fragment is an external mould showing the original valve to be concave with ridges radiating from the umbo. The smaller fragment consists of original shell material with the growth lines closer together.

Fig. 1b. Shell fragment from the posterior margin of the right valve showing growth lines closing together.

Fig. 2. Reconstruction based on many fragments, and on a drawing made in the field.

Plate 25

OCL 6

Fig. 1a

OCL 7

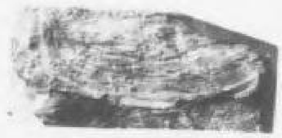


Fig. 1b.

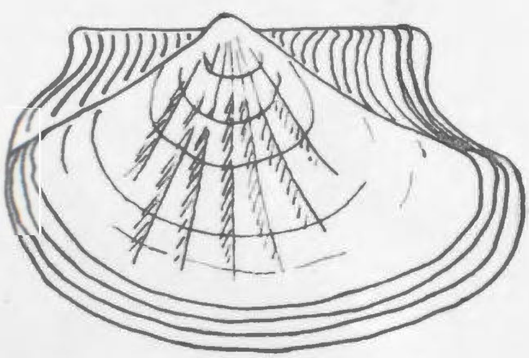


Fig. 2

PLATE 26

HEXAMEROCERAS CF. H. PANDERI (BARRANDE, 1867)

Fig. 1. Internal mould of brevicone showing constricted aperture apically. The aperture is partly obscured and only the margin of the hyponomic sinus, extending towards the ventral side, and the right dorso-lateral and antero-lateral sinuses can be seen in this side view.

ORMOCERAS SP.

Fig. 2. Longitudinal section showing broken cameral deposits, and annulo-siphonate deposits.

Plate 26

OCC1


Fig. 1

OCC 2

Fig. 2

# PLATE 27

## LEPERDITIA CF. L. SCALARIS (JONES, 1886)

Fig. 1. Surface showing numerous crushed carapaces of different instar stages.

Fig. 2. x 2. Large right valve of adult animal.

Fig. 3. x 2. Large left valve. The eye tubercle is obvious in the anterodorsal area of the valve.

OCM 1

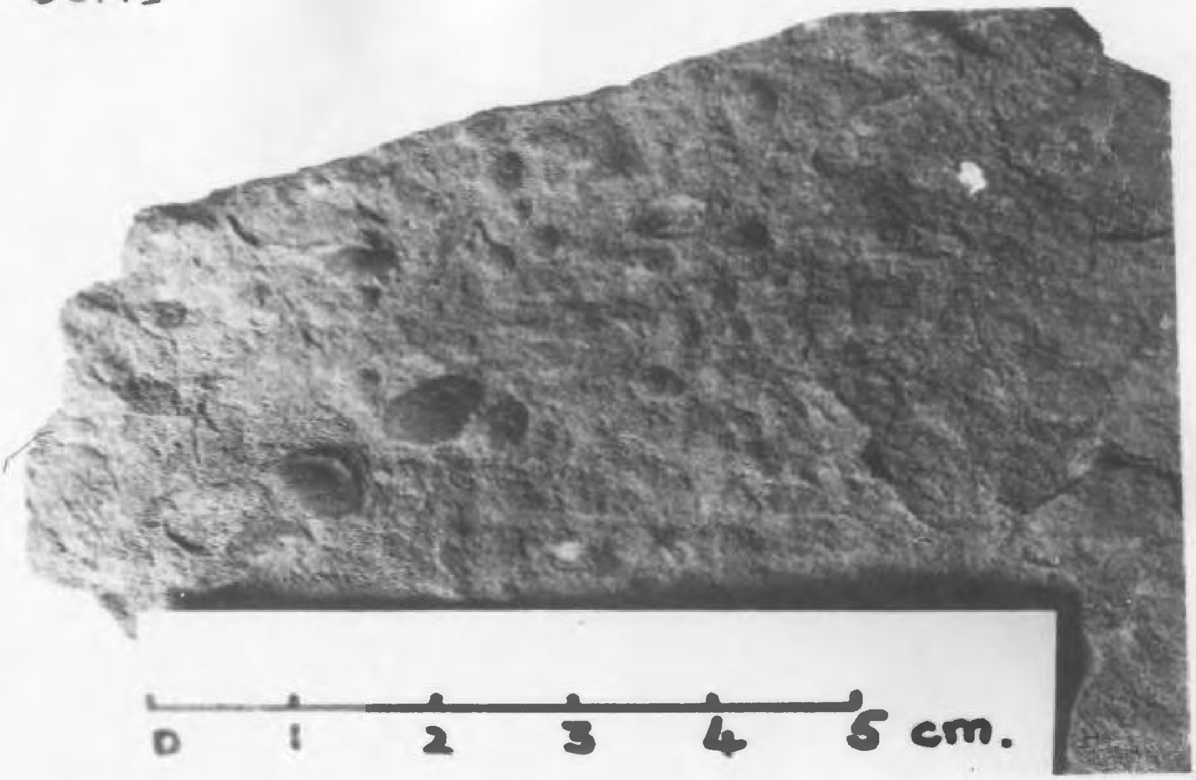



Fig. 1

OCM 2

Fig. 2

OCM 3

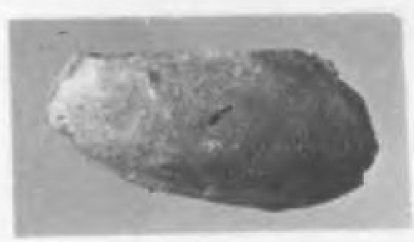


Fig. 3

PLATE 28

BEYRICHIA CF. B. TONOLOWAYENSIS ULRICH & BASSLER 1923

Fig. 1. Right valve of male specimen showing straight hinge line, three lobes, and the striate frill along the margin of the valve which is best developed in the midventral and anteroventral portion of the shell.

OCM 4

Fig. 1.

Subclass OSTRACODA Latreille, 1806

Order LEPERDITICOPIDA Scott, 1961

Family LEPERDITIIDAE Jones, 1856

Genus LEPERDITIA Rouault, 1851

*Leperditia* cf. *L. scalaris* (Jones, 1886)
(Plate 27, Figs. 1 to 3)

**Material**

Numerous carapaces of all instar stages are found in the shales of Beds 5, 6, and 7, Unit 2 of the Clam Bank Formation. Specimens were collected from the shales and limestones in the southwestern corner of Lourdes Cove, from Salmon Cove, and also from the road gutter near the stream at Tucker's Barn at the western end of the community of Lourdes. Many shells are crushed, and most are slightly eroded. No good hinge lines or muscle scars were found.

**Description**

Many of the specimens are of large size; the largest has a length of 18 mm and a width of 6 mm. The hinge line is straight, and the shell is smooth and unornamented. It is rather angular on the anterior margin, and is rounder and deeper in the posterior. The anterior cardinal angle is slightly obtuse, and the posterior angle highly obtuse. A small eye tubercle is present in the anterodorsal area. There is a slight rim along the margin of the left valve which acts as a stop for the right valve.

**Discussion**

The Clam specimens are similar in outline, size and convexity to L. scalaris (Jones). Hinge lines and muscle scars are not well enough preserved to compare fine detail so that the designation cf. is used for the Clam Bank specimens. L. scalaris (Jones) is found in the Upper Silurian (Cayugan) of Ontario and also near New York (Shimer and Shrock, 1956). Some of the middle sized Clam Bank specimens of 5 to 6 mm length seem rather broader and more convex. This is either a characteristic of the instar of that age or else it is possible that another species of Leperditia is present. Some of the shalier beds are almost entirely composed of small carapaces, either whole or as separate valves. Usually when they are very abundant the valves are smaller, earlier instar stages indicating an accumulation of molted valves rather than the remains of dead animals. In the limy beds the valves tend to occur only on bedding surfaces where they are associated with Beyrichia, small brachiopods and bryozoa.

Family BEYRICHIIDAE Matthew 1886

Genus BEYRICHIA M'Coy 1846

Beyrichia cf. B. tonolowayensis Ulrich & Bassler 1923

(Plate 28, Fig. 1)

Material

Two right male valves in good condition, and numerous crushed and broken specimens were collected from Bed 7, Unit 2 of the Clam Bank Formation at Red Point and in Salmon Cove. The shell material is well preserved but the valves are too fragile to remove from the matrix and no interiors were seen.

Description of male valve

The hinge line is straight and the valve is distinctly trilobate. The cardinal angles are slightly obtuse and subequal, and the posterior sulcus is slightly longer than the anterior sulcus. The middle lobe is the smallest and is detached. A wide striate frill, almost half as wide as the valve, is developed around the free margins. The valves are up to 2 mm long.

Discussion

This species is found in the Tonoloway Limestone of the middle Appalachian region of the Eastern United States of America (Shimer and Shrock, 1956). It has been tentatively dated as Pridoli age (Berry and Boucot, 1970). The Clam Bank specimens are also similar in form to *Velibeyrichia paucigranulosa* Swartz and Whitmore, 1956 but they are more trilobate, and the decoration of the shell surface is much finer, so they are more closely related to *Beyrichia tonolowayensis*. They are found in association with *Leperditia* in the more lime rich beds of Unit 2.

Family BEYRICHIIDAE Matthew, 1886

Genus KLOEDENIA Jones and Holl, 1886

Kloedenia deckerensis (Weller, 1903)

Material

A few small specimens were collected from the shales of Bed 5 at the top of Unit 1, and from the shale of Bed 6, Unit 2, Salmon Cove.

Description

The hinge line is straight for most of its length. The carapace is subovate in outline and the cardinal angles are slightly obtuse and subequal. The anterior margin is higher and more broadly rounded than the posterior margin. The ventral margin is moderately convex. The surface of the shell is rather granular.

A flattened border parallels the free margins. Trilobed, with the lobes moderately convex. The median lobe is about one fifth the width of the shell, and it is obpyriform with the summit elevated and rounded. It does not reach the dorsal margin of the valve. The median sulcus is subvertical, quite wide, and extending halfway to the ventral margin. The anterior sulcus is moderately deep in the upper quarter of the valve. The best specimen is a female as a well-developed brood pouch is present in the anteroventral and mid-ventral part of the shell.

Discussion

The best specimen is without doubt a female, and it seems no female of this species has been described before as Swartz and Whitmore (1956) only describe a male valve. The Clam Bank specimens are also close to *Kloedenia ventralis* (Ulrich & Bassler), but they are a little more elongate, and the slightly obpyriform median lobe confirms the diagnosis of *K. deckerensis*. Shimer and Shrock (1956) report *K. sussexensis* as of Devonian age from the Helderberg and Keyser Limestones. In the Decker Limestone, Swartz and Whitmore (1956) found that *K. sussexensis* is associated with *K. deckerensis*. The lower part of the Keyser Limestone has now been given a Pridoli age, and only the upper part is Devonian (Berry & Boucot, 1970).

Class TENTACULITA Boucek, 1964

Family TENTACULITIDAE Walcott, 1886

Genus TENTACULITES Schlotheim, 1820

*Tentaculites* aff. *T. attenuatus* Hall, 1885

(Plate 29, Fig. 1)

*Material*

Numerous broken and eroded specimens were collected from surfaces in Bed 10, Unit 3 of the Clam Bank Formation. Other fragments were also found in the lower sandy limestones and shales of Bed 7, Unit 2.

Description

The longest specimens measure 15 mm but they are broken at both ends. Most other specimens measure between 3 mm and 10 mm in length. The juvenile part of the shell is very slender and pointed and the annulations are regular. In the more mature portion of the shell the size of the growth angle is reduced to 4½° to 5° and the annulations are more irregular, averaging 2 rings/mm. Between the rings the surface shows occasional transverse striae. One steinkern of a portion of a mature shell is preserved showing the internal shape of the rings which differs from those on the exterior of the shell. The shells are thick, and the outer layers are pierced by radial canals.

Discussion

Size, shell thickness, the slimness of the entire shell, and the pointed juvenile portion of the shell agree with the diagnostic characters of the genus Tentaculites as redescribed by Bouček (1964). The steinkern also shows an internal pattern which differs from the rings on the exterior of the shell. Fisher (1962) uses this feature to separate the Tentaculitidae from the other members of the class. Specific differences normally are features of the size and decoration of the shell, and the decoration of the Clam Bank specimens is mostly eroded. The rather slim, fragile nature of the Clam Bank specimens most closely resembles the features of *T. attenuatus* (Hall) as figured in Shimer and Shrock (1955). This form is found in Ontario and the east coast of the U.S.A. from New York to Maryland, in rocks of Middle Devonian age. The Clam Bank specimens are very similar in form and may be related to *Tentaculites attenuatus* Hall.

Family CONULARIIDAE Walcott, 1886

Genus MESOCONULARIA Bouček, 1939

*Mesoconularia* aff. *M. fragilis* (Barrande, 1867)

(Plate 29, Fig. 2)

*Material*

One rather crushed fragment was collected from Bed 7, Unit 2 of the Clam Bank Formation in Salmon Cove.

*Description*

The specimen is steep sided and pyramidal in form. Reconstructed it would be at least 2.5 cm long. The faces are marked with transverse ribs which are deflected abaperturally in crossing the face, which is a distinctive characteristic of the genus *Mesoconularia*. The corner grooves are developed but do not interrupt the transverse sculpture. The midline is distinct and emphasized in the broken portion of the periderm. The periderm is thin with no thickening on the corner grooves.

Discussion

The Clam Bank specimen is small and delicate. It is similar in form and decoration to M. fragilis (Barrande) which is a Lower Devonian form from Czechslovakia. No description of any member of the genus Mesoconularia could be found in the literature from North America. The designation aff. is given because although the specimen closely resembles the Czechoslovakian form, it is incomplete, and may well belong to a different species.

TRACE FOSSILS

Genus PELECYPODICHNUS Seilacher, 1953

Pelecypodichnus anticostiana (Twenhofel, 1928)

(Plate 30a, Fig. 1)

Material

Numerous specimens were found covering a single bedding surface in Bed 6, Unit 2 of the Clam Bank Formation in the southwest corner of Lourdes Cove.

Description

These small podlike fossils, tapering to a sharp point at either end, are similar in shape to a grain of long rice. Their length is variable, and ranges from 0.5 to 1.0 cm, but the majority are closer to 0.5 cm than to 1.0 cm. They are aligned in all directions on the rock surface.

Discussion

These fossils are described by Twenhofel (1928) from the English Head Formation of Anticosti Island under the name of Lockeia anticostiana. Other fossils of this type were described from Cincinnati by James in 1879. Like those figured in the Treatise on Invertebrate Paleontology, Part W, from Germany, the Cincinnati specimens are broader and stumpier in outline than the Clam Bank specimens which are similar in size and shape to those from the Ordovician of Anticosti Island.

Worm Burrows

Bedding surfaces in Bed 7, Unit 2, and in Bed 10, Unit 3, are covered with horizontal worm tubes of varying lengths. Where the surface of the tube is preserved, long striations parallel to the side of the tube can be seen along the length of the burrows. The average width of the tubes is 0.3 cm. Some tubes are up to 6.0 cm long, whilst others are more pellet-like in form.

Superclass PISCES

Class AGNATHA

Fish fragments

(Plate 30b, Figs. 1 and 2)

Material

(1) The posterior half of the trunk of a fish (without tail) was found in Bed 8, Unit 2 of the Clam Bank Formation in Salmon Cove in association with shells of brachiopods and bivalves. The body is flattened and covered with small diamond-shaped plates; the fragment is about 6.5 cm long and 4.0 cm wide at its greatest width. A vertical section of the plates reveals a cone-shaped opening towards the surface. 2.5 mm below the plated surface, a layer bearing striations is present; the striations are oriented along the length of the fish.

(2) A very large fish plate was found in Bed 6, Unit 2 of the Clam Bank Formation in Salmon Cove. The scale is suboval in shape and about 2.5 cm across its long axis. The surface is dished and covered by a layer of "dimpled" calcite beneath which a finger-print-like pattern is apparent. This pattern is continued up into the calcite layer to give rows of crystals following this pattern; the dimples of the upper surface are superimposed on the oval pattern beneath. The left margin of the plate is rounded but the right margin appears to be

extended to a point.

Algal mound

One small, dome shaped algal mound was discovered at the top of Bed 11, Unit 3 of the Clam Bank Formation in Salmon Cove. This mound measures about 80 cm in diameter and has a maximum height of 40 cm. The surface is pustulose. Laminae of fine sediment can be seen lying parallel to the surface of the pustules, but no evidence of a filamentous algal form or any other morphological feature of any kind can be distinguished.

Algal mats

Several grey horizons in the red shales of Unit 4 of the Clam Bank Formation in Salmon Cove reveal thinly bedded grey-green shale with a pustulose surface containing an easily erodable mineral which leaves behind a holey, uneven, patchy surface much redder in colour than the rest of the grey layer. On top of this pustulose layer, in each case, there is a thin shale layer which is finely cracked in a polygonal pattern. These algal patches are of variable lateral extent, and their vertical thickness is about 1.0 cm. Vertical sections show laminae lying parallel to the surface of the pustules and a few uneven small blobs in short strings can be seen close to the upper surface of the pustules.

## Plant remains

At the top of Bed 6, Unit 2 of the Clam Bank Formation, a layer of fragmentary plant remains is present. They are associated with shells of the inarticulate brachiopod genus *Orbiculoidea* and with scolecodonts. The whole bedding surface is stirred up and the fragments are distributed haphazardly throughout the layer. On the surface, some larger fragments like that figured in Plate 31, Fig. 2, remain preserved as a carbonaceous film. The figured specimen is composed of a hollow tube, which is somewhat compressed, made up of small segments. The width of the tube is more or less constant but the length of the individual segments varies; other fragments are of different widths.

PLATE 29

'<u>TENTACULITES</u> AFF. <u>T</u>. <u>ATTENUATUS</u> HALL, 1885

Fig. 1. Specimen showing simple, regular annulations, and slender pointed tip.

<u>MESOCONULARIA</u> AFF. <u>M</u>. <u>FRAGILIS</u> (BARRANDE, 1867)

Fig. 2. Broken specimen showing transverse ribs deflected abaperturally and not interrupted by the corner grooves.

OCM 5

Fig. 1 ×4

OCM 6

Fig. 2 ×3

PLATE 30a

PELECYPODICHNUS ANTICOSTIANA (TWENHOFEL, 1928)

Fig. 1. Small podlike trace fossils usually about 1 cm long showing no surface markings or internal structure.

OCM 10

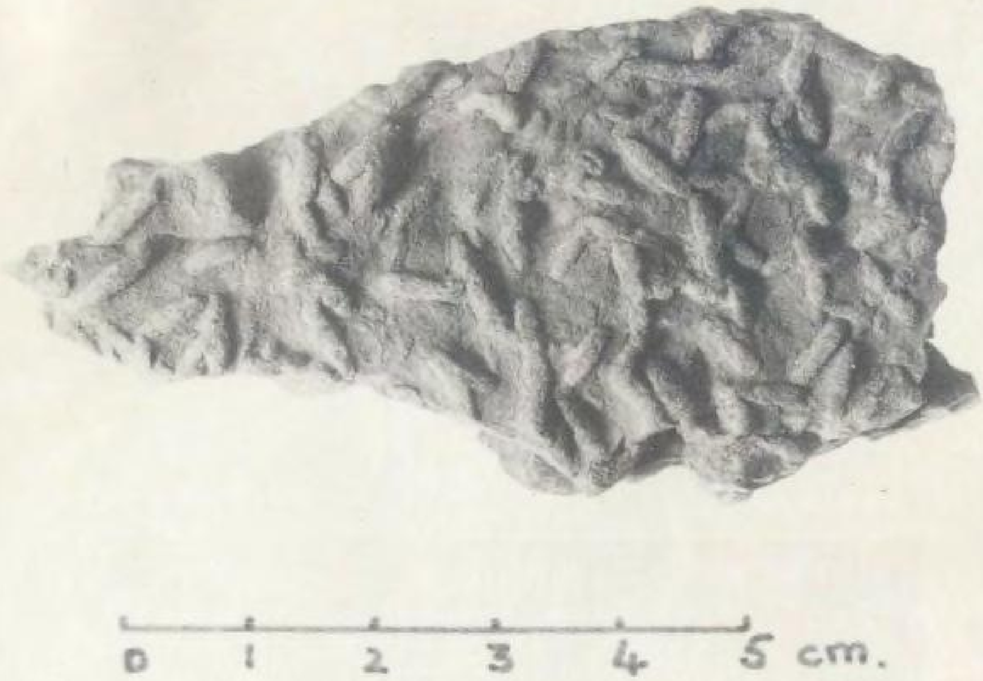



Fig. 1

# PLATE 30b

## FISH REMAINS

Fig. 1. Portion of body of fish showing covering of diamond-shaped plates.

Fig. 2. Large, suboval fish plate.

OCM 7

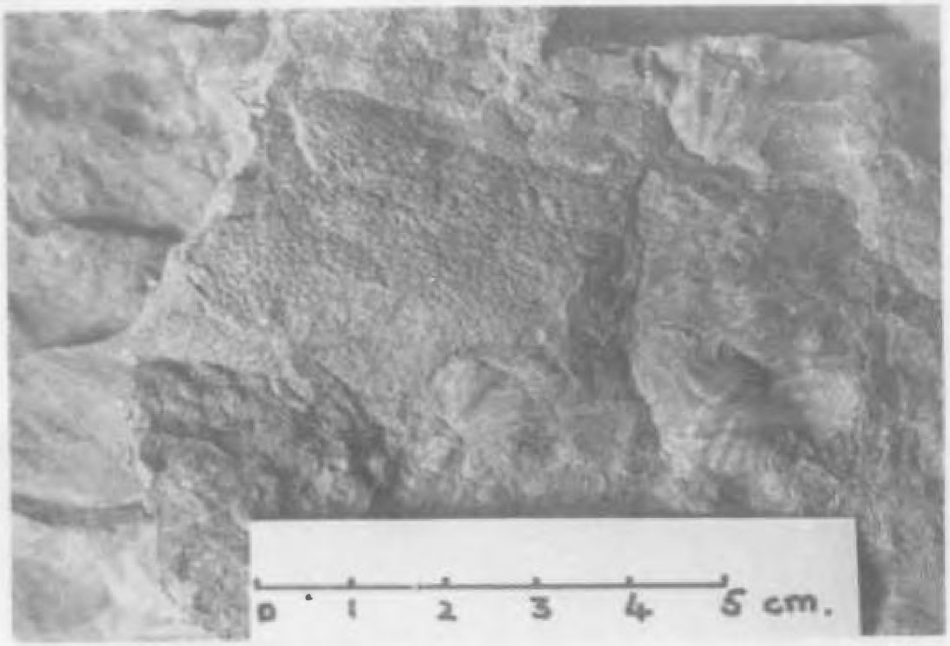



Fig. 1

OCM 8

×2

Fig. 2

PLATE 31

ALGAL MOUND AND PLANT FRAGMENT

Fig. 1. Small dome-shaped algal mound with pustulose surface.

Fig. 2. Plant fragment preserved as a carbonaceous film.

Fig. 1

OCM 9

x 4

Fig. 2

# CHAPTER 6

# DISCUSSION

## Distribution and relationship of the Long Point and Clam Bank Formations

The most recent interpretation of the geology of the area is that of Rodgers (1965) who made brief visits to the west coast of the Port au Port Peninsula in the summers of 1963 and 1964. His map (see Fig. 3, Ch.1) shows the Clam Bank Formation as underlying two narrow coastal strips, north and south, respectively, of Lourdes Cove, with the intervening stretch, in the cove itself, occupied by rocks of the Long Point Formation, which also border the Clam Bank outcrops on their landward side. The northern strip extends from the northeastern corner of Lourdes Cove to Misty Point, and the southern, from the southwestern corner of Lourdes Cove to just north of Salmon Cove; these strips are hereafter referred to as the northern and southern outcrops.

The northern outcrop consists of some 250 feet of almost unfossiliferous red, maroon, and brown conglomerates and sandstones with subordinate red, and, less commonly, green shales that enclose occasional lenses of limy sandstone. The southern outcrop is made up of generally fossiliferous grey-green limestones (often sandy or muddy), shales, siltstones and sandstones, and, at the top and the bottom of the stratigraphic succession, unfossiliferous red-beds which are mainly sandstones. However, the red sandstones at the top of the succession are particularly coarse and include conglomeratic layers; red shales and sandstones also occur as intercalations in the main part of the succession. The total thickness of strata represented in the southern outcrop is 1,365 feet. It is evident that the northern sequence is dominated by red-beds, and that comparable beds are only present at the top, and, to a lesser extent, at the bottom of the southern sequence.

Previous workers have assumed that because the apparently similar red-beds of the northern and southern outcrops have more or less the same strike and are only separated from one another by a short distance, as well as being bordered to landward by Long Point strata, that they belong to the same sequence, i.e. the Clam Bank Formation. The distribution of rocks attributed to the Clam Bank Formation, almost as shown on Rodgers' (1965) map, has, in fact, been accepted since Schuchert and Dunbar (1934) first studied them in some detail, but whereas earlier workers considered the northern outcrop to represent either the uppermost or lowermost part of the Clam Bank sequence, Rodgers (1965) suggested that it is equivalent to the whole of the succession present in the southern outcrop. Thus, according to Rodgers (1965), "if a single large cross-fault is postulated just north of Clam Bank (Lourdes) Cove" (to explain the offset to the east of the northern outcrop in relation to the southern), " then the entire sequence beyond can be explained as a redder and coarser version of the sequence southwest of the cove", and "the pockets of limy sandstone with large shells seen at Winterhouse .... represent all that is left of the zone of fossil limestone" of the southern outcrop. It should be noted that Rodgers (1965) did not observe a fault in the place suggested and neither, apparently, did he collect or identify the large shells seen at Winterhouse. While a fault is necessary to explain the offset of the northern outcrop in relation to the southern, although it need not be just north of Lourdes Cove, a reduction in thickness of the Clam Bank succession from 1,365 feet to 250 feet over a distance of a few hundred yards seems unlikely, particularly in view of the fact that the greater part of the thicker, southern sequence does not consist of red-beds. Assuming, however, for the time-being, that such a drastic reduction in thickness is possible, and that the two sequences are stratigraphically equivalent and, therefore, of the same age, i.e. the late-Silurian age (see below) of the undoubted Clam Bank strata of the southern outcrop, then the Clam Bank Formation would have to have either an unconformable or a faulted contact with the Long Point Formation, because the latter is of Middle Ordovician age. Rodgers (1965) did not observe the contact but he thought that the red colour of the rocks of the uppermost part of the Long Point Formation hinted at a gradation, which implies that the Clam Bank Formation overlies the Long Point Formation conformably. This is clearly impossible because of the difference in their ages - sediments representing the Upper Ordovician and the greater part of the Silurian are missing. It is obvious that as far as the southern outcrop is concerned, a gradation cannot exist, but it is still possible for the beds of the northern outcrop to conformably succeed the Long Point strata provided that they are not of Clam Bank age. It follows that if the red-beds north of Lourdes Cove are not of Clam Bank age, they are unrelated to either part or all of the southern sequence of undoubted Clam Bank strata. Furthermore, if the red-beds of the northern outcrop grade downwards into the Long Point Formation, they are only slightly younger than the uppermost Long Point strata and it seems reasonable to include them in the Long Point Formation. These conclusions are, of course, in part, theoretical since it has not been shown in the discussion up to this point that the red-beds of the northern outcrop are not of Clam Bank age, or that they grade downward into the Long Point succession. However, the same conclusions have been arrived at as a result of the writer's field and laboratory studies, and the evidence is presented below.

1. Just north of the stream seaward of the waterfall in the northeast corner of Lourdes Cove, there is a small headland which is underlain by coarse, non-calcareous red sandstones that are identical lithologically to sandstones in the cliff across the small bay to the north, on the "other side" of Rodger's (1965) postulated fault, and similar to red sandstones that crop out on the southwestern side of Lourdes Cove. The sandstones of these three localities are on the same strike, and it is evident that they belong to the same succession, and that no lateral movement has taken place between them. There is, then, no evidence for a fault in the position suggested by Rodgers (1965), which, in any case, appears to coincide with a covered interval in the cliffs. A careful search also failed to reveal the fault between the Long Point Formation and the beds of the northern outcrop that Schuchert and Dunbar (1934) claimed could be seen in the vicinity of the waterfall. A fault is still necessary, however, to explain the eastward shift of the Long Point strata in relation to those of the Clam Bank Formation south of Lourdes Cove because of their similar strike. This fault has been recognized at the southern end of the Cove (see 3 below).

2. A careful examination of the sequence of beds at the bottom of the waterfall, and on the small headland immediately north of it, indicates that there is a continuous transition (depositionally and lithologically) from grey-green, calcareous fossiliferous rocks through red, calcareous rocks to the red unfossiliferous clastics like those between Lourdes Cove and Misty Point. No indication of a disconformity, unconformity or fault was found. Since most of the fossiliferous beds referred to above are already recognized as belonging to the Long Point Formation, there is clearly a transitional sequence between the beds of the Long Point Formation and those formerly attributed to the Clam Bank Formation. Fossils discovered in red-beds above the level of those already included in the Long Point Formation indicate a Middle Ordovician age for the beds containing them. These beds have, therefore, been added to the Misty Cove Member which previously included red, fossiliferous beds in its uppermost part (see Table 8, Ch. 2). The addition of these beds to the Long Point Formation leaves some 217 feet of red-beds overlying the Misty Cove Member conformably, and the discovery of an Ordovician gastropod in the upper part of this sequence shows that these beds also belong to the Long Point Formation. The 217 feet of red-beds thus form the uppermost part of the Long Point Formation, and as they constitute a distinct stratigraphic unit, it has been

designated the Lourdes Member. The distribution of the Misty Cove Member and Lourdes Member is shown in Fig. 1.

3. In the southwest corner of Lourdes Cove, a short covered interval separates two outcrops of red sandstone. Those south of the covered interval strike seaward at N 30°E, and they are overlain conformably by shales containing late-Silurian fossils so that they are definitely associated with the Clam Bank Formation. The red sandstones north of the covered interval strike at N 50°E toward the headland on the north side of the cove, and as they are similar to the Long Point sandstones underlying the headland which now form part of the Misty Cove Member, they belong to the Long Point Formation. Thin section studies confirmed that the two sandstones are different from one another (for descriptions see Appendix at the end of this chapter).

The covered interval with sandstones of the Long Point and Clam Bank Formations on either side of it, evidently conceals the contact between the two formations. The absence of Clam Bank strata north of the covered interval, the shortness of the covered interval, and the difference in the strike of the beds on either side of it, indicate that the contact is a fault. A small valley which runs from the top of the cliffs, immediately above the covered interval, in a southwesterly direction towards the large ENE-WSW valley in front of Round Head, is believed to be a topographic expression of this fault because the low ridge of Long Point limestone which passes in an almost E–W direction through the community of Lourdes can only be traced as far as the valley. In the northern bank of the stream in this valley, shales containing Leperditia scalaris of Bed 6, Unit 2 of the Clam Bank Formation, crop out just across the road from Tucker's Barn (see Fig. 1).

The faulted junction between the Clam Bank and Long Point Formations thus follows a broad curve which becomes N 75°E before turning abruptly to N 97°E on the beach about a mile north of the community of Salmon Cove. The change in strike at the southern end of the outcrop of the Clam Bank Formation is believed to be due to another fault which cuts off the end of Round Head and also results in the reappearance of the lower members of the Long Point Formation further west along the coast at Three Rock Point.

The Clam Bank Formation is, therefore, in fault contact with the Long Point Formation, and possibly with the Table Head strata of Round Head. In fact the entire outcrop of the Clam Bank Formation (on land) appears to be fault bounded.

The age of the upper part of the Long Point Formation.

Weerasinghe (1970) concluded from his study of the fauna of the Long Point Formation that it was partly of Middle, and partly of Upper, Ordovician age. Riva (1969) found that the graptolite _Climacograptus spiniferous_, which is abundant throughout the Misty Cove Member, is indicative of the youngest strata of the Middle Ordovician. The calcareous alga, _Ischadites iowensis_, from the upper part of the Misty Cove Member, is characteristic of the Middle Ordovician in Eastern Canada and throughout the U.S.A. (Shimer and Shrock, 1955). Most of the limited number of brachiopod species collected from the upper part of the Long Point Formation have a fairly wide range, but taken as a whole, the brachiopod fauna is most like that found in the Cobourg and Sherman Falls beds of the Ottawa Formation of the Ottawa Valley of Ontario. which are thought to be of youngest Middle Ordovician age (Wilson, 1946). There seems little doubt from the foregoing that the upper part of the Long Point Formation is of youngest Middle Ordovician age (late Caradocian).

_The age of the Clam Bank Formation_

The Clam Bank strata were originally thought to belong to the Carboniferous (Murray, 1866; Howley, 1881) but subsequently Schuchert and Dunbar (1934) assigned these beds to the Lower Devonian because the fossils they collected included "a _Spirifer_ more like a Devonian than a Silurian form" and a single specimen (since lost) of _Camarocrinus_ (the root of the crinoid _Scyphocrinus_). The

Silurian/Devonian boundary has been redefined since the time of Schuchert and Dunbar, and Camarocrinus is now an index fossil for the Pridolian Series (= Downtonian in part) of the Upper Silurian (Berry and Boucot, 1970). Unfortunately, neither Camarocrinus nor graptolites of Pridoli age were found by the writer but a few specimens of the ostracode Kloedenia deckerensis were found which are normally indicative of a Pridoli or Devonian age. The fauna as a whole indicates that the Clam Bank Formation is of Pridoli age. Several authors have compared the Clam Bank Formation with the Helderberg Limestone of New York, and also with the Decker Limestone of New Jersey and eastern New York (Berry and Boucot, 1970), but it appears to be closest in its fauna, faunal range and associations to the Moydart and Stonehouse Formations of Arisaig, Nova Scotia, described by McLearn in 1924; the parts of these formations which correspond to the Clam Bank Formation are also of Pridolian age.

# APPENDIX

## Description of red-beds in southwest corner of Lourdes Cove

### a) Long Point Formation

These arkosic sandstones contain little or no calcite, but abundant quartz and plagioclase, microcline and a few grains of quartz intergrown with feldspar, which have the twinning of the feldspar at 90° to the lines of intergrown quartz giving an almost plaid effect when examined in polarised light. The cement of the sandstones is mostly haematite. The grains are moderately well sorted and become more angular towards the top of the beds as the size of the grains decreases. The lowest part of these graded beds is a conglomerate with clasts from 1" - 3" in diameter, whilst the highest part of this outcrop is a medium to coarse-grained sandstone. The colour of the rock is due to the cement.

### b) Clam Bank Formation

These calcareous sandstones are composed predominantly of quartz grains, each of which has a haematite skin. They contain quite a high, but variable, proportion of rock fragments and grains of iron minerals. The grains, which are very well rounded and well sorted, are fine to medium size, and the sandstones are cemented with calcite. The colour of the rock is mainly due to the haematite skins on the quartz grains.

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