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ABSTRACT

THE STRATIGRAPHY OF THE WINDSOR GROUP IN THE ANTIGONISH QUADRANGLES AND THE MAHONE BAY - ST. MARGARET BAY AREA, NOVA SCOTIA

by

Nathaniel McLean Sage Jr.

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Submitted to the Department of Geology and Geophysics on May 18, 1953 in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

This study of two map-areas in Nova Scotia shows that the uppermost beds of the Windsor Group, of Mississippian age, may be correlated with the D_2 and D_y faunal zones of the British Upper Viséan. This correlation is based upon the identification of a reef-coral fauna in the Mahone Bay area, and upon the presence of a zone of Gigantoproductus which immediately overlies the reef-coral fauna.

Examination of the foraminifers in these same Upper Windsor beds shows that the Upper Windsor E subzone, including the Gigantoproductus and reef-coral faunas, may be correlated with the mid-Chesteran beds of the Type Chesteran of Mississippian age in the United States. A large foraminiferal fauna is present in the E subzone. The endothyrid population and forms of Millerella from these beds agree favorably with species found in the Paint Creek formation and the Glen Dean limestone of the Type Chesteran.

The Antigonish area was part of an elongate, down-sinking basin in the Carboniferous Period and received from 17,500 to 20,000 feet of terrestrial, marine, and evaporite sediments during this time. The structural basin occupied the southern and lower-western margin of a larger horse-shoe-shaped area, which was open to the north. During the Carboniferous period, tectonic forces acted

as if to close the tips of the area and produced faulting and folding along the southern and western margins. The structural axes of these faults and folds swing from a north-east direction along the western map margin to a north-west direction on the eastern map margin. Block faulting of the basement rocks initiated the downwarping of the Antigonish basin, and much of the detritus which was dumped into the basin during the Carboniferous Period was derived from uplifted fault blocks.

Two distinct facies of sediments are present in the two map-areas. Windsor beds in the Antigonish Quadrangles were deposited in an enclosed shallow sea, which from time to time was cut off from the ocean. During these periods of isolation, life within the Windsor sea was killed off and gypsum beds and a single salt bed were laid down. Faunal and stratigraphic study of the Antigonish area shows that although this area is closely correlated with the Windsor Type Area at Windsor, Nova Scotia, and probably connected with it for much of Windsor time, the Antigonish area was further away from the entrance to the Windsor sea than was the type area. Tectonic events occurred within the Antigonish area which did not effect the Type Area.

The Mahone Bay - St. Margaret Bay facies of the Windsor Group indicates that marine waters covered this area at least twice, during B and E subzone times, and that the area became more shallow in late Upper Windsor, eventually shoaling to a lagoonal stage, when brackish water killed off the last marine forms. Although this area is typically marine in most respects, some remnants of gypsum beds are found, and presumably this area was lagoonal at other times during Windsor times although marginal to an open ocean. The Mahone Bay - St. Margaret Bay area may have been the entrance to the more interior Windsor sea; however, the lack of C and D subzone fossils indicates that it probably was not the actual entrance to the Windsor sea.

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(1951)

SUBMITTED IN PARTIAL FULFILLMENT OF THE
REQUIREMENTS FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY

at the

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
(1953)

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May 18, 1953

Certified by ______________________________
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Chairman, Departmental Committee on Graduate Students

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CHAPTER I

INTRODUCTION

PURPOSE OF STUDY

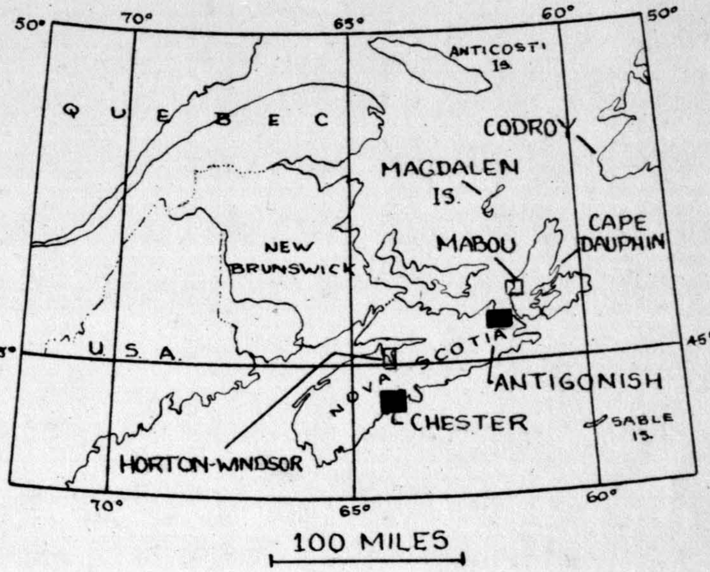
This paper is chiefly concerned with a detailed study of the Windsor Group, of Upper Mississippian age, in the two map areas: one, the Antigonish basin, where study was confined entirely to the exposures in the East and West Antigonish Quadrangles, and two, the Mahone Bay - St. Margaret Bay area on the south shore of Nova Scotia. The main emphasis was to have been the fauna of the outcrops in these two areas, and from such a study, to reexamine Bell's (1948, p. 39) thesis that the Windsor exposures along the south shore of Nova Scotia (the Mahone Bay - St. Margaret Bay area) are more typically marine than other Windsor exposures, and that this area might represent the actual inlet into the Windsor seas from the Atlantic. To accomplish this purpose, it has been necessary to unravel the stratigraphy and structure of the two areas, and, although of secondary importance originally, this work now has received equal weight with the faunal study. Lastly, comparisons are made within the Windsor Group with the Windsor Type Section, at Windsor Nova Scotia, and with other Windsor exposures described on Cape Breton Island, the Magdalen Islands, and in the St. George Bay area, Newfoundland.

LOCATION AND AREA

The map on the following page, Location of Map Areas, shows the location of the areas studied for this paper as solid black squares. Other Windsor areas with which they are compared are shown, and it can be readily seen that all these Windsor areas lie along a north-east trend.

The Antigonish area lies along the southern margin of George Bay, on the north-east shore of the mainland of Nova Scotia. The only large town in this area is Antigonish, which lies just within the western margin. The

LOCATION OF MAP AREAS



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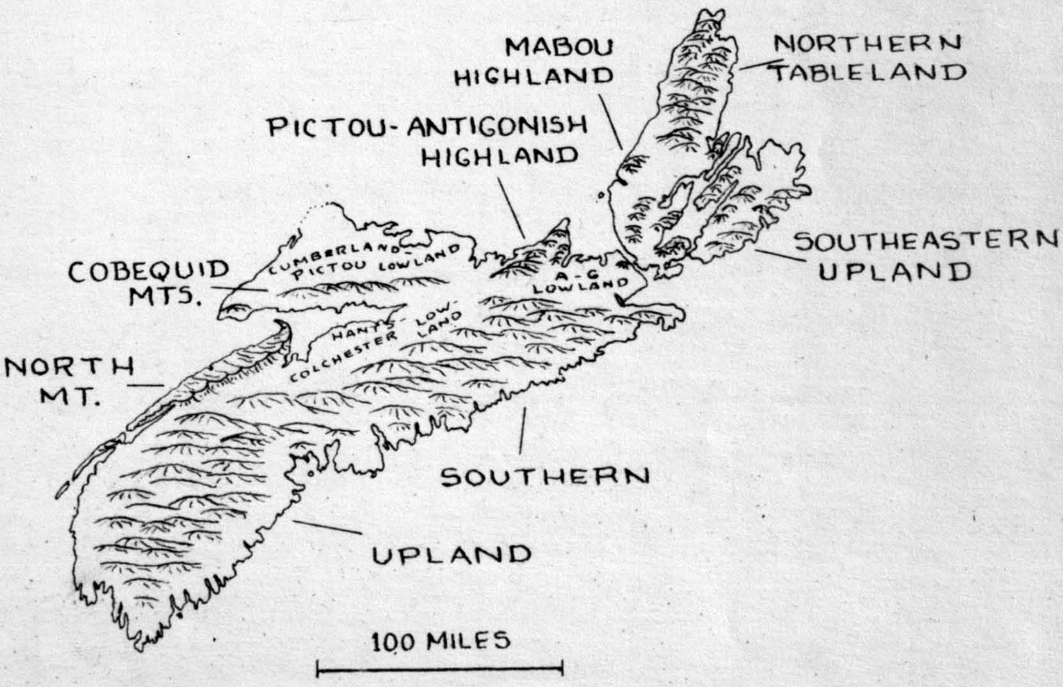


Figure 1

remainder of the map-area contains many small towns, is well traversed by good dirt roads, is crossed by the Sydney Branch of the Canadian National Railroad, and is readily accessible for field examination.

The Mahone Bay - St. Margaret Bay area includes the two large bays, as in the title, and the more widely known towns of Chester and Lunenburg. The name Chester has been purposely omitted from the title of the paper because of the possible confusion arising from the Upper Mississippian Epoch name. This area is simply two large bays, filled with islands, and surrounded by a divided community of year-round farmers and fishermen, and summer visitors. The roads are good, and transportation to areas of Windsor exposures is simple, with the exception of the many islands in Mahone Bay. And although these same islands do not show Windsor outcrops, they do contain with few exceptions, all the fossils of Windsor age coming from this region. Boat rental from Chester, Indian Point and Mahone Bay is not only reasonable, but the boat trip extremely pleasant.

The other areas shown on the location map are described in the following paragraphs.

PREVIOUS WORK

Early studies of the geology of Nova Scotia have already been well outlined by Bell (1929, p. 3-11) and are not further discussed here. These studies include work on a wide front and of a general nature by such men as Francis Alger, A. Gesner, Sir Charles Lyell, Sir William Logan, and Sir J. William Dawson. Their findings were reported at home, outside of Nova Scotia, and they were in turn followed by the specialists from abroad, C. F. Hartt, T. Davidson, and Charles Schuchert working on the brachiopods of the Windsor Group, R. Ruedemann, L. M. Lambe, and J. W. Beede, and others, each working on some detailed problem of Nova Scotian geology. R. A. Daly made the first intensive study of the physiography. More recently, additional work has been done by J. W. Goldthwait and Douglas W. Johnson. And working along contemporaneously with the more famous visiting geologists were the two mainstays of Acadian Geology, Hugh Fletcher, who mapped 65 quadrangles in Nova Scotia during his lifetime (Brock, 1910, p. 1), including the Antigonish Quadrangles of this report, and E. R. Faribault, whose work included the Mahone Bay - St. Margaret Bay area.

The findings of these early workers, and others, as they apply to the two map areas will be discussed separately. Those papers which deal strictly with the stratigraphy and faunal relationships of the Windsor Group will follow.

ANTIGONISH QUADRANGLES

Knowledge of the general geology of this area may be said to have begun with Fletcher (1887, including detailed maps), who mapped the region in detail, and indicated outcrop locations and accurate stream and road locations. Fletcher mapped all Carboniferous beds from the Windsor up as a single unit, and the underlying Horton beds as two distinct formations. Those along the north-west margin of the map he correctly called Carboniferous conglomerate, but those along the southern margin of the map he mapped as Devonian. This was seemingly a lithological division, since the north-west Horton exposures are poorly cemented, coarse sandstones and conglomerates for the most part, and the beds along the southern margin are fine-grained, and well indurated, even showing an incipient cleavage in some exposures. Fletcher paid little attention to fossils, but he should not be criticised for this neglect here, for the Horton is unfossiliferous in the area mapped.

Fletcher studied in some detail the rocks of Cambro-Silurian (Ordovician) age belonging to what is now called the Brown's Mountain Group, and was able to differentiate three mappable units therein; the lower flinty slates and quartzites (Jame's River fm.), and the uppermost red and gray sandstones, grit and conglomerate (Malignant Cove fm.). Although not differentiated or measured, these formations can be distinguished and separated in the Sugarloaf Mountain and ridge running north-eastward towards Crystal Cliffs. The James River formation comprises almost two thirds of the western margin of this Ordovician outlier, and the remainder is about evenly divided between the Baxter's Brook and the Malignant Cove fm. The entire block has been rotated eastward, and the beds generally dip eastward, although locally much disturbed.

M. Y. Williams (1914) made a detailed and now well-known report on the Arisaig-Antigonish district. To Williams goes the credit for definitely establishing the age of the Brown's Mt. Group, and for the name of the group, and the name Malignant Cove fm. The other two names of the Brown's Mt. Group were proposed by Fletcher. The Lower Mississippian rocks were called the McAras Brook fm. by Williams, and the Upper Mississippian the Ardness fm., and these same beds today are correlated with the Horton Group and the Windsor Group, respectively. In the Sugarloaf region, north of Antigonish, Williams mapped several small diabase outcrops, and also made petrographic studies of these and other pre-Mississippian igneous rocks in the map area.

Goldthwait (1924) divided the Antigonish Quadrangles into two physiographic provinces; an outlier of the Pictou-Antigonish Highland, which is made of resistant rocks of the Brown's Mountain Group, and the Antigonish-Guysboro Lowland, comprising the Carboniferous rocks. The highland Area is 760 feet in maximum elevation, and the lowland area gains in elevation southward, reaching a maximum elevation along the southern map-margin of about 500 feet. The massive ridge of Brown's Mt. Group rocks played an important part in the structural development of the Antigonish basin.

For other references on the geology of the Antigonish Quadrangles it is necessary to turn to the work of students attending the Nova Scotia Centre for Geological Sciences. Many of these papers are S. B. or S.M. theses for M.I.T. Alderman (1948) measured the Horton section exposed along Ogden Brook, directly behind Crystal Cliffs, and Decker (1948) made a study of this same Group northward along the east coast of Cape George. Their work is discussed under Horton Stratigraphy. Puech (1949) studied the Mississippian contacts along the west edge of the Antigonish Quadrangles and showed that the Horton Group is in a fault contact with the underlying Brown's Mt. Group, and that the Windsor Group overlies the Horton with an angular unconformity along this same map margin. Locally a sharpstone conglomerate, made up of Brown's Mt. Group pebbles, separates the two Mississippian Groups. Sage (1951) worked out the structural geology of the western portion of the map area, and the conclusions are summarized in Chapter III. The Canso Group beds, admirably, but incompletely exposed in the Pomquet River, have been measured in detail by both Wetzel (1952) and Sims (1951).

Lastly, two exploration groups have made reports upon the geology of the Antigonish area. Pohl (1930) investigated the Potash possibilities of the region, mapped the salt springs, and generalized on the geology. And more recently, the Nova Scotia Government has carried out an intensive program in its search for salt and limestone. This program was carried out under the geological advice of Dr. Donald J. MacNeil, of Antigonish, and included the drilling of several holes, which reached a salt body. The drills exposed a surprisingly thick shale and gypsum section. A geophysical survey of a limited area was made and reported on by Pohly (1952). Results of this recent survey are summarized in Chapter III.

Only a few fossils are reported from Windsor beds in the early literature. Fletcher (1887, p. 17) reports Leperditia okeni, Cyrtoceras, Conularia, and Dentalium from the limestones capping the Williams Point intrusive body. What the nature of the Leperditia and Dentalium were is not known. Possibly specimens of the genus Paraparchites are the ostracod which Fletcher reported; no Dentalium-like fossil has been noted in this area. The Cyrtoceras reported may have been a specimen of Stoloceras, known from the type area at Windsor (Bell, 1929) but not so far identified in the Antigonish area, or Fletcher may have mistaken the numerous Spirorbis for a small Cyrtoceras; certainly they are common in this bed, and incomplete specimens suggest a small cyrtocone. Numerous specimens of Conularia planicostata have been found in this limestone, which is identified as being in the B subzone of Bell (1929), and the B_1 limestone of Stacy (1952) and this report.

Both Dawson (1889), and Pohl (1930) report fossils from the Antigonish Quadrangles, but the locations are not known, although similar fossils are listed later in this paper. Honeyman (1879) reported the finding of a Phillipsia, a trilobite, from the Antigonish environs, but this seems to have been from one of the limestones in the Ohio region, southwest of the town of Antigonish. The exact location is not known, but the finding is of interest since no Phillipsia have been found elsewhere in the county of Antigonish.

MAHONE BAY - ST. MARGARET BAY AREA

Study of the geology of this area has been confined largely to the rocks underlying the Windsor Group, namely the Meguma Series, and a large granite body which represents much of the rock exposed in the map area. The Meguma Series includes rocks of unproven age, either late pre-Cambrian or Cambrian age, and is divided into the lower Goldenville formation, a gray to olive quartzite, and the upper Halifax formation, which is a dark slate, displaying excellent axial plane cleavage throughout the area. Two Gold Mining areas lie within the map area on the Gold River anticline and on the Blockhouse anticline.

Intruding the Meguma Series is a large mass of granite, of Devonian age, and upon the surface afforded by these two bodies of rock the Windsor Group was deposited unconformably. No Horton Group rocks are known in this area.

E. Rudolphe Faribault mapped most of this area, and was responsible for the compilation of data to make up four geological maps which essentially cover the area as shown in this thesis. These maps were issued by the Geological Survey of Canada as shown: St. Margaret Bay, No. 71 (1908), Aspotogan, No. 70, (1908) Chester Basin, No. 87 (1924), and Mahone Bay, No. 88 (1929) All are on a scale of 1 mile to the inch, and it is these maps which provided the basis for the study of this Windsor region. Numerous short references are made to this area by Faribault in the Summary Report of the Geological Survey of Canada.

In 1907 (p. 78-80) Faribault mentioned the very heavy glacial drift in the area, and the fact that the only gypsum exposed was on Sheep Island; he also reported boulders of shell limestone on Goat Island, Sheep Island, and on the southern tip of Stephen Island (later mapped as Rouse Island). In 1908 (p. 155) he noted the numerous sink holes along the east shore of Chester Basin and along Middle River, pointing out that two had undergone movement recent enough to have been seen by inhabitants of the region. In 1909 (p. 235-236) he states that there are no outcrops along the second Peninsula, but that the many blocks of shell limestone found there must surely indicate the boundary of the Lower Carboniferous basin. Here also he gives the paleontological report of Lambe, who identified _Lithostrotion caespitosum_ Martin, _Dielasma Sacculus_ Martin, and a many large specimens of *Productus cora* D'Orbigny, the latter coming from Goat, Sheep, and Stevens Islands and from the south side of Deep Cove and the north shore of the Second Peninsula.

Faribault in 1909 (p. 239) mentions the old limekiln operated by the French on the west end of the Second Peninsula, indicating that this surely meant a limestone outcrop. A similar limekiln found by the writer on the south shore of Weihnacht Cove was investigated carefully, and although lying on an area which is mapped as Windsor, the limestone was not locally derived for this kiln. The older inhabitants all agreed that the limestone was brought in by ship from the quarries near Goat Lake in East Chester, or from the quarries near East River. This seems to have been no problem in the old days, for shipping and fishing was one of the larger industries, and also indicates that the mere presence of a lime kiln in this coastal area does not prove the presence of limestone outcrops in the immediate vicinity.

In 1911 (p. 340) Faribault examined the notorious Oak Island, where Captain Kidd's treasure is supposed to lie buried. At this time digging had been going on for "the last 60 years", and Faribault mentioned that several hundred thousands of dollars had already been spent in this futile search. He thought that the original depressions which encouraged the search for this treasure must have been sink holes. The writer agrees with this view. A good deal of fancy has been written about Oak Island, particularly in the Sunday newspapers, but little of fact, and nothing so far as is known of a geological nature.

Goldthwait (1924) included the Chester Basin - Mahone Bay region in his study of the Physiography of Nova Scotia, and included a drumlin map of the area. The map in this thesis shows more drumlins, but was made with the additional help of airplane photos. The maps are essentially in agreement, but no attempt has been made in this report to settle differences. Several excellent photographs are shown by Goldthwait, and the cliffing action of the waves at the base of the drumlins is well shown. The writer believes that it is through just such an action that many of the limestone boulders of Windsor age have been concentrated peripheral to many of the islands in Mahone Bay.

Bell (1948, p. 39) has expressed dissatisfaction with the theory that the Windsor sea entered the Windsor basins from the north, either across Newfoundland or through the Cabot Straits, separating Newfoundland and Cape Breton Island. He points out the scarcity of limestone in the Sydney area as compared with the Windsor area, the increase in bryozoans, brachiopods and cup corals in the Windsor area, and the more marine aspect of this more southern Windsor exposure, and points out that this suggests a more southerly entrance for the Windsor seas. He further gives two reasons for not accepting the Bay of Fundy as a southerly entrance for the Windsor seas; one, that New Brunswick exposures are largely Lower Windsor in age, and two, that the Mahone Bay- and St. Margaret Bay exposures have the most marine look about them of any Windsor beds, and are difficult to explain as an outlier to a westerly Windsor Sea. He has concluded that the Windsor sea entered the Windsor basins through the Mahone Bay - St. Margaret Bay area, and retreated through the same area.

The only fossils known from the Windsor in this south-shore map area are those mentioned by Faribault as having been identified by Lambe, and several reported to the writer by Dr. W. A. Bell (private correspondence). These last included species of Corwenia and Lithostrotion, and Gigantoproductus, which had been collected by Dr. Bell personally on Goat Island, with the identifications of the two corals being somewhat tentative.

Returning to the Canadian Geological Survey maps of this region, several errors should be cleared up. The errors do not appear to be Faribault's, for he has clearly stated that no outcrops occur in the immediate vicinity of southeastern Mahone Bay. These map errors show limestone outcrops on Mason Island, Lucy Island, the Second Peninsula, and a host of other islands in the bay, as well as a large area of limestone immediately north of Chester Basin. The writer visited every island in Mahone Bay marked as Windsor on the G.G.S. maps, as well as all mainland areas of reported Windsor outcrop. Only three islands show possible outcrops, namely shales on Sheep Island and gypsum on Goat Island and Graves Island, but nowhere on the islands is limestone exposed as bed rock. The large area just north of Chester Basin which is mapped as Windsor Limestone, is in fact Goldenville quartzite, and only a small single outcrop of limestone is present in this area, immediately behind the garage on the Chester Basin main street, where incidentally, it is completely unfossiliferous. The source of Windsor boulders is admittedly close to the many drumlin islands which dot Mahone Bay. Details on the many small Windsor patches around these bays are presented under a later chapter dealing with the geology of this Bay region.

WINDSOR STRATIGRAPHY

A detailed report on the early attempts to work out the succession of Windsor beds is given by Bell (1929); indeed, present knowledge of Windsor stratigraphy depends largely upon Bell's work in the Windsor District. In this badly deformed area, Bell was able to work out five faunal subzones for the Windsor Group. Characteristic faunal assemblages for each subzone were worked out (p. 66-68), and the fauna of single key limestone beds given in detail. Based upon exposures in the type area, one or two fossils appear to be quite characteristic of certain faunal zones, in particular, Martinia galatea is present only in the Upper Windsor, the E, D, and C subzones (descending the section), and is reasonably common throughout this sequence. In the Lower Windsor, species of Composita, particularly Composita dawsoni, are common and widespread. Martinia is confined exclusively to the Upper

Windsor, and although some species of Composita are found in the Upper Windsor, C. dawsoni is not, and the other forms are only found sparingly, or with abundant other diagnostic Windsor fossils. At least two more characteristic forms are assigned to each sub-zone by Bell for the type area.

It is of interest to note here that Martinia galatea is the most abundant Upper Windsor fossil in the Antigonish Quadrangles, and that C. dawsoni is likewise common for the Lower Windsor. In the Mahone Bay - St. Margaret Bay area, only one specimen of Composita dawsoni was noted by the writer, although Lower Windsor outcrops and boulders were identified. Martinia galatea is not as common as in the Antigonish region, but many specimens were identified here. Of the other 15 fossils listed as characteristic of the Upper Windsor, only four are known from the Antigonish Quadrangles and five from the southern map area. Of the five species characteristic of the Lower Windsor at the type area, not including Composita dawsoni, only two are known in the Antigonish area, one of which, Diodoceras avonensis, occurs not where it does in the type area, but in the Upper Windsor. Of those same five characteristic Lower Windsor fossils, only two are known in the Mahone Bay region. From this it is apparent that more weight should be placed upon faunal assemblages than on any single characteristic fossil.

Preceding Bell's work by nineteen years, is the report by Beede (1910) on the Carbonic Fauna of the Magdalen Islands. Stratigraphic measurements are not given, and a geologic column cannot be determined from Beede's paper. Faunal descriptions are detailed and these beds are of Windsor Age. It is also probable that the four highest faunal subzones, B - E, are represented in these Island exposures. Since the A subzone is reasonably unfossiliferous everywhere in the Windsor province, its presence or absence is not known on the Magdalen Islands.

In 1935, Norman reported upon the Lake Ainslie Map-area, on Cape Breton Island, which includes the Mabou area shown on Figure 1, the location map. Several stratigraphic sections of the Windsor Group were measured and fossil occurrences were reported. The Hood Island section isof particular interest because it was the key used by the writer to decipher the Antigonish Quadrangle stratigraphy. Stacy and the writer measured the Hood Island section together, and so agree with each other but not with Norman as to sequence and thickness. Several pictures of the Hood Island section are shown by Norman, one of the G_3 limestone horizon (Norman, 1935, p. 38), but the negative was unfortunately reversed, showing the algal clubs on the upper side of the bed, whereas they actually lie on the lower side of the bed.

Stacy's work (1952) carries on southward, where Norman left off. Several Windsor sections were carefully mapped, and faunal occurrences listed by subzone. Three of Stacy's sections are plotted on Figure 11, (Geologic Sections of the Windsor Group,) of this thesis.

Finally, Bell's paper on the early Carboniferous strata of St. Georges Bay Area, Newfoundland, is considered for the light it throws upon the Codroy series. Bell, (1948, p. 36-37) correlated this series with the Windsor Group, and his detailed measurements indicate an extraordinarily thick fluviatile section in this region. The great thickness of terrestrial conglomerates, grits, sandstone and siltstone, represent the coarsest Windsor section yet studied. In spite of this thick terrestrial sequence, marine beds are found throughout the section, with every indication that each faunal subzone of the Windsor area is represented in the south-eastern Newfoundland area.

To summarise these Windsor sections, thirteen have been plotted to scale in Figure 11, of this report. Stacy's sections from Cape Breton

Island were transferred directly, with only a change of scale altering them from their original form. The Windsor Type section has also been plotted to scale, but here the writer has made several modifications; for instance, limey shales are shown as sandstone or siltstone, and silty limestones are shown as pure limestones. The Maxner and Miller horizons, from the B subzone, are shown as separate beds, for reasons explained later, and two gaps in the type section have been closed. If salt was ever present in the type section, which seems likely, it presumably belongs close to, or within the large gypsum body immediately overlying the Miller limestone.

Even more liberties have been taken with the sections of the Codroy series. Here again, the gaps have been closed up, and everything placed in three groups, limestones, gypsum and clastics. Since large thicknesses are covered in the Codroy series, and since many faults were suspected by Bell (1948), many errors may have been introduced. Yet taking an average point of view, and neither attempting to seriously thin, or thick this section, it represents a thickness about ten-fold that of any other Windsor section, and as such is necessarily plotted on its own separate scale.

ACKNOWLEDGMENTS

Field expenses in the preparation of this thesis were provided by the Nova Scotia Research Foundation and the Nova Scotia Bureau of Mines. Funds for graduate study came largely from the United States Government through the Veteran's Training Program of the Veteran's Administration.

Professor Walter L. Whitehead gave the original and continued encouragement to the author in this work, andhas given valuable advice on all phases of the work. He also arranged untold hours of assistance from undergraduates at the M.I.T. Summer Geology Camp at Crystal Cliffs, Nova Scotia. Professor Robert R. Shrock has worked with the author in the field and has supervised the paleontological work. Professor Donald J. MacNeil has visited most of the critical outcrop areas in the field and has generously made available to the author drill hole data from the program of salt exploration recently carried out by the Nova Scotian Government. The collection of Windsor fossils in the Peabody Museum at Yale University were made accessible to the author, as was the collection of Gigantoproductus material in the National Museum in Washington, D. C.

Grateful acknowledgements are due the following persons for technical and field assistance: Dr. M. C. Stacy and Claude Hill for field assistance and discussions of Windsor problems; Dr. W. A. Bell for advice and correspondence on Windsor problems; Dr's. G. A. Cooper, L. G. Herbert, W. H. Easton, Helen Duncan and A. Boucot of the United States National Museum for suggestions and aid in identification of paleontological specimens; Dr. O. W. Bain for use of the facilities of the Pratt Museum at Amherst College and personal photographic equipment; the many students from the M. I. T. Summer Geology Camp for field assistance.

The author wishes to extend his thanks to the staffs of the Nova Scotia

Research Foundation and the Nova Scotia Bureau of Mines for their generous assistance and loans and gifts of aerial photographs and base maps.

Figured specimens of this thesis will be placed in the collections of the Nova Scotia Centre for Geological Sciences.

SUMMARY

The study of the Windsor faunas from the two map-areas shows two faunal groups which are useful in correlating the Windsor Group with Mississippian strata lying outside the Province of Nova Scotia and associated Maritime Provinces. In the Mahone Bay - St. Margaret Bay area, boulders of Windsor limestone are being concentrated by wave action peripheral to the drumlin- and drift-covered islands. These boulders contain a rich reef-coral fauna of E subzone, Upper Windsor age, and members of this fauna are similar to reef-corals from the D_2 and D_y zones of the Upper Visean of Great Britain.

A lowering of sea level in this southern map-area brought about shallow water and lagoonal conditions in upper E subzone times. These conditions proved unfavorable to the reef-corals but allowed the development of vast numbers of a large brachiopod, *Gigantoproductus* and a foraminiferal fauna. The *Gigantoproductus* is specifically different from other American, Asiatic and European members of this genus and seemingly this group may not be correlated on a generic basis. The Nova Scotian forms probably developed later than forms in other countries.

The foraminiferal fauna is present in both map areas and best developed in the Upper Windsor strata. This is a facies fauna, found in former areas of shallow waters and protected sites, with reef-corals or where protected by algal growths or islands in the Windsor seas. Oolitic beds are relatively free of these small animals. The Foraminifera of the Windsor Group are closely comparable to the fauna of the Lower Carboniferous limestones of Scotland, although the exact zone is not known, and the endothyrid members of this population are comparable to forms from the Chesteran Type section in the Miss-

issippian of the United States. Windsor E subzone forms most closely resemble United States Chesteran forms from the Paint Creek formation and from the Glen Dean limestone.

The Antigonish area was part of an elongate, down-sinking basin in the Carboniferous Period and received from 17,500 to 20,000 feet of terrestrial, marine and evaporite sediments during this time. The structural basin occupied the southern part of what is today called George Bay, and in Carboniferous times seemingly was similarly shaped, like a horse-shoe, and open to the north. During the Carboniferous Period, and principally after the deposition of the Carboniferous strata, tectonic forces acted as if to close the open, northern end of this basin and produced faulting and folding along the southern and western margins. The structural axes swing from a north-east direction along the western map margin to a north-west direction along the eastern map margin. Block faulting of the basement rocks initiated the downwarping of the Antigonish basin, and much of the detritus which was dumped into the basin during the Carboniferous Period was derived from uplifted fault blocks.

Two distinct facies of sediments are present in the two map-areas. Windsor beds in the Antigonish Quadrangles were deposited in an enclosed shallow sea, which from time to time was cut off from the ocean. During these periods of isolation, life within the Windsor sea was killed off and gypsum beds and a single salt bed were deposited.

The Antigonish basin extended during Windsor times to include the Hood Island area on Cape Breton Island. These two areas were connected for most of Windsor time although minor variations in the sequence of the beds and in faunal distribution indicate local warping of the sea floor or short breaks in the connection of the Windsor sea. This Antigonish - Hood Island sub-sea was connected with the waters at the type section at Windsor, Nova Scotia from time to time, if not throughout Windsor time, but does not contain as rich a fauna as the Windsor type section or as many limestone and limey beds. Increased terrestrial sediments and variable salinities over shoal and deep waters are thought to be the limiting factors for the Antigonish fauna.

The facies of the Windsor Group in the Mahone Bay - St. Margaret Bay area indicates that marine waters covered this area at least twice, in B and E subzone times, and that the area became more shallow in late Upper Windsor, eventually shoaling to a lagoonal stage, when brackish water killed off the last marine forms. Although this area is typically marine in most respects, some remnants of gypsum beds are found, and presumably this area was lagoonal at other times during Windsor time although marginal to an open sea, or ocean. The Mahone Bay - St. Margaret Bay area may have been the entrance to the more interior Windsor sea. The lack of C and D subzone fossils indicates that this area was not the actual entrance to the Windsor sea.

CHAPTER II

STRATIGRAPHY

Rocks present in the two map-areas of this thesis range in age from the Meguma series, of probable late pre-Cambrian age, to some rather young gravels, of probable tertiary age, which are cemented by limonite. These gravels overlie the peneplained Meguma surface in the Mahone Bay area, and appear to underlie the Pleistocene glacial deposits, which blanket that area. Lying between these extremes in age are beds of the Brown's Mt. Group of Ordovician age, several varieties of igneous rock, probably all Devonian in age in both map areas, and then the thick Carboniferous rocks, well developed in the Antigonish area, and including Horton, Windsor, Canso, and Pennsylvanian beds. In the Mahone Bay - St. Margaret Bay area only the Windsor Group is represented from the Carboniferous. The following table indicates the age relationships of the rocks found in both map areas:

AGE	Antigonish	Mahone Bay - St. Margaret Bay
Pleistocene	Glacial drift	Glacial drift
Tertiary (?)		Limonitic gravels
	Pictou Group (?)	
Pennsylvanian	Cumberland Group	
	Riversdale Group	
	Canso Group	
Mississippian	Windsor Group	Windsor Group
	Horton Group	
	Basic dikes and sills	
Devonian (Igneous)	Granite Diabase Grano-diorite	Granite
Ordovician	Brown's Mt. Group	
Pre-Cambrian (?)		Halifax formation Goldenville formation

The discussion of the stratigraphy is to be largely centered upon beds of Windsor age. Since measurements have been taken of other Carboniferous strata in the Antigonish area, these beds will be treated briefly. Lastly to be discussed are limonitic gravels which crop out in isolated patches in the Mahone Bay region.

HORTON GROUP

In the Antigonish Quadrangles two quite different facies are represented in the Horton rocks. Along the eastern and southern boundaries, the Horton beds consist of round-stone conglomerates with pebbles up to 4 inches in diameter, fine-grained sandstones, and siltstones, the latter predominantly maroon in color. These beds show well developed cross lamination, of a small scale, and typical of that which would be formed by streams or small rivers on a low gradient. They have been well cemented with quartz, and in places approach a true quartzite. Although a small intrusive body has cut the basal Windsor limestone just south of the map border, and at its western edge, the induration of this area of Horton rocks is thought to be due to regional metamorphism of a low grade.

Several excellent sections of Horton rocks are exposed along this south-east border. The writer measured one section along the upper end of the Pomquet River, beginning at the overturned, but conformable Windsor contact. 5,940 feet of red sandstones, conglomerates and siltstones were measured to a point where the dip became 12 degrees, and then the section was covered. A few isolated outcrops indicate at least 6,000 feet for this section, with possibly more hidden upstream or removed by erosion. In the Black Avon River just to the east, approximately 6,300 feet were measured before the section is covered. In this last stream the conglomeratic element in the Horton is more predominant, and the extra thickness may be accounted for by the coarser material. Neither of these figures should be accepted as a final, or maximum thickness for the Horton at these points, but rather as a minimum figure which may be increased with further field work. Other Horton sections are exposed in the upper portion of Afton River, in Monastery Brook, in Black River, and in Havre Boucher River. The Havre Boucher River exposures are folded and faulted, and no true Horton thickness can be determined in this river bed.

Ten exposures of the Windsor - Horton contact are visible along the south-east map boundary, and the bedding in half of them is overturned at the contact. Yet this contact is everywhere conformable so far as is known.

The Monastery Brook contact is buried deep in a pool of water but appears conformable. The general composition of these Horton beds is that of an arkose, but many of the beds are rather free of feldspar, and approach an orthoquartzite, with iron and manganese staining.

Along the north-western margin of the Antigonish Quadrangles the variations within the Horton Group are more extreme, and the cementing has taken place to a lesser degree. Two former M.I.T. students attending the Crystal Cliffs Centre for Geological Sciences during the summer geological session measured Horton sections west and north of Crystal Cliffs, and these must stand as a standard Horton section for the Antigonish area until something better turns up. Measuring along the Ogden Brook, Alderman (1948) measured 2,200 feet of basal Horton conglomerate, and 5,280 feet of Upper Horton interbedded sandstones and conglomerate. The basal conglomerates are unlike anything so far noted along the south-east map border. The boulders reach several feet in diameter, many being over 1 foot, and are complex petrologically. Granites, diabase, basalt, rhyolite, and chunks of the Brown's Mt. Group are included in the boulders and pebbles, and plainly were derived from the Pictou-Antigonish Highland, lying today some 10 to 15 miles to the west. The Upper Horton in this section more nearly resembles the south-west Horton exposures, but still is slightly coarser on the average. Alderman's section is entirely continental in character, representing the detritus washed out on an old alluvial fan.

Decker (1949) measured his Horton section from Gribbean Head to the north. Gribbean Head lies just north of the map area, and this section represents a facies found in some sections of the map area. Two marine shales are present in this section, which undoubtedly represents the fringe of the Horton alluvial fan, where it flattened out to swampy and then marine conditions.

Seven quite different and smaller sections of Horton beds are present in the north-west portion of the map-area. At MacIsaac Point, in well cores at Crystal Cliffs (water wells), and in two places in the North River region, isolated Horton sections can be correlated with Decker's section on the basis of lithology alone. In Rights River, and in Ogden Brook, just east of the Brown's Mt. metamorphic ridge, two isolated Horton sections can be correlated with Alderman's section. These correlations are shown in Figure 2, on the following page. This figure has been borrowed from an earlier paper (Sage, 1951). A seventh Horton section is present in the Big Marsh syncline in the very north-west corner of the map-area. Here about 90' of black fissile shale, bearing small fish scales, is present. It is near the top of the Horton section, and probably is equivalent to the uppermost marine shale of Decker's section. How far it lies below the basal Windsor limestone and conglomerate, which crop out in the Big Marsh syncline, just off the map, is not known.

WINDSOR GROUP

Thirteen Windsor sections are discussed briefly. Number 1 is the incomplete, and almost completely buried, Windsor section from the Mahone Bay - St. Margaret Bay region, and number 2 is Bell's type section at Windsor. Numbers 3 through 9 were measured by the writer within the Antigonish Quadrangles. Number 10 is the Hood Island section, measured jointly by Stacy and the writer, as well as by Norman. Sections 11 and 12, from Ragged Point and Cape Dauphin, Cape Breton Island, were measured and reported by Stacy (1952). Section 13 is the astonishing section measured and written up by Bell (1948). These were set out in this manner to give a general north-east, or structural trend to the sections, rather than a subzone by subzone approach to Windsor stratigraphy.

In the following sections, the numbering of limestone beds is that employed by Stacy (1952). Each bed in a single faunal subzone (as established by Bell (1929) in the type section,) bears the letter of that subzone, and

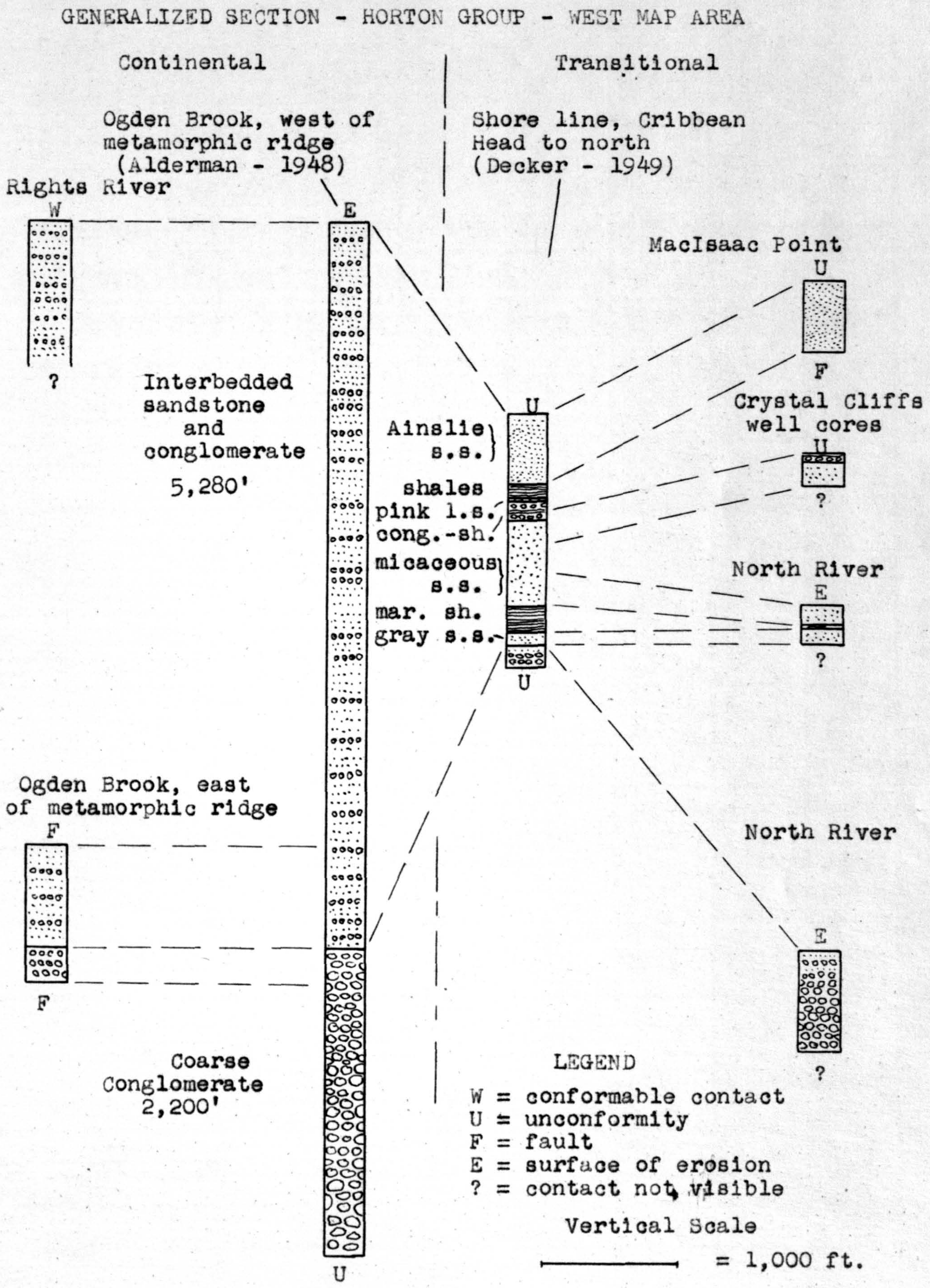

GENERALIZED SECTION - HORTON GROUP - WEST MAP AREA
Continental
Transitional
Ogden Brook, west of metamorphic ridge (Alderman - 1948)
Shore line, Cribbean Head to north (Decker - 1949)
Rights River
W
E
?
Interbedded sandstone and conglomerate
5,280'
MacIsaac Point
U
F
Crystal Cliffs well cores
U
?
Ainslie s.s.
shales
pink l.s.
cong.-sh.
micaceous s.s.
mar. sh.
gray s.s.
U
North River
E
?
Ogden Brook, east of metamorphic ridge
F
F
North River
E
?
Coarse Conglomerate
2,200'
U
LEGEND
W = conformable contact
U = unconformity
F = fault
E = surface of erosion
? = contact not visible
Vertical Scale
= 1,000 ft.

Figure 2

is numbered within the subzone in ascending order, with A_1 being the basal Windsor limestone. Only the limestone horizons have been correlated in this paper, although it will be obvious from examination of figure 11 that many gypsum and siltstone horizons can also be correlated from one section to another. Lower case letters for each bed in a section have no correlation significance from one section to another, but are simply used for discussion purposes within a single section.

The limestone horizons so far identified in the Cape Breton to Antigonish region are listed below, being taken from Norman (1935), Sage (1951), and Stacy (1952), and the assignment to faunal subzones is taken from Stacy's paper:

Subzone	Number	Name in Antigonish Area
E	E_1	Schizodus
D	D_3	No name
	D_2	No name
	D_1	Giant Ripple
C	C_3	Columnar algal
	C_2	No name
	C_1	Small algal
B	B_3	1st. oolitic
	B_2	2nd. oolitic
	B_1	Quarry
A	A_2	Canary (unfossiliferous)
	A_1	Basal, ribbon, "sandy-lamey"

This sequence of beds is correct for limestone beds in the Antigonish area, and from the fossils found, the correlation with the Windsor type section is correct. The only questionable bed is the A_2, or Canary limestone, which does not yield fossils in the Antigonish or Cape Breton regions. Based on the possibility that the Mazner limestone and the Miller limestone of the type section are the same bed, repeated by faulting, Stacy tentatively drew the B subzone boundary at the base of the Quarry limestone, an extremely fossiliferous horizon, and similar lithologically and faunally to the Miller limestone of the type section. The exposures of Windsor limestone at the East River Quarries, and elsewhere in the Mahone Bay appear to correlate better with the Mazner bed, than with the Miller bed, and lend support to Bell's identification of two separate beds (Bell, 1929, p. 46-47).

SECTION 1, COMPOSITE FROM MAHONE BAY - ST. MARGARET BAY AREA.

Along the south shoreof Nova Scotia, two large but relatively shallow bays break the southern shoreline, and, dotted around their margins, six small exposures of Windsor Group limestones are found. A single thin veneer of dolomitic limestone, perhaps 6' thick, lies unconformably upon the Goldenville quartzite and directly behind and under the garage in Chester Basin, which in 1950 belonged to Webber Motors. It bears no fossils, but is lithologically similar to the next Windsor exposure along the east shore of Frail Cove, in East Chester. It is presumed to be B subzone.

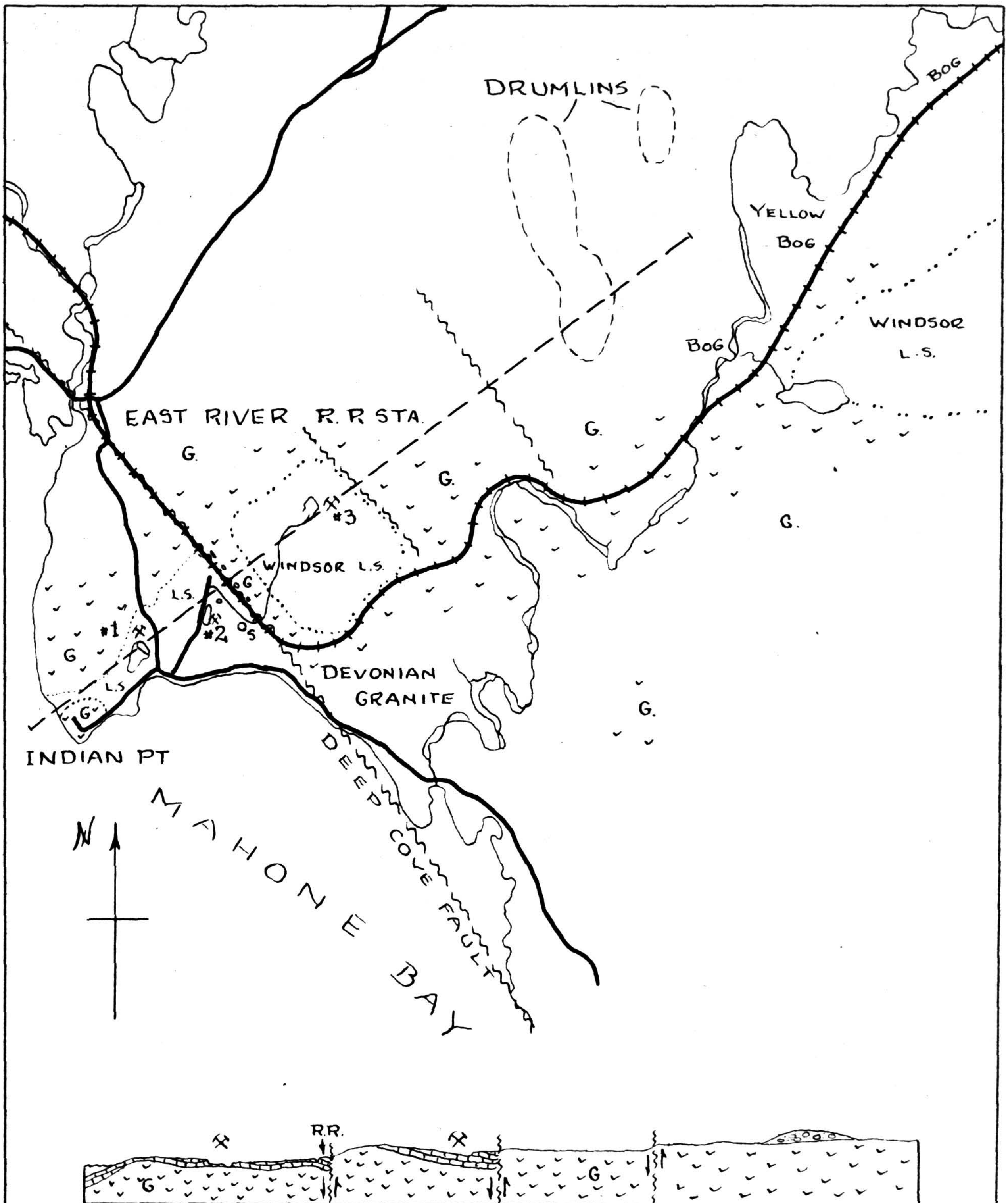
The Frail Cove exposure is best seen by walking along the shore southeastward from the Owl's Head Tuna Camp. Here the limestone is earthy, but durable and dolomitic. It contains a few specimens of Beecheria sp. Structurally it represents the remains of three small overlaps by the Windsor on a small patch of Goldenville quartzite. The limestone beds show dips of from 15 to 35 degrees, and indicate that some folding of the Goldenville floor has taken place since the deposition of the limestone. The small sketch and photograph on the following page show the structural relationships of this exposure. The basal foot of the Windsor is composed of a sharpstone conglomerate with quartzite pebbles, and the limestone reaches a thickness of only 4 feet along this shore. The beds at their western-most exposure on Frail Cove disappears under glacial cover and seem to continue westward, under the Chester-Halifax road, reappearing in a small cliff on the east shore of Goat Lake, on the property of Harry Zink. Here the limestone forms the back of an old lime kiln, and reaches a thicknessof not less than eighteen feet. Solution along cracks and joints makes it nearly impossible to determine the attitude, but the beds seem to dip only slightly toward Goat Lake. From this exposure many specimens of Beecheria, probably representing several species, were collected. The limestone is a flat gray color, crystalline, and with a high calcium content. Adding the dolomitic base along Frail Cove to the Goat Lake 18 feet gives a minimum thickness for this Windsor exposure of about 22 feet. More may be hidden, but this figure is only 2' less than that of the East River exposures. On the hillside above Mr. Zink's farm, deep sink holes continue to develop, and Mr. Zink stated that he had filled many of them with gravel and boulders several times. The solution probably is taking place between the quartsite, or granite as the case might be, and the base of the Windsor beds. The writer believes that solution caverns already exist and that in wet seasons, the muds and clays choking these holes are allowed to flow down, producing a surface slump. These sink holes develop too fast even for gypsum, and the underground cavern must already be present.

The next Windsor exposures can be seen at the East River Quarries, on the shore and inland from the north-east corner of Mahone Bay. Here three quarries were open in 1951, but only the inland one was operative. High calcium limestone is quarried for use by the Mersey Paper Co. of Liverpool, and the quarry manager, Mr. Bruce Cook, stated that the two lower quarries were abandoned because the lower beds were becoming too dolomitic to be used in the paper process. This agrees with the exposures at Chester, and Frail Cove and Goat Lake. The lithology of these East River Quarries is also similar; gray limestones forming the bulk of the bed, with the more tan-colored, and dolomitic beds forming the basal few feet.

Figure 3 on the following page shows the structural relationships of these exposures. The number 1 and 2 quarries, now abandoned, are on the same level, but the number 3 quarry has been elevated by the Deep Cove fault, and lies about 85' above the lower quarries. A line of sink holes along the railroad track marks the surface trace of this fault, and north-east of the track, the granite is exposed along the fault scarp. The Deep Cove fault then must be post-Mississippian.

Traveling eastward from the upper, or number 3, quarry, the evidence of two other faults is found. Here the uplifted or eastern side of the fault, presents a sheer face varying from 5 to 15 feet in height. Flexures of the granite are apparent on the very end of Indian Point, just north of the area covered by Windsor limestone. The writer believes that this set of folds and faults represents only a small portion of a rather large fault system, where minor breaks of only tens of feet are common. The streams flowing over the exposures of Devonian granite appear to be structurally controlled, maintaining a remarkable degree of parallelism, and are probably paralleling faults such as these East River faults. Cameron (1949) includes the Deep Cove fault in his paper, along with many others cutting the Meguma Series, and states that the age of these faults is definitely established as being post-Middle Devonian but pre-Carboniferous in age, but this is not the case near East River.

Measurements taken in the number 1 East River quarry show 12' of limestone exposed, with the upper few feet very limonitic from weathering, and in small patches sufficiently high in limonite to be used as a brown ochre for mixing paint. An indefinite band of Beecheria sp. is located about four feet from the top of this section and may also be located in the number 2



EAST RIVER LIMESTONE QUARRIES

MAHONE BAY - ST. MARGARET BAY AREA

NOVA SCOTIA

SCALE

0 1/2 1 MILE

Figure 3

and 3 quarries at about the same location. In a water filled pit in the number 1 quarry, an additional 10' of high calcium limestone is covered by water. Allowing 4' for the magnesian limestone, this section is about 26' thick and rests directly upon a granite basement.

Only 19' are exposed in the number 2 quarry, and perhaps as much as 15' in the upper, or number 3, quarry. Along the south-west shore of Indian Point, near East River, the limestone appears to be draped and slumped into a depressed area of the granite. Bedding along the shore varies from horizontal to vertical, and no accurate thickness can be determined. But this area is the most fossiliferous, containing numerous specimens of Beecheria, and fewer specimens of Conularia planicostata, and Straparollus minutus. These were the only specimens found by the writer in any of the quarries or in surrounding limestone exposures. Because of the numbers of Beecheria (Dielasma, Bell, 1929), the writer believes this bed to correlate with the Macumber limestone of the type section. Other reasons for making this correlation, rather than with the Miller limestone, are: 1. Conularia planicostata although more common in the Miller limestone, was found in the Macumber limestone by the writer and Stacy while on a collecting trip there, but Straparollus minutus is known only from the Macumber limestone; 2. a few other fossils characteristic of the B subzone are found in boulders in the Mahone Bay area, and presumably did not come from the East River exposures, since the particular species from the islands are not found in the quarries. If the source of these other B subzone fossils stratigraphically underlies the East River beds, then, by sequence, the East River beds more likely would be the Miller horizon, but do not have the vast number of fossils characteristic of the Miller limestone. More likely, the source of the additional B subzone fossils stratigraphically overlies the East River beds, which allows a tentative correlation therefore with the lower, or Macumber, limestone horizon of the type section.

One interesting feature of the East River Section is the tree growth in several of the sink holes which follow the line of the Deep Cove fault. In one sink hole, for example, the smaller trees growing along the inside, sloping surface of the sink hole grow vertically from their very base. Trees 6 to 8 inches in diameter started at an angle of about 20 degrees from the vertical, growing into verticality at about 10' above the ground, and a single tree of about 12' diameter, started at an angle of nearly 30 degrees from the vertical. Plainly the surface upon which these trees are growing, the inner surface of the sink hole, has been sinking gradually over a period of time. From an estimate of the age of the trees, sinking of the ground through solution has been active in this particular sink for approximately 80 years. Since no larger trees are growing in the sinks, this does not give a total time for activity of these sinks.

Another outcrop of limestone which may have been deposited from ancient Mahone Bay is an outlier midway between the East River exposures and Fox Point. This outlier extends from a small unnamed lake eastward towards, and perhaps to, Farm Lake. No thickness can be taken here, for the limestone lies as a thin veneer over the granite basement, and only a few exposures can be seen. All of these exposures are more sandy than the East River exposures, more limonitic, and seem to represent the most shoreward facies of the East River beds. No fossils were found. It was only through the kindness of Dr. F. S. Coolen, of Fox Point, that the western extension of this outlier was defined, and subsequently mapped, as shown on the geological map of this thesis.

In a small cove north of Red Bank a new development of summer cottages is fast covering the remains of another Windsor limestone exposure. This gray, crystalline limestone is quite clean of sand, except for a few stringers of quartz, and shows only laminated algal structures for fossils. Their structures resemble the algal growths of Gaets Cove, which because of their association with Gigantoproductus sp. are thought to be E subzone. From the resemblance of the algal structures, the Red Bank limestone is tentatively placed as E subzone, or very uppermost Windsor.

Half way between Glen Margaret and Seabright, on the eastern shore of St. Margaret Bay, a large drumlin and a pile of glacial gravels all but cover a good exposure of Windsor limestone, and from the few outcrops which appear through the cover, no true picture of this exposure area is known. The B subzone limestone, similar to the East River exposures, is present and appears to overlie thin quartzitic beds. The same Beecheria sp. are found here. A great number of quartzite pebbles are found as rubble at this site, and presumably these beds were derived from erosion of the granite basement. The pebbles are too low in feldspar to be considered arkosic. Another more limey and more fossiliferous limestone is present, but crops out slightly above the B subzone exposures. The large fossils are too fragmented to be identified, but the foraminifera indicate an Upper Windsor section, probably E subzone. And lastly, although no corals were found at this exposure area, a single boulder was located containing two individuals of Gigantoproductus sp.

The last site on the mainland at which actual outcrops were located is at Gaets Cove, on the eastern shore of Mahone Bay. Today the limestone may be seen in the bottom of several water wells, but not along the shore. Structurally, the Windsor limestones appear to occupy a small syncline in the underlying Halifax slate, although a similar syncline slightly north, does not contain the limestone. The only fossils present which have been identified generically are a few specimens of Gigantoproductus. Not identified generically are many large rippled surfaces ascribed to algal activity. Photos of these algal structures are shown on page 90. Three feet below one of the algal layers, and in the same boulder, a few Gigantoproductus were found. It is thought by the writer that this algal zone, of a maximum thickness of about 6 feet, represents the uppermost Windsor deposits of limestone in either the Mahone Bay or St. Margaret Bay area. Possibly this algal limestone represents a brackish water facies, where a saline-low barrier excluded the marine fauna. The limestones associated with the algal structures are more sandy than the Gigantoproductus limestones, which are typically black in color, and contain only fine silt. A few Halifax slate fragments are included in this upper limestone member, as would be expected, but proportion of sand grains to slate fragments is well over 50:1, or surprisingly high.

The last three possible exposures of Windsor include a shale outcrop on Sheep Island, (not confirmed by the writer in either '50 or '51, but reported to him in a letter from Dr. W. A. Bell), a small block of gypsum on the southwest end of Goat Island, and lastly, a possible gypsum area on the north end of Graves Island. Mr. Graves reported that during his youth, several cattle drinking holes were cleaned out, and a white material was found about four feet below the ground surface. When shown a piece of gypsum, Mr. Graves identified it as having been the material in the cattle drinking hole. This exposure is covered with muds and leaves today.

The remaining areas mapped as Windsor do not show outcrops of Windsor material, and are mapped either on the basis of sink holes, or limestone boulders in the drift. This distinction is carried out on the map which accompanies this report, although not on the earlier Canadian Geological Survey maps.

The remainder of the stratigraphy of the Windsor Group in the Mahone Bay - St. Margaret Bay area must be worked out from the numerous boulders associated with the drumlins and glacial deposits in this area. The chief sources of these boulders are the drumlins which are now undergoing erosion by the sea. As the sands and clays of the drumlins are removed by the waves, the larger boulders are cleaned up and exposed along the shores, readily accessible at low tide. Some transfer of these boulders is carried out during cold winters by the ice. Mr. Stevens, who lives on the eastern tip of the Second Peninsula, reports the arrival of erratics by such a method, and even collected from such an ice raft a large white quartz boulder now decorating his property. Such rafting does not account for all the boulders of limestone, however, for their assortment is good; that is, rocks bearing one species of Windsor fauna are generally located on one island. The source of these boulders seems to be the bottom of Mahone Bay, and travel presumably has not been far. The ice direction was approximately south, 20 to 40 degrees east, and projecting back the two clusters of limestone-bearing drumlin-islands, leads 1) to the Indian Point shore, near Mahone Bay (town), and 2) to the east shore of Chester Basin, east and south of the town of Chester Basin. Since both these areas are spotted with sink holes, whose recent activity indicates them to be from solution of limestone or gypsum and not kettle holes, they may be taken as the source regions of the limestone boulders along with the bay bottoms. The Windsor type area could not have been the source of these Windsor boulders because 1) the fauna is quite different, 2) the lithology is also different, 3) the ice direction is wrong, and 4) the distance seems excessive. Many of the boulders measure 6 feet or more in their longest dimension.

Upon study, these fossiliferous Windsor limestone boulders yield the following information:

1. B. subzone fossils are particularly common, for this area, on Snake, Lynch, and Birch Islands, and a few are found in isolated boulders on Saddle, Meisner, Quaker and Clay Islands. All of these islands belong to the group in the immediate vicinity of Chester. Boulders similar to the East River

limestones are found on Snake, Saddle, and Meisner Islands, and fossils from the B subzone, not found in the East River exposures, but common in the Miller limestone of the type section, are found on Lynch, Quaker, and Birch Island.

2. Birch and Lynch Islands also contain a few boulders with E subzone fossils, including a few corals.

3. E subzone fossils, including Gigantoproductus at most places, were found in good numbers of specimens, although not species, on Sheep, Goat, Rouse, and Lucy Islands, and along the north shore of the Second Peninsula, and a few boulders containing E subzone fossils were found on Kaulbach, and both Mason Islands, as well as on Gull ledge.

4. Only three species were found in the entire Mahone Bay - St. Margaret Bay area, which in the type section, were confined to either the C or D subzones, or both. These specimens in the Mahone Bay area were in each case found in boulders with fossils more characteristic of the E subzone. The possible C or D subzone fossils include Edmondia hartii, Allorhynchus hartii, and Spirifer cf. nox Bell.

5. A large fault is suspected of dividing the Chester group of islands from the south-westerly group of islands. The evidence of this fault may be seen in the offsetting of the Great Tancook Island anticline, which when projected westward towards Lunenburg, meets with a syncline, and the Long Island anticline, with which it surely belongs, lies farther to the south. Similar offsetting is shown at the more northerly end of the strike of this fault, in the Gold River mining district, where three breaks occur in the Gold River Anticline. The Goldenville-Halifax formation contact is similarly offset, just below the railroad and highway bridges over the Gold River.

6. The north-eastern block of this fault has moved up relative to the south-western block. This movement may well have exposed the C, D, and E subzones north-east of the fault to erosion before the arrival of the glacier, and when the glacier arrived, ripping up the upper layer of Windsor beds, B

subzone fossils would then be most common north-east of the fault, and E subzone fossils would be most common south-west of the fault.

7. Another explanation for the absence of C and D subzone fossils is that they may not have been deposited so far into Mahone Bay. The Rodman Hill exposure, on the east shore of St. Margaret Bay, with evidence for only B and E subzones, gives weight to this last explanation. Neither explanation may be the whole story.

8. There are no oolitic beds or boulders exposed in the Mahone Bay - St. Margaret Bay Area.

9. From the fragmental evidence supplied by the glacial boulders, no further stratigraphic section may be found for the B subzone, except that it must have existed, in two horizons, which appear to correlate with the Maxner and Miller limestones of the type section. No evidence of any kind is found for the stratigraphy of the C and D subzones. By measuring boulders, and matching Gigantoproductus bands, and then adding the upper algal beds from Gaetz Cove, and coral bearing boulders which are representative of a section immediately underlying the Gigantoproductus zone, the following incomplete section for the E subzone may be set down:

(c) Algal zone, crystalline, laminated, sandy, light gray to light yellow in color . . . . . 6'

(b) Gigantoproductus zone, dark gray to black, silty, organic limestone, with alternating bands of Gigantoproductus bearing limestone and non-Gigantoproductus bearing limestone. Individual beds varying from 2" to 12" within narrow horizontal limits. . . . . 10'

(a) Coral zone, gray limestone, somewhat cleaner than overlying member, but in some boulders quite sandy. . . . . 4'

A more exact location of individual coral genera in the E subzone is given in Chapter IV.

SECTION 2, WINDSOR TYPE SECTION

The type section was worked out and described by Bell (1929) and is not given here, bed by bed. The writer, with M. Stacy and Claude Hill, visited the type section for three days during the summer of 1951. Our biggest concern while there was the identity of the Meaner and Miller limestones, and whether these are the same bed, or successive beds. From a field examination, considering structure only, these two beds could well be identical. From lithology and faunal content they also correlate rather closely until a statistical approach is made on them, and as Bell has partially indicated (Bell, 1929, p. 48-49), there are some differences. Stacy (1952) based his correlation upon the premise that these two beds were identical. The writer agreed with this idea at that time, and wrote Dr. Bell that this was the present Stacy-Sage assumption. In answer Dr. Bell wrote that "there is basis for an assumption that the two may be contemporaneous facies." Without further reference to the type section, but based upon exposures in the Mahone Bay - St. Margaret Bay region, and upon sequence of limestone horizons within the Antigonish Quadrangles, the writer now supports the separate bed idea, and on Figure 11 of this paper, the two beds are plotted as separate beds.

Several points of importance are shown by this type section. It is the most fossiliferous of any Windsor section studied to date. It also is higher in limestone than any of the other sections, and the five thick beds of gypsum are unique for Windsor sections. Several Antigonish - Cape Breton sections contain as many as five gypsum sections, and some more than five, but only the development of the A subzone sections can compare in thickness with the Windsor gypsum beds. The Antigonish - Cape Breton sections show an increasing amount of siltstones, and the clastic sequences on Newfoundland, assignable to the Windsor correlative there are unbelievably thick when compared with the type section. The exact location of a salt horizon is not known for the type section, and indeed, it may be missing in parts of this area. But if present, it may best be placed within, directly above, or directly below the gypsum bed immediately overlying the Miller limestone.

Additions in faunal distribution, as found or as written up, at the type section were noted during the '51 visit. Bellerophon sp. though mentioned by Bell (1929) as being present in the Kennetcook limestone, omits it from the table on page 67. Diodoceras sp., presumably D. avonensis, is present in the Kennetcook limestone, and Conularia planicostata is present in the Macumber limestone. Lewis (1935, p. 130-136) also shows additions to the Windsor fauna, and reports Pseudozaphrentis sp. and Koninckophyllum cf. interruptum from the Kennetcook limestone, or E. subzone, and Koninckophyllum cf. θ Vaughan from the C subzone.

ANTIGONISH SECTIONS - GENERAL

The Windsor Group in the Antigonish Quadrangles, as in the Windsor type section, is made up of a sequence of marine fossiliferous limestone beds, gypsum beds, a single salt bed, and thick siltstone beds. The western margin of these Windsor beds is in fault contact with older Horton Group sandstones or Brown's Mt. Group metamorphics, and the south-eastern margin is in conformable contact with the underlying Horton sandstones or siltstones. The upper Windsor contact with the overlying Canso Group is nowhere known to be conformable in this area. Rather, the Windsor is overlain unconformably by the Canso (from the Black Avon River eastward), or is in fault contact with the Canso beds (as in the Pomquet River), or is buried under glacial cover. This burial takes place at every place where this contact seems to be conformable.

The stratigraphy in the Antigonish area has been worked out in many small and badly broken sections, by comparing these broken fragments with the Hood Island section and the Windsor type section. The Pomquet River

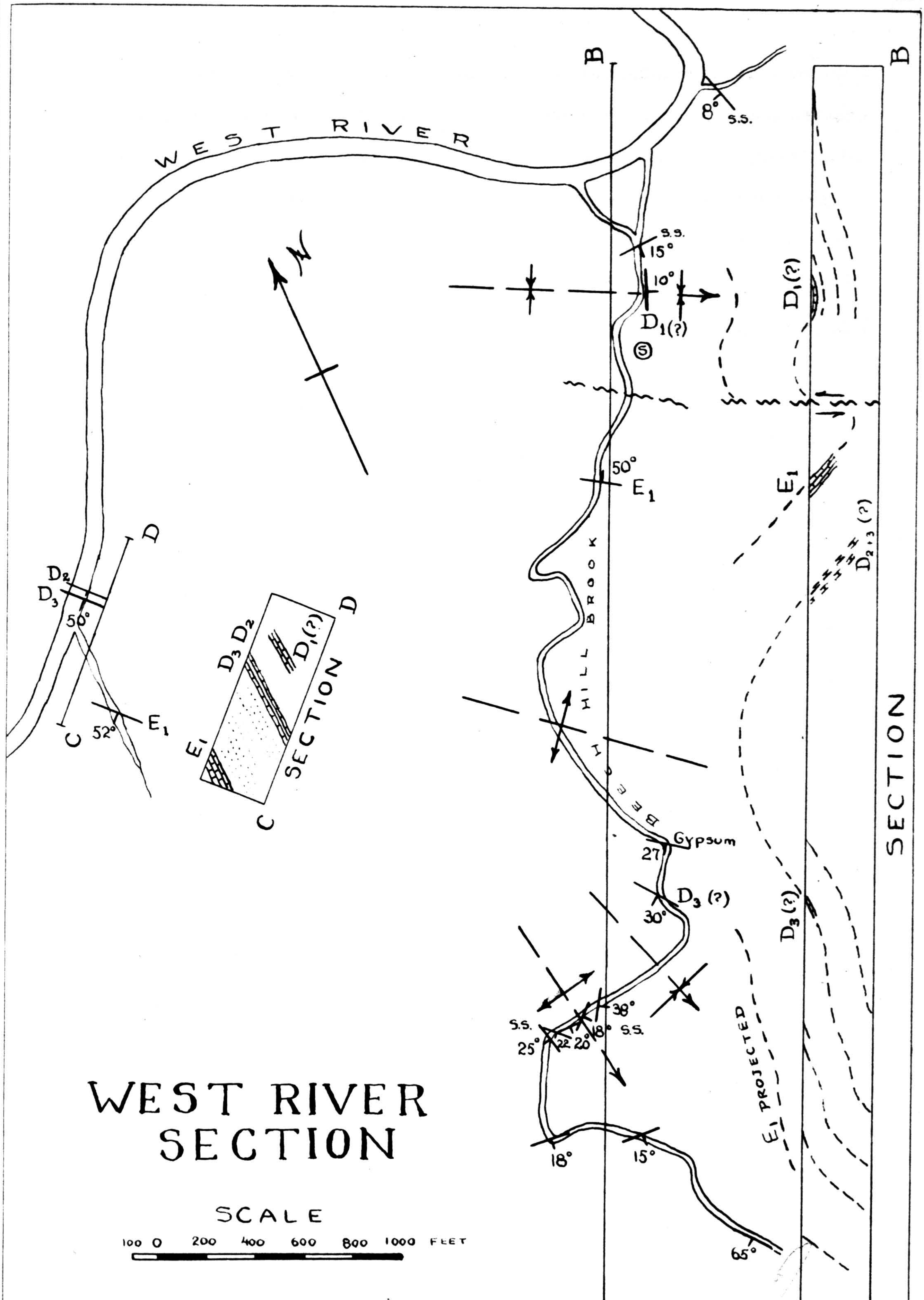
Section, No. 8, and the Monks Head section, No. 7, represent the most complete ones so far as the number of limestone marker horizons are concerned. In both cases the structure is such that intervals between limestone beds are impossible to determine. In addition, about one half the Pomquet River section is overturned, and it is badly faulted, and the Monks Head section has been shuffled like a pack of cards. And lastly, to complicate the Antigonish stratigraphy even further, the intervals disclosed by the 1951-52 salt drilling program are out of all proportion to any exposed, or suspected, intervals. And since no single drill hole passes through both the salt body and a limestone marker horizon, the location of the salt body is based only upon circumstantial evidence.

SECTION 3, WEST RIVER SECTION

This section is exposed in two small streams tributary to the West River, and about 1 mile south of the town of Antigonish. Figure 4 on the following page indicates the location of outcrops, and structure present there.

E Subzone

(k)	Covered to first Canso bed		40'
(j)	Maroon and gray siltstones, becoming limey towards top, mostly covered		180'
(i)	E_1 limestone, gray crystalline to brown oolitic, buried in stream beds		40'
(h)	Maroon and gray siltstones, partially covered in both streams		230'
(g)	Covered, both stream beds		40'
(f)	D_3 limestone, yellow, earthy		3'
(e)	Covered		20'
(d)	D_2 limestone, soft, silty, yellow		3'
(c)	Maroon siltstones, mostly covered	70'	110'
(b)	Gypsum and marl, mostly covered	40'	
(a)	D_1 limestone, oolitic, exposed only		4'



WEST RIVER
B
B
8° S.S.
S.S. 15°
10°
D1(?)
D1(?)
50°
E1
E1
D2,3(?)
HILL BROOK
BEECH
D
D2
D3
50°
52°
E1
C
D3 D2
D1(?)
SECTION
E1
C
D
Gypsum
27°
D3 (?)
30°
D3(?)
SECTION
38°
S.S.
25°
22
20°
18°
S.S.
E1 PROJECTED
18°
15°
65°
A
A
WEST RIVER SECTION
SCALE
100 0 200 400 600 800 1000 FEET

Figure 4

This section exposes a good E subzone for the Antigonish area but does not show the Canso-Windsor contact. The covered (k) zone possible contains a small gypsum bed, for this zone projected eastward runs immediately into low, swampy areas, in which no gypsum is actually seen. When this zone reaches the Beech Hill road, gypsum beds are seen beside the road, but no limestones are present here, and assigning this gypsum to uppermost Windsor is conjectural, for it may represent the gypsum known to be associated with the D subzone limestones.

SECTION 4, MILK PLANT

Fault

(e) E_3 limestone, yellow, earthy and crystalline, partially lost in fault . . . . 4'

(d) Maroon, yellow, blue and gray siltstones, seemingly continuous, exposed in stream and road cuts . . . . 500'

(c) E_1 limestone, gray-black, bituminous and silty, containing single specimens of Bellerophon sp. and a coral Dibunophyllum lambii Bell . . . . 24'

Subzone D

(b) Black shales, laminated . . . . 8'

(a) Maroon siltstones, mostly covered . . . . 200'

The most southerly limestone bed in this section seems to be assignable to the E subzone without question. The Dibunophyllum is characteristic of this uppermost Windsor subzone (Lewis, 1935, p. 133-134), and the Bellerophon specimen fits this designation. The tremendously thick siltstones lying above this bed are unusual for this area and lie but two miles north of section 3, where the siltstones above the E_1 horizon are only 220' thick at a maximum. Three possibilities may exist: that a portion of (d) and all of (e) of this section are Canso, that the siltstone section is not actually continuous, but somehow faulted or isoclinally folded, or that this section

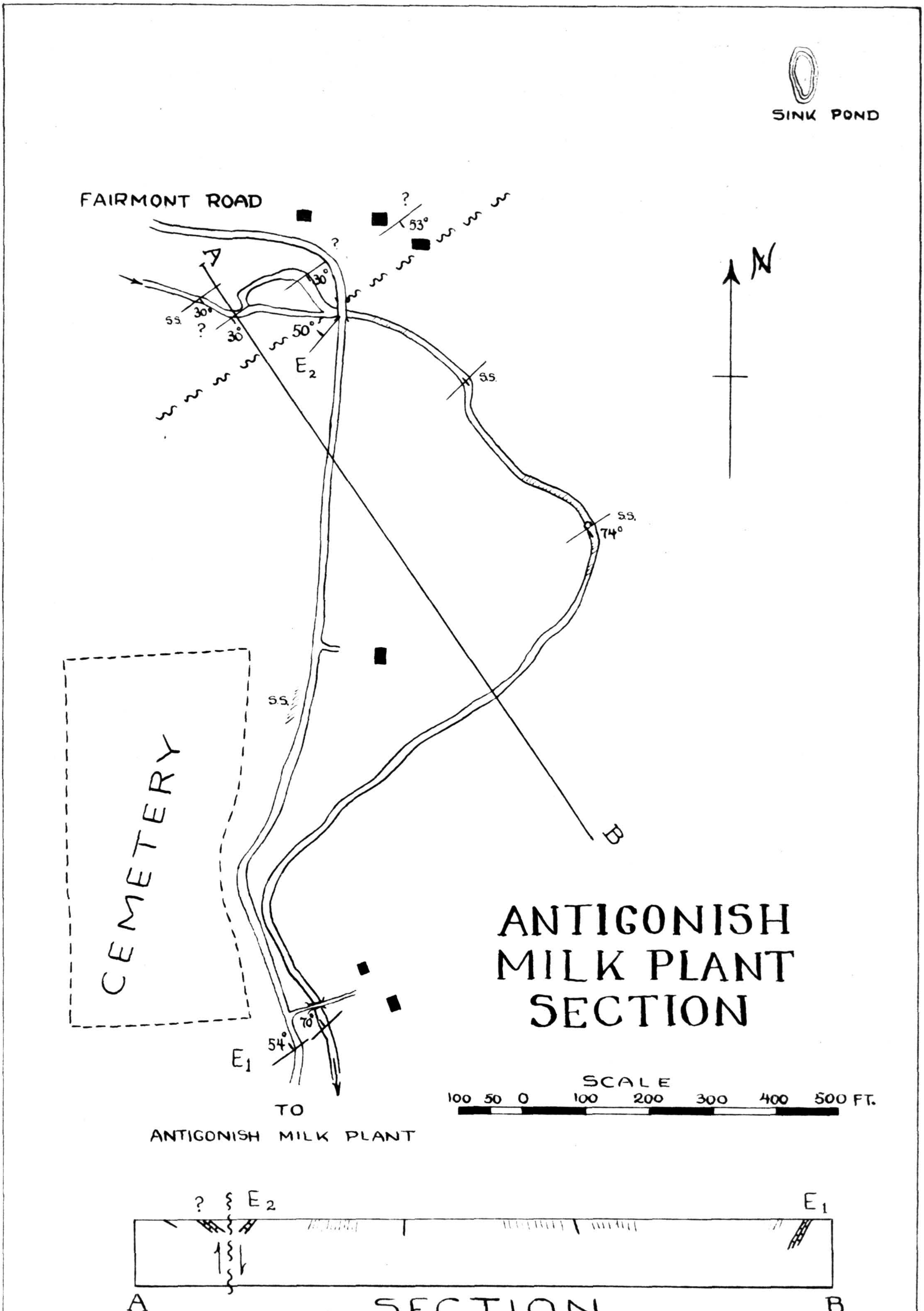

SINK POND
FAIRMONT ROAD
A
?
53°
30°
30°
30°
S.S.
50°
E2
N
S.S.
S.S.
74°
S.S.
CEMETERY
B
ANTIGONISH
MILK PLANT
SECTION
70°
54°
E1
TO
ANTIGONISH MILK PLANT
SCALE
100 50 0 100 200 300 400 500 FT.
E2
E1
A
SECTION
B

Figure 5

represents the deeper portion of the Windsor basin that received sediments at over twice the rate of the area only 2 miles to the south. Since tops and bottoms were determined every 100' or so along the exposed portion of (d), the structural interpretation is considered correct, and there exists about an even choice for the Canso section, or the unusual rate of deposition. Further search of this (d) section may turn up a small gypsum bed, in which case the Canso idea should be adopted.

SECTION 5, CRYSTAL CLIFFS

Subzone A is best exposed in its normal sequence in the close proximity of Crystal Cliffs, namely, east on the shore, and northward along this steep shore to MacIsaac Point, where the lowest members of the section are exposed. Here the basal member lies unconformably upon nearly vertical Horton sandstone beds.

Covered by beach sands

(i)	Gypsum and some anhydrite	80'
(h)	A_2 limestone (Canary), nodular with silt pebbles, or vuggy, yellow to red	20'
(g)	Gypsum and anhydrite	50'
(f)	Gray gypsiferous marl, without fossils A_1 limestone (Basal, or Ribbon) (b-e)	50'
(e)	Conglomeratic, sharpstones of yellow, laminated, sandy limestone in similar matrix	30'
(d)	Yellow, sandy, laminated limestone	25'
(c)	Pink, sandy, laminated limestone, frequently deformed into tight concentric folds, with hematite and dendritic manganese common	20'
(b)	Massive, sandy, blue-grey to pink limestone	12'
(a)	Sharpstone conglomerate and thin shales, pebbles from Brown's Mt. Group, locally derived, greatest thickness measured	9'

This section is well known to students and visitors at the Nova Scotia Centre for Geological Sciences located at Crystal Cliffs, for it lends its name to the Centre, provides a secluded swimming beach for the weary, and a fine nesting place for a large colony of cormorants. No two measurements of this section would agree, since lateral variations in thickness are extreme, and since the entire section is being rapidly deformed by slump and wave erosion.

The (a) bed varies locally along this coast, and in the Antigonish Quadrangles is never very thick. Less than a mile north-west of the northwest corner of the map, a drill hole put down in the center of the Big Marsh syncline penetrated 167' of basal Windsor conglomerate without reaching the Horton beds below. In many places this basal conglomerate is absent, or consists of thin sandy layers, inches thick.

The massive sandy (a) bed is more characteristic of the A_1 limestone than the others assigned here to the Ribbon limestone, but the overlying laminated beds are also quite common. This (a) zone at MacIsaac Point contains the only A subzone fossils known in the Antigonish or Cape Breton regions. These fossils lie about 2 ½' above the base of the (b) bed and are spread over a single time surface. No specific identifications can be made but three forms are present at this location; a small brachiopod, averaging about 6 mm. in width and length, perhaps 2mm. in height, and tentatively identified as Composita sp.; a pearly, white pelecypod, compressed flat, about 1 cm. in length and probably Schizodus sp.; an even more poorly preserved form, from 2 to 3 cms. long, flattened, and tapering from about 4 mm. to about 1 mm. Bell (1929, p. 66-67) lists a species of Conularia (C. cf. of tenuis Slater) and Schizodus cheverionsis Bell as the only species in the A subzone of the type section.

The (c) and (d) beds differ from each other only in color and clearly have been ripped up from the bottom and brecciated by storm waves, or slumping, to form the upper conglomeratic zone, or (e) bed of this section.

The thickness of the gypsum beds can only be approximate, but an even greater thickness of the upper gypsum (i) bed is found in the North Brook area, south of Crystal Cliffs; a minimum thickness of about 140 feet is probable.

The A_2, or Canary, limestone is unfossiliferous in this section, as elsewhere in the Antigonish Quadrangles, and conglomeratic, with red or yellow silt balls making the pebbles. In places this silt weathers free, giving the bed a vuggy appearance. The voids are definitely secondary, and this bed, found at depth, should not possess sufficient porosity to act as a reservoir for oil or gas accumulation. Bituminous stains in many of these voids indicate that this statement may not always be true.

SECTION 5A, QUARRY NEAR FAIRMONT ROAD

Concealed by drift

A Subzone

(c)	Limestone conglomerate, sharpstone pebbles of limestone, exposed only	3'
(b)	Gray, massive, sandy limestone, weathering yellow	35'
(a)	Sharpstone conglomerate, pebbles of green quartzite, and purple baked shales	50'
	Cover	

This section is located 1½ miles north of Antigonish in an old quarry, east of and below the surface of the Fairmont, or Old Gulf, Road. It is given to show the variation in the sharpstone conglomerate which underlies the basal Windsor limestone, beds (b) and (c) above. The green pebbles come from the Brown's Mt. Group, which makes up the bulk of the Antigonish Sugarloaf Mt., directly above this exposure. The purple baked shale pebbles may well be fragments of indurated Horton beds, or may be assignable to the

Brown's Mt. Group also, although no exposures are known locally of this distinctive color. No fossils were noted in this A_1 horizon, or in any other, excepting the aforementioned Crystal Cliffs exposure. This section is not plotted in Figure 11.

SECTION 6, SOUTH SIDE ANTIGONISH HARBOUR DRILL HOLES

This section is not written up as a single measured section since its variations are too many, and only the No. 1 drill hole is plotted on Figure 11. Overlapping the granodiorite high of William's Point, the B_1 horizon is succeeded by gypsum, and the limestone may be as thick as 20 feet. In the Quarry Point area, north-east of William's Point, the B_1 limestone overlaps a granite basement and locally reaches thicknesses of 110 feet. (Messervy, 1945). This great thickness is undoubtedly due to slumping, or perhaps an extraordinary faunal development on this old buried peak. Some 40' of this limestone was encountered in the bottom of the number 1 drill hole, which when corrected for dip, amounts to 22 feet. This hole was bottomed in granite, and the 22 feet may therefore represent only the upper 22 feet of a much thicker horizon. The B_1 limestone does not crop out elsewhere in the Antigonish Quadrangles and other thickness therefore are not known.

The logs of six of the drill holes are plotted on Figure 6, on the following page, with the vertical scale four times the horizontal scale. The general level surface of the salt body indicates that it has not been materially disturbed since its deposition, yet the 45 degree dip of the B_1 limestone in the bottom of hole No. 1 indicates that it has. However, assuming no fault between drill holes, the cross sections strongly indicate a general lowering of sea level, and the salt itself being deposited as an offlap deposit. Whether gypsum, or anhydrite, was deposited at the same time, but peripheral to the salt body, as shown in the cross section, is

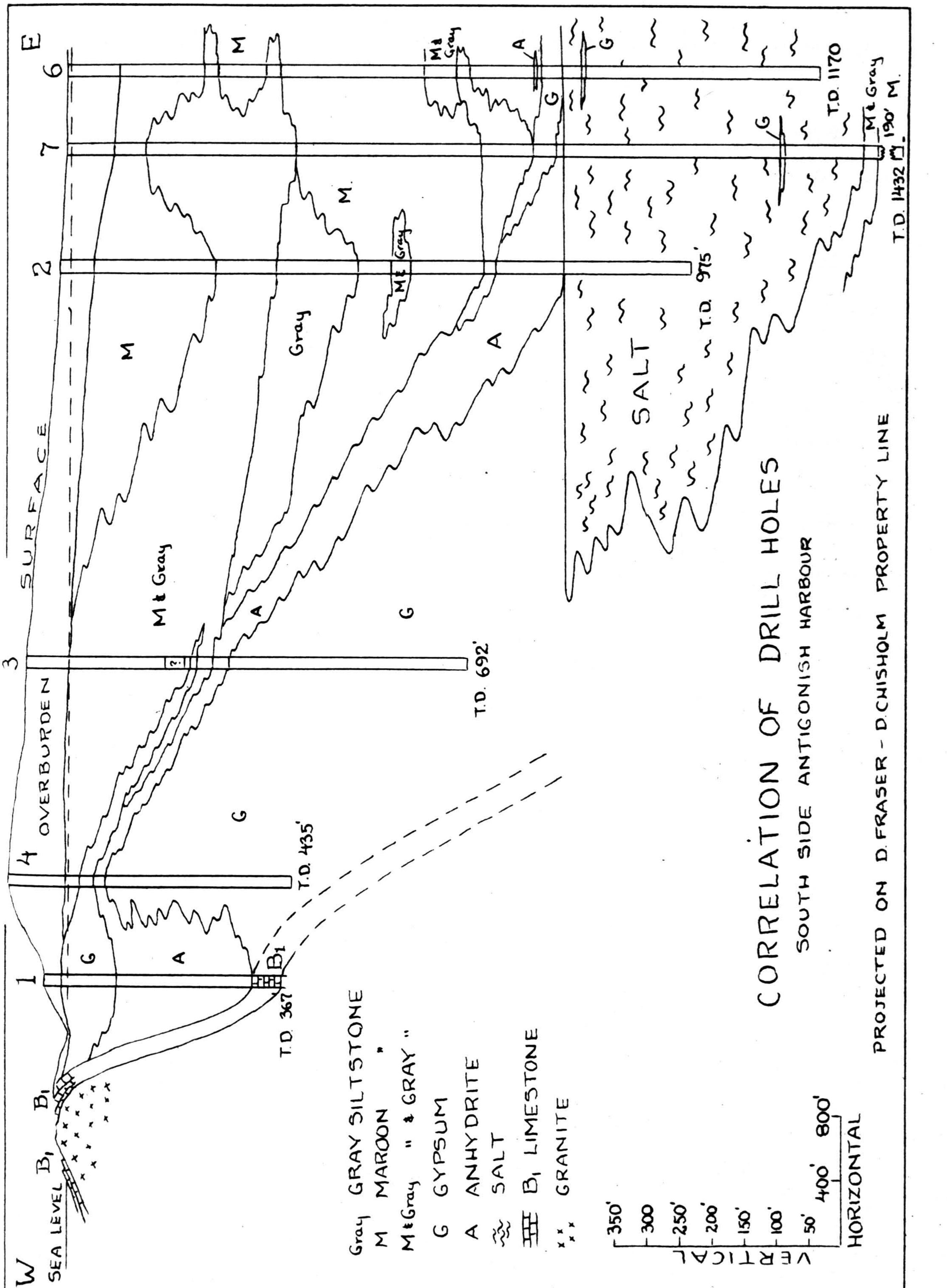

CORRELATION OF DRILL HOLES
SOUTH SIDE ANTIGONISH HARBOUR
PROJECTED ON D. FRASER - D. CHISHOLM PROPERTY LINE
W
E
SEA LEVEL
SURFACE
OVERBURDEN
1
4
3
2
7
6
T.D. 367
T.D. 435'
T.D. 692'
T.D. 975'
T.D. 1432
190' M.
M & Gray
T.D. 1170
B1
G
A
M
M & Gray
Gray
SALT
Gray GRAY SILTSTONE
M MAROON "
M & Gray " & GRAY "
G GYPSUM
A ANHYDRITE
SALT
B1 LIMESTONE
GRANITE
VERTICAL
350'
300
250'
200'
150'
100'
50'
400'
800'
HORIZONTAL

Figure 6

not known; the salt may in fact lap directly upon the granite, indicating extreme aridity.

Again, assuming no faults present across this section, or no major ones, the salt body must lie between the B_1 limestone horizon and the B_2 limestone. Nearly 700 feet of siltstones overlie the salt in the No.s 6 and 7 drill holes, and are separated from it by about 50 - 70 feet of gypsum or anhydrite. Correlations of this 700 feet of siltstone were based on color only and probably are not significant, but the gypsum-anhydrite correlations are interesting.

If the top of the gypsum, or anhydrite, bed is taken as a time line, then the area in which salt was being deposited grew smaller with time, and calcium sulphate was being deposited farther and farther from shore, or at least from the old granite peak. This strongly suggests that the concentrations of sulphate and salt are being built up, or replenished by streams, rather than by refilling of the basins from the open seas. This is not too strong an argument since the line of the cross section is extending east-west, and since the granite peak was probably isolated from the real Windsor shore line.

However, if the top of the salt body is taken as the time line, then a blanket of calcium sulphate was being laid down in a protective fashion around the granite peak, while siltstones were allowed to fill the off-shore basin. In view of the clean nature of much of the drilled gypsum, this does not seem reasonable.

The writer believes that the B subzone, as presently defined, will show several sequences:

either,
(g) B_2 limestone
(f) Siltstones
(e) Gypsum, or anhydrite
(d) Salt
(c) Siltstone
(b) Gypsum, or anhydrite
(a) B_1 limestone

or, without the (c) bed in off-shore areas,

or, without the salt bed (d), in near shore areas.

The (f) siltstone bed which approaches 700 feet in the No.s 6 and 7 drill holes, is only 34 feet thick on Hood Island, and due to offlap of this same zone in the Monastery Brook section, and some cover, shows only 12 feet there.

The B_1 limestone is extremely fossiliferous, and in the Antigonish area, at the two known exposures, is characterised by numerous specimens of Linoproductus lyelli, Leptodesma sp., Beecheria sp., Aviculopecten lyelli, Conularia planicostata, and Anomatina (?) sp.. It has not so far yielded the vast fauna as shown in the Windsor Type section.

Crude determinations of porosity on a 1 foot section of core from the number 1 drill hole showed a porosity of 17% at a point 19 feet from the top of the bed. This was done by comparing the weight of the core with the weight of a hypothetical core of similar size (roughly) composed of pure calcite. The numerous brachiopod interiors provide much of the porosity, but vugs are also common. This specimen was also quite permeable, allowing cigarette smoke to pass through it freely in many places. The foot measured represented the most obviously porous fragment removed from the well hole, and would represent a maximum figure, but much of the B_1 limestone approaches such porosity figures.

SECTION 7, MONKS HEAD

As shown in figure 7, a map of the Monks Head section, it is apparent that the true thickness of the Windsor Group cannot be determined here. The stratigraphy is complicated by numerous faults, and six separate segments of this exposure have been tied together to construct the section shown on the following page. In order to present these beds with a more normal spacing, the thicknesses determined in section 7A, the Saw Mill section, were reduced

15% to serve in spacing the Monks Head beds and limestone horizons. These sections are located about 2½ miles apart on the same anticline, so that presumably the sequence of beds, and spacing would be roughly equivalent. The reduction of 15% was made to account for the probable thickening of the Saw Mill beds through folding over the anticlinal axis. Measured thicknesses in the following section are accurate, but the Monks Head section plotted on figure 11 is spaced on the evidence from the Saw Mill section.

The Monks Head section is measured along the sea cliffs at Monks Head, and is given below, in descending order:

E Subzone

(e')	E_1 limestone, 3/4 miles south-west of Monks Head, oolitic, fragmental, limestone exposed in low cuesta, exposed only	12'
(d')	Covered across Monks Pond	(?)
(c')	Slumped, brecciated zone, containing siltstone, and some gypsum in lower portion	(?)

D Subzone

(b')	D_3 limestone, light gray, earthy and crystalline . .	10'
(a')	Maroon and gray siltstone	20'
(z)	D_2 limestone, bituminous and marly, with few oolites and numerous <u>Paraparchites</u> sp.	2' 6"
(y)	Maroon and gray siltstone, disturbed	80'
(x)	Gypsum	20'
(w)	D_1 limestone, upper surface with pararipples, and lettuce-like algal growths in troughs, dark oolitic limestone with Martinia galatea . . . 11'6"); gray bituminous crystalline limestone . . . 3'; gray blocky crystalline limestone . . . 6")	15'

C Subzone

(v)	Maroon and gray siltstone, exposed only	230'

Section broken by faults

(u)	Maroon and gray siltstone, exposed only	245'

The two maroon and gray beds above are the same bed, but faulted at opposite ends, and total true thickness may be about 350'

(t)	Covered			4'
(s)	G_3 limestone, yellow to light brown, crystalline,			
	with Linoproductus lyelli	4'	)	
	coarsely crystalline, few oolites	5'	)	
	Brecciated crystalline zone	4'6"	}18'	
	black crystalline, vuggy, bituminous	3'	)	
	Algal clubs, columnar, dragged by fault . . .	1'6"	)	
(r)	Section lost by fault			(?)
(q)	Gypsum in caving bank, estimated			30'
(p)	Siltstone, maroon			34'
(o)	Gypsum			4'
(n)	Maroon siltstone			8'
(m)	G_2 (?) yellow crystalline limestone			8' 6"
(l)	Gypsum			6'

Section broken by faults

(k)	Maroon and gray siltstone in fault zone			(?)
(j)	Gypsum, partially eroded by sea			10'
(i)	G_1 crystalline limestone, algal structures . .	5'	}10'	
	oolitic, brown, with ostracods	5'	)	

B Subzone

(h)	Disturbed maroon siltstones	(?)

Section broken by fault

(g)	Maroon siltstone, most fault gouge	15'
(f)	Maroon and blue-gray siltstones	156'
(e)	B_3 limestone, upper surface covered by wide dome structures, on 14' in diameter, about 2' above other surface, remainder of bed chiefly oolitic, with crystalline layers near base	17'
(d)	Siltstone section, multicolored, from maroon to gray to blue to yellow	239'
(c)	Marly layer, bituminous	2' 6"
(b)	Gypsum, folded and faulted, maximum in thickness . .	10'

(a) B_2 limestone, oolitic, shot with gypsum veins and selenite crystals, but containing numerous *Composita dawsoni* . . . . 11'

Section covered, no A subzone exposed

Beds of this section are, in almost every way, comparable to the Hood Island Windsor beds. The similarity of lithology, location of algal markers, thicknesses, sequence of beds, and contained fossils strongly indicate that these two sections were deposited in a connected seaway. Nevertheless, there are differences noted and some evidence is present as to the nature of the Windsor sea floor.

During early C subzone time the Hood Island section is C_1 limestone, siltstone, gypsum, while the Monks Head sequence is C_1 limestone, gypsum, with the siltstone missing from between the non-clastic beds. Gypsum is present between the C_2 and C_3 beds on Monks Head, and represented by only a 1 foot gypsiferous band on Hood Island. Such minor variations indicate that the up and down movement of the Windsor floor was common for small local areas, as well as over the large areas implied by the general correlation of these Windsor sections.

SECTION 7A, SAW MILL SECTION

The Windsor strata for this section lie almost completely buried with only the uppermost member, the E_1 limestone, available for accurate identification. The resistant limestone beds, and the non-resistant gypsum beds, indicate their presence topographically. An oolitic limestone bed is also partially exposed by an old lime kiln and shows enough to be identified as probably the C_3 horizon. The remainder of the section is by inference, but fits well with the Windsor sequence as known in the Antigonish area.

The beds of this section wrap around the southward plunging end of the Monks Head anticline and represent the thickened crest of the anticline. This structure does not appear to be faulted and shuffled like the northern exposure at Monks Head, but rather seems to be a normal anticlinal structure.

MONKS HEAD SECTION
SHOWING
STRUCTURE
AND
STRATIGRAPHIC SUBZONES
KEY
GYPSUM
NORMAL
DISTURBED
SILTSTONES
SHORE LINE AT LOW TIDE
BASE OF CLIFF
B3 L.S. MARKER HORIZON
APPROXIMATE SCALE
0 100 200 300 400 500 FEET
GEORGE
BAY
N
3/4 MILE TO E1 LIMESTONE
SUBZONE D
SUBZONE B
B2
SUBZONE C
SUBZONE D
COVERED
SUBZONE C
PENN. S.S. + CONG.
D3
D2
D1
B3
B2-1
C1
C2(?)
C3
U
D

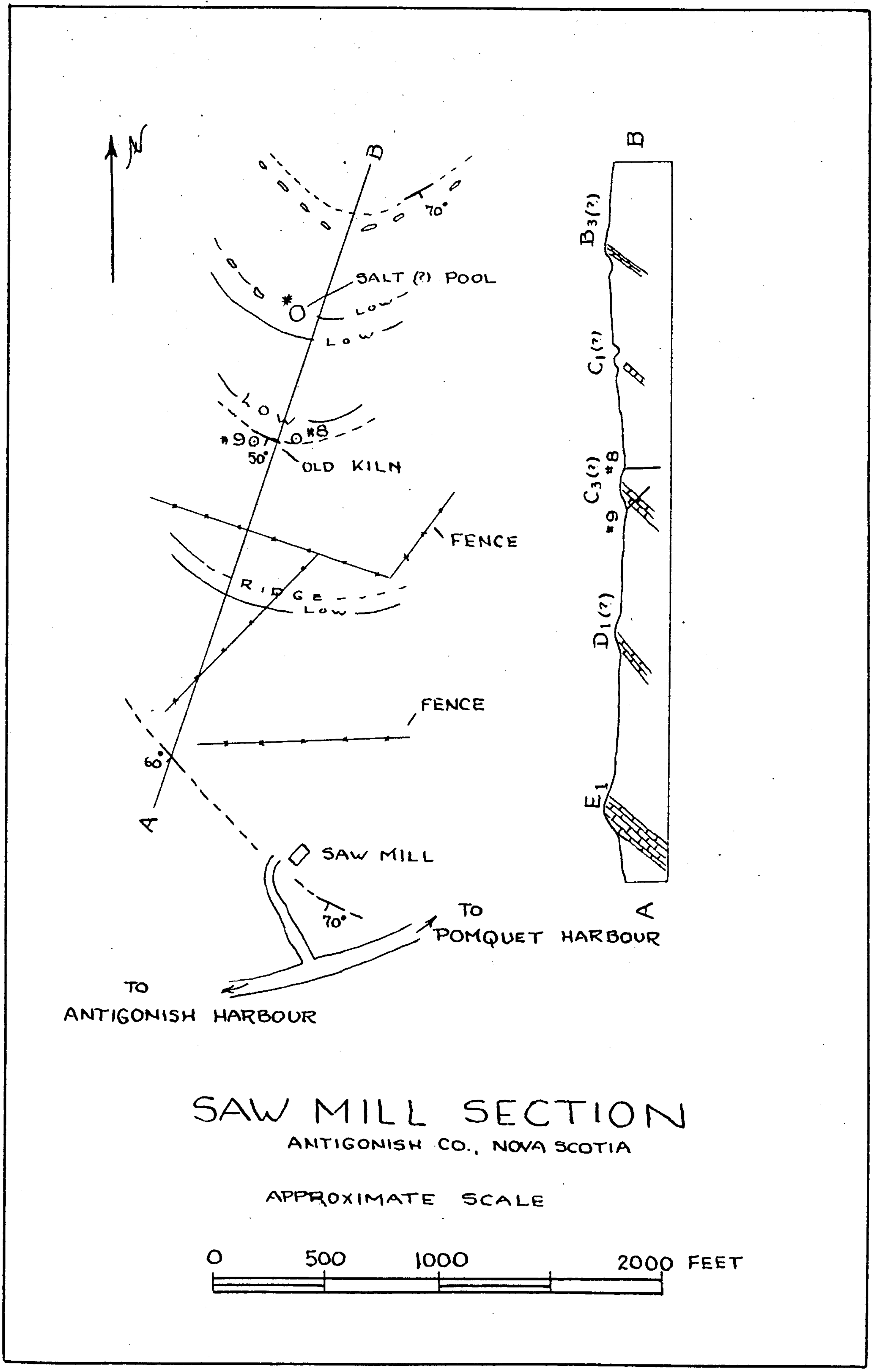

N
B
70°
SALT (?) POOL
LOW
LOW
LOW
#9
#8
50°
OLD KILN
FENCE
RIDGE
LOW
FENCE
60°
A
SAW MILL
70°
TO
POMQUET HARBOUR
TO
ANTIGONISH HARBOUR
B
B3(?)
C1(?)
C3(?)
#8
#9
D1(?)
E1
A
SAW MILL SECTION
ANTIGONISH CO., NOVA SCOTIA
APPROXIMATE SCALE
0
500
1000
2000 FEET

Figure 8

It is interesting to note that beds along the western flank of this structure dip westward and seemingly pass below the salt body as shown in the drill program further to the west. But the drilling strongly indicates that the salt lies in the B subzone. It has been necessary, therefore, to extend the South Side fault as far as Captain Pond to allow the salt-bearing B subzone to have been brought up above the Upper Windsor beds. Surface expression of this South Side fault is actually seen near the South Side railroad station, in ruptured E subzone blocks found there, and in the southward extension of Captain Pond into the drilled area.

The Saw Mill section is not plotted on figure 11 since so much is buried. The map thicknesses for this section were worked out as shown on the preceding page; these same thicknesses were used for spacing the Monks Head section on figure 11 after first being reduced by 15%.

Saw Mill Section

E_1 limestone, silty, dolomitic	40'
Covered section	570'
D_1 limestone, not exposed, but shown as topographic high .	(?)
Covered section	450'
C_3 limestone, exposed in lime kiln	20'
Covered section	350'
C_1 and C_2 limestones, not exposed, but position shown by sinks and ridges	50'
Covered section	450'
B_3 limestone, not exposed for definite identification, but for dip	(?)

The sketch map of this section is shown on the preceding page, and the section may be reached by dirt road from either Pomquet Chapel or South Side Antigonish Harbour. Three drill holes are shown on the map. These were put down to check the calcium content and volume of the limestone bed exposed at the kiln. Drill hole No. 9, drilled at an angle, passed through 85 feet of limestone, which, corrected for dips, indicates a thicker limestone bed than shown in the section above, perhaps as high as 80 feet. The vertical drill holes No. 8 and No. 10 north of the C_3 limestone passed through maroon siltstones only, as the surface structure clearly indicates. The northernmost hole was abandoned after penetrating 55 feet of siltstone, and the next hole was abandoned after passing 35 feet of siltstones.

SECTION 8, POMQUET RIVER SECTION

This section represents the most extreme development of the A subzone in the Antigonish area, and the only section with representative limestone markers from all five faunal subzones. There are several factors which call for caution before this section is accepted. One, it is broken by many exposed, and several hidden but implied faults; two, fossils are scarce and none of those recognized can be considered as diagnostic of a single subzone; three, the lithology of the beds is quite different from nearby Windsor sections and seems to represent a more sandy, shoreward facies; four, detailed work was done during flood conditions, and low water may reveal more fossil evidence; five, the A subzone has two extra beds, only one of which is known elsewhere in the Antigonish Quadrangles; and six, both the lower and upper portion of the section is overturned, and the B_3 limestone identified in the Pomquet River bed seems certain, but the B2 and B_3 limestones shown on the sketch map in the Glenroy Brook (figure 9) may be mistakenly identified, and for this reason the B_2 horizon was left off the section as plotted in figure 11.

Pomquet River Section

Subzone E

(k') E_1 limestone, gray, oolitic, overturned, and only partially exposed . . . . 12'

Subzone D

(j')	Covered, but largely siltstone	195'
(i')	Maroon and gray siltstones	30'
(h')	Covered, mostly siltstones	170'
(g')	Maroon siltstone	20'
(f')	Covered, some siltstone and gypsum	55'
(e')	D_3 limestone, 1½' clayey top and 2' black crystalline limestone below	3' 6"
(d')	Covered (Gypsum?)	24'
(c')	D_2 limestone, soft, yellow	3' 6"
(b')	Maroon siltstone . . . . 20')	
(a')	Gypsum . . . . (?))	60'
(z)	Covered . . . . (?))	
(y)	D_1 yellow oolitic and crystalline limestone, broken by fault	18'

Subzone C

(x)	Maroon and gray siltstones, contorted, and partially covered	275'
(w)	Covered	75'
(v)	C_3 limestone, upper 2' dark crystalline, 6' chalky, silty, 5' 6" yellow crystalline	13' 6"
(u)	Cover	(?)

Section broken by fault

Subzone B

(t)	Cover	(?)
(s)	Limey gray siltstone	4'
(r)	B_3 limestone, 3' upper black earthy bituminous with <u>Composita windsorensis</u> and <u>Linoproductus</u> lyelli, 13' earthy, bituminous and vuggy, 9' 6" " silty limestone .	25' 6"
(q)	Maroon and gray siltstones	150'
(p)	B_2 limestone, crystalline, yellow . . . . (Identification of B_2 limestone not definite, and (q) bed in this case also uncertain.)	3'
	Cover	

Section broken by faults

Subzone A

(o) Cover

(n) Gypsum, exposed only . . . . 25'

(m) A_2 limestone, gray, weathering yellow, crystalline, nodular and soft in places 32

(l) Covered, some maroon siltstone . . . . 88'

(k) Massive maroon fine-grained sandstone . . . . 2'

(j) A_{1-II} limestone, yellow magnesian, crystalline . . . 3'

(i) Maroon and gray siltstone, upper zones exposed, middle 50' covered 144

(h) Covered 65

(g) Gypsum, exposed only 32

(f) Maroon siltstone, sandy at base . . . . 64'

(e) Covered . . . . 112'

(d) A_{1-I} limestone, gray crystalline, magnesian, soft and yellow in places . . . . 10'

(c) Maroon siltstone . . . . 22'

(b) Covered, red siltstone and gypsum included . . . . 160'

(a) A_1 limestone, gray, sandy laminated . . . . 20'
Horton siltstone in conformable contact

The Ribbon limestone is well exposed south-west of the bridge over the Pomquet River at Meadowgreen, and is measurable, but was overlooked during field work, and the 20 feet shown above is not exact. At this exposure it is overturned east of the river, but right side up west of the river, although nearly vertical in both cases.

The limestones above the A subzone were identified by lithology and sequence. Thin sections taken at one foot intervals across the limestone outcrops compare favorably with similar ones made from the Monks Head and Hood Island exposures. The most notable difference is the predominance of silty beds and decrease of oolitic beds in the Pomquet area. The sequence

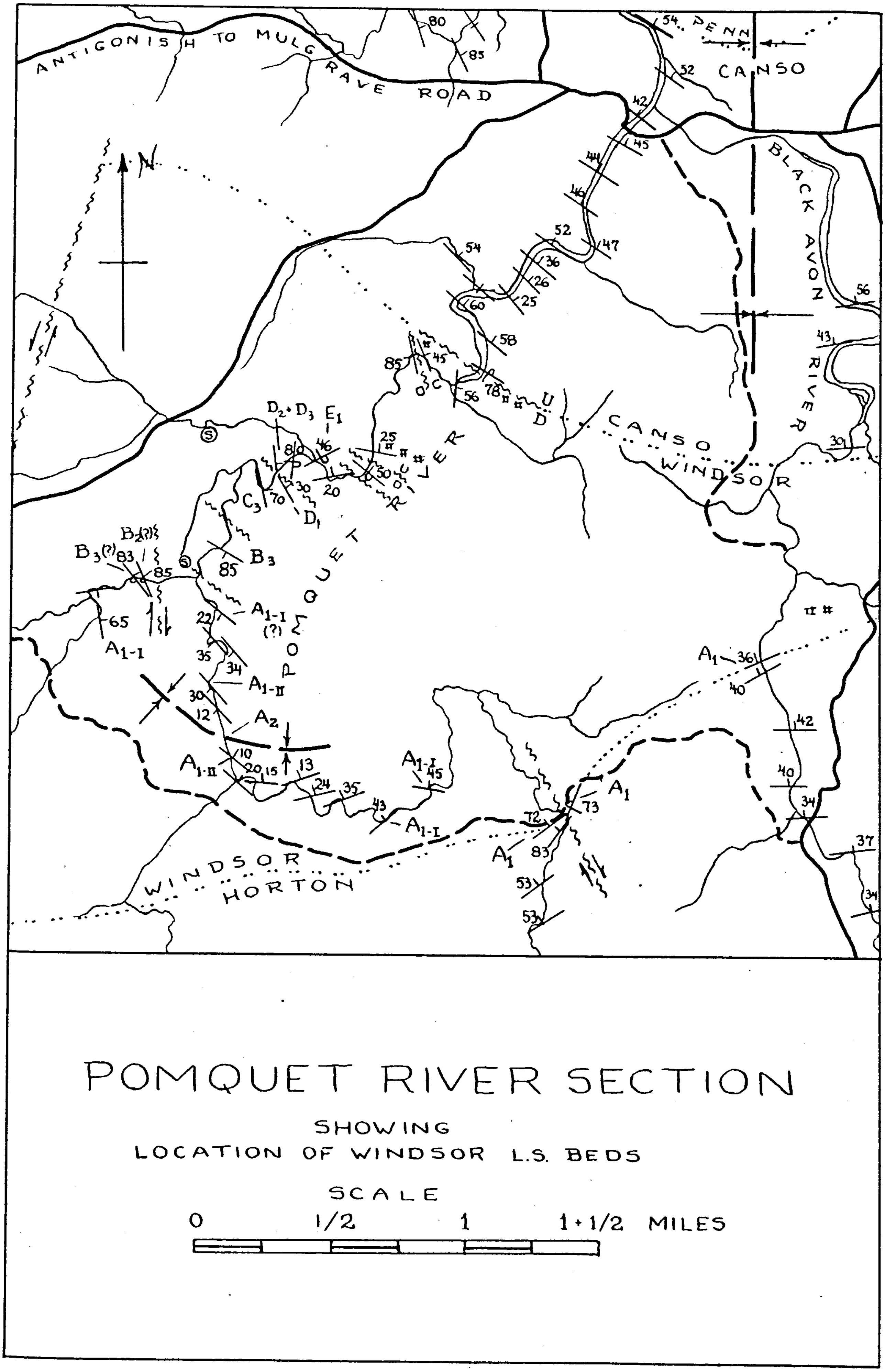

ANTIGONISH TO MULGRAVE ROAD
PENN
CANSO
BLACK AVON RIVER
N
POMQUET RIVER
CANSO
WINDSOR
WINDSOR
HORTON
POMQUET RIVER SECTION
SHOWING
LOCATION OF WINDSOR L.S. BEDS
SCALE
0 1/2 1 1+1/2 MILES

Figure 9

of beds here is comparable to other Windsor sections in the Antigonish area but the thicknesses of all the Pomquet subzones are large by comparison. For example, the Pomquet River A subzone is about 700 feet thick, compared with about 300 feet for the Crystal Cliffs A subzone, and the Pomquet section from the base of the C_3 limestone to the base of the E_1 limestone is 130 feet thicker than the corresponding section on Hood Island. Owing to the folding and faulting of this Pomquet region, measured thicknesses are thought to represent an extreme condition for structural reasons, and the sedimentation rate may not have been too much greater than in the then more seaward Windsor sections. Further study of this section at low water may well prove profitable and could possibly throw more light on the A subzone, or offer evidence for revision of other portions of this sequence.

The sketch map of the Pomquet River section is shown on the preceding page. This area is easily accessible from the Meadow Green end, or from the main road from Antigonish to Mulgrave, and this latter way of entry passes over the excellent Canso section in the lower end of the Pomquet River.

SECTION 9, MONASTERY BROOK SECTION

This exposure of Windsor strata may be seen in the bed of Monastery Brook as it flows by the Monastery of St. Augustine near Tracadie Harbour. The contact between the Canso and Windsor beds is unconformable, with the Canso overlapping the more steeply dipping Windsor beds; the actual contact, unfortunately, is obscured by stream gravels just east of the main Monastery structure. Another unconformity is present in the area, and B_2 limestones are separated from A_1 limestones by a break in the sedimentation. It is presumed by the writer that a general lowering of sea level must have taken place during upper A and lower B time, which would account for the absence of the beds at this point; local upwarp may have helped.

The Monastery Brook section is given below:

Canso Group siltstones and limey shales
Angular unconformity

B Subzone, Windsor Group

(p)	Covered by stream gravels	10'
(o)	Maroon and gray siltstones, fine siltstones . . .	300'
(n)	Covered by stream gravels	90'
(m)	B_3 limestone, 18' (top) brown-yellow, sandy crystalline limestone, 2' brecciated, 10' sandy, bituminous, crystalline limestone	30
(l)	Black and tan laminated limey shales	6
(k)	Yellow-gray siltstone	5'
(j)	Gray siltstone	8'
(i)	Maroon siltstone	121'
(h)	Gray siltstone	26'
(g)	Maroon siltstone	66'
(f)	Covered	12'
(e)	Maroon and gray siltstones	8'
(d)	Covered, appears to be some gypsum	28'
(c)	B_2 limestone, silty, oolitic limestone	11'
(b)	Maroon and gray, siltstones and shales exposed for 12' below limestone, remainder of section covered, sink holes indicate some gypsum, total thickness varies along strike from 310' to 450' . . .	350'
(a)	A_1 limestone, gray, sandy, laminated . . . . Conformable with Horton (?)	16'

The concealed interval (b) of the above sequence presents a problem of considerable interest. Because of the suspected proximity of the salt bed to the B_1 limestone, the absence of this part of the Windsor Group in many outcrop areas has generally been ascribed to faulting, or burial by glacial debris and erosion products. This is more than likely for areas

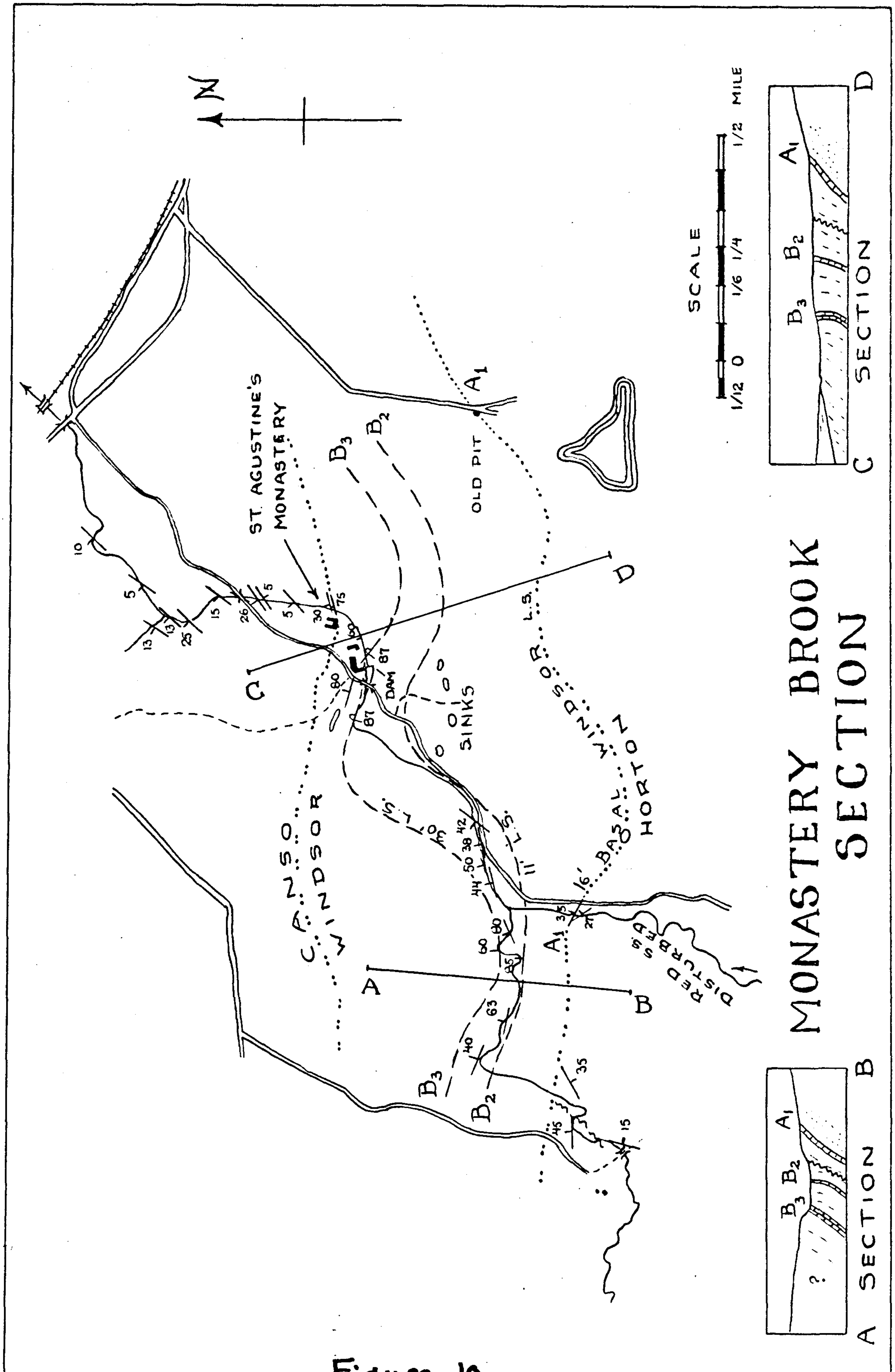

MONASTERY BROOK
SECTION
N
SCALE
1/12
0
1/6
1/4
1/2 MILE
ST. AGUSTINE'S
MONASTERY
DAM
SINKS
OLD PIT
CANSO
WINDSOR
WINDSOR L.S.
BASAL WINDSOR
HORTON
DISTURBED
30' L.S.
11' L.S.
16'
A
B
C
D
A_1
B_2
B_3
SECTION
A
B
C
D
?

Figure 10

where the B_1 is known to occur. The Monastery Brook area gives support to the evidence from the Drill Hole area that upper A and lower B times may have seen a generally lowered level for the Windsor seas. If such is the case, the B_1 limestone is probably present down dip, and since it is highly porous and permeable in the known exposures, and in the one drill hole in South Side Antigonish Harbour, represents a possible stratigraphic trap for gas and oil along the many small anticlines and synclines located from the Pomquet syncline eastward to Cape Blue.

SECTION 10, HOOD ISLAND

This section was described by Stacy (1952, p. 37-44) and is of interest in studying the Antigonish Windsor beds because of the very great similarity to them. One minor bit of evidence is supplied by the Hood Island Gypsum as to the possible source of calcium sulphate for the very thick gypsum beds. Two possibilities exist: 1) that sea water was allowed to enter the Windsor basins from time to time, with evaporation following each influx of new sea water, or 2) that fresh water streams supplied the salts following the evaporation of those waters originally blocked off from the open ocean.

Below the B_2, or second oolitic bed, on Hood Island there are found 34' of siltstone, underlain by a huge mass of gypsum which spreads laterally along the ground for 560 feet. This represents a thickness of about 350 feet (Stacy, 1952, p. 43), and in this mass, about 70' from the upper contact, a 30' band of gypsiferous marl is found. Stacy, at the request of the writer, collected a specimen of this marl, and the writer, in examining it for foraminifera, broke out a deformed, but recognizable Composita dawsoni. The brachiopod not only is an index of the Lower Windsor, but indicates strongly the presence of normal marine waters for at least a short time, and strongly suggest a new influx of marine waters from the open seas.

SECTION 11, RAGGED POINT

Stacy's section of Windsor beds from Ragged Point is presented on the Cross Sections of figure 11 since it represents a clean contact of the Windsor and Canso Groups. The Uppermost Windsor bed was taken by Stacy (1952, p. 36) to be an 8 foot gypsum bed. This relationship is suspected by the writer for undisturbed contacts in the Antigonish Quadrangles, but such a contact is not as yet known to be exposed in the Antigonish Quadrangles.

SECTION 12, CAPE DAUPHIN

This exposure of Windsor strata was described also by Stacy (1952, p. 45-48) and is included here, and in the cross sections of figure 11, for several reasons. It shows again a Canso - Windsor contact, although here the uppermost Windsor bed appears to be a lime mud-rock rather than a gypsum bed. It also shows another limestone horizon above the B_1 limestone, as does the Milk Plant section, No. 4. It does not compare as favorably with the Hood Island section, as do the Antigonish sections, for the limestones are greatly varied in lithology, thickness, and sequence from the Hood Island section. It shows the foraminifera Nodosinella priscilla in the B_1 limestone, and elsewhere in the Windsor strata this foraminifera is confined to the C subzone. And finally, it shows an unbroken B subzone, although partially covered, in which no gypsum beds are exposed, and in which no salt horizon appears to be present. Gypsum blocks indicate the presence of a concealed gypsum bed (Bell and Goranson, 1938) but surely this section would not be so regular if a salt body had been present through the deformation of this section, and the subsequent exposure by erosion.

SECTION 13, CODROY SERIES FROM SOUTHEAST SHORE OF ST. GEORGE BAY

The final Windsor section present here is the writer's interpretation of Bell's (1948) description of the correlative of the Windsor Group, the Codroy Series, as it is exposed along the south-east shore of St. George Bay,


SUBZONES
E
D
C
B
A
1
MAHONE BAY
2
WINDSOR TYPE SECTION
KENNETCOOK L.S.
AVON L.S.
MILLER L.S.
MAXNER L.S.
3
WEST RIVER
4
MILK PLANT
5
CRYSTAL CLIFFS
6
DRILL HOLE NO. 1
7
MONKS HEAD
8
POMQUET RIVER
9
MONASTERY BROOK
CANSO
10
HOOD ISLAND
11
RAGGED POINT
CANSO
12
CAPE DAUPHIN
13
CODROY SERIES
S.E. SHORE OF
ST. GEORGE BAY
NEWFOUNDLAND
CRABBS L.S.
JEFFREYS L.S.
Nodosinella ZONE
EACH HORIZONTAL LINE OF SECTION 13 REPRESENTS ONE, OR MORE, L.S. BEDS.
BLANK ZONES ARE LARGELY S.S. OR SILT STONES.
BARACHOIS L.S.
HEATHERTON L.S.
FISHELS L.S.
GYPSUM
GYPSUM
SHIPCOVE L.S.
GEOLOGIC SECTIONS OF THE WINDSOR GROUP
LEGEND, SECTIONS 1-12
CONCEALED
S.S. OR SILTSTONE
GYPSUM
LIMESTONE
S.S. {CHIEFLY CONCEALED
SECTION MEASURED BY
1, 3-9 SAGE
2, 13 BELL, W.A. - 1929, 1948
10-12 STACEY, M. - 1952
200' VERTICAL SCALE SECTIONS 1 - 12
2,000' VERTICAL SCALE SECTION 13

in Newfoundland. The section is of interest because it represents the most northerly of any carefully-measured Windsor age beds lying within the zone of deposition of the ancient Windsor seas. It is extremely thick in clastic sediments when compared with other Windsor strata, and is ample evidence to the writer, as it was to Bell (1948, p. 39), that the entry of the marine waters into the semi-enclosed Windsor was not made close to the southeast shore of St. George Bay, or in other words, from the northwest. Bell did not try to correlate his Codroy limestone beds closely with the Windsor type section limestones, but does state (1948, p. 18) that the Ship Cove limestone is "similar to basal Windsor limestone of many areas in Nova Scotia."

The writer undertakes to correlate The Fishels limestone with B_1 limestone in the Hood Island - Antigonish area, the Jeffreys limestone with at least part of the E_1 limestone of the Antigonish - Hood Island area, and the Nodosinella band with the C_3, or Columnar Algal limestone, although the Nodosinella band of the Codroy Series could well correlate with the B subzone of the Cape Dauphin area. In any case, the greatest marine invasions seem to have affected this most northern area only lightly compared with other areas, and reflects a series of changes of sea levels, relative to the surrounding land areas.

CANSO GROUP AND PENNSYLVANIAN GROUPS

The Canso Group, although present over wide areas in the Antigonish Quadrangles, is not the primary concern of this thesis and no detailed sections are given; likewise for beds of Pennsylvanian age. Also, neither of these particular age strata is present in the Mahone Bay - St. Margaret Bay region. Both Sims (1951) and Wetzel (1952) have made detailed measurements of the Canso section in the lower end of the Pomquet River, upstream, or south of the Antigonish-Mulgrave highway bridge. They both started from different points, and finished at different points, but what they measured in common is in good agreement. Wetzel's figure for this section was 4,259 feet from the fault contact with the Windsor Group to the highway bridge, where he drew his upper boundary of the Canso Group. The loss of beds at the fault contact seems to be from the Windsor Group, so this figure is accepted for this interval.

Wetzel's Canso - Pennsylvania (Riversdale Group) boundary has not been accepted for this thesis, but moved downstream 1,690 feet stratigraphically so as to include in the Canso Group the thin fissile sandstones and limey sandstones that outcrop in the small stream flowing into Pomquet Harbour close to the mouth of the Pomquet River, but about 1/8th of mile northwest of the mouth. Above this lithological contact, no limey beds are known to occur. Further field work will be required to locate this contact correctly, but it appears to be a possible task, since a few plant fossils are present through these sections; the ferns all appearing above the Canso-Riversdale contact as established for this report.

The structure from the mouth of the Pomquet River to the coal seam which appears just under water north-east of Pomquet Chapel is not known, but, assuming that the synclinal flattens out to the west, a minimum map thickness for the Pennsylvanian beds underlying the coal seam is about 1,500 feet, and probably more. Map thicknesses from the coal seam across Pomquet Harbour to the south-east end of Monks Head (show about 1,580 feet, and exposed along the shore of Monks Head) are 720 feet of grits and conglomerate. These measurements give a total minimum thickness of 3,800 feet of Pennsylvanian beds above 5,949 feet of Canso beds. What the position of the sandstone beds exposed on Pomquet Island and along the western end of Pomquet Point is, is not definitely known, since too much of the area is covered by sands and glacial drift, but very likely these red sandstones lie stratigraphically above the coal seam and below the Monks Head conglomerates.

The coal seam, actually two thin seams, if projected eastward, would roll over a small anticline, pass under the Pomquet syncline, and finally reach the bay again about the vicinity of Bay-field. Other interpretations of this structure give far greater thicknesses for the Pennsylvanian beds.

Additional measurements of Canso sections include several taken by undergraduates during the summer of 1951. The writer spent two weeks doing field work on the east half of the Antigonish Quadrangles, and confined his activities to the Windsor as much as possible, setting M.I.T. undergraduates to work measuring the Canso and Pennsylvanian. The writer has walked all the sections, and the following descriptions are brief, but the measurements probably quite accurate, being measured bed by bed.

Measurements along the main stream of the Avon River, from the presumed Windsor-Canso contact, an unconformity, to the Canso-Pennsylvanian contact gave 6,107 feet, including all covered sections. This compares with 5,949 feet in the Pomquet River. The Pennsylvanian beds exposed from this contact to the mouth of the Avon River gave 778 feet, of which the last 200 feet is covered. The lower third of the Canso is chiefly black and gray limey, thinly-laminated shales and siltstones, the middle third about half gray-black and half maroon shales and siltstones, and the upper third predominantly thinly-bedded, fissile, maroon shales and sandstones. The Pennsylvanian beds are predominantly alternating massive, red, medium-grained sandstone beds and red shales; the sandstone beds varying from 6" in the lower portion to 4 or 5 feet in the upper part, and the shales maintaining a nearly constant thickness of from 6" to 1 foot.

Measurements from the mouth of the Avon River, eastward down section along the coast, gave figures of 800 feet of Pennsylvanian beds, matching the lithology of the Avon River section, but two big zones are covered, as is the location of the Pennsylvanian-Canso contact on the shore of Tracadie

Harbour. Canso sections are displayed on both Bowman Head and Middle Head, and two marker horizons indicate both sections are the same, the maximum thickness exposed at both places being 194 feet. At Barrio Head the writer measured 514 feet of Canso, which shows no beds, or sequences in common with the Middle and Bowman Head sections. If this shore section of Canso is compared with the two river sections, it shows a thickness approximately 5,300 feet less than the river measurements. The loss of section may be either structural, through faulting, or stratigraphic, through non deposition. Comparing lithology, the Barrio, Middle and Bowman Head exposures are correlative with the lower third of the Canso, as seen in the Avon River section, and in the Pomquet River section. The lost section therefore belongs to beds which should outcrop between Bowman Head and the west end of Tracadie Harbour, or Quarry Point, where the next beds are exposed westward from Bowman Head. It should be pointed out that the faults mapped on Bowman Head on the large geological map, and those seen at Barrio Head are minor breaks only, but indicate that this shoreline was compressed.

The writer believes this loss of section to be through a fault. The line of such a fault must run from Black Bridge, passing just west of Bowman Point, and movement such that Bowman Head moved up relative to Quarry Point. Since red sandstones appear at the very top of the Bowman Head section, a little of the loss may take place between Barrio Head and Middle Head, a little of the section is covered, and perhaps displacement on this supposed Black Bridge-Bowman Head fault amounts to no more than 3,500 feet and possibly about half this value. The relation of this possible fault is discussed more fully under the structural history of the Antigonish Quadrangles.

In summary, the thicknesses for these post-Windsor beds, as well as those for the Windsor and Horton Groups as units, are shown below. It should be remembered that these figures are rough averages, and that the Canso-Pennsylvanian contact is not established from fossil evidence.

		Average Thickness
Pennsylvanian beds, undifferentiated	. . . .	3,200 feet
Canso Group	. . . .	6,000 feet
Windsor Group	. . . .	2 - 3,000 feet
Horton Group	. . . .	6 - 7,500 feet

These measurements would give a figure for Carboniferous sediments in the deeper portions of the Antigonish Basin of from 17,500 to 20,000 feet.

TERTIARY (?) GRAVELS

Coarse grits and gravels, cemented with limonite, are found in three exposures in the Mahone Bay region that can be mapped. Two small exposures are seen on either side of the point of land which juts into Chester Basin, between the town of Chester Basin and the Gold River. The largest exposure is along both sides of Martins River, on the seaward side of the highway bridge.

These are actually conglomerates, firmly cemented by limonite, and containing stratification, so that coarse sand-sized particles are banded with small pebbles, up to an inch in diameter. The pebbles are almost entirely composed of Halifax slate fragments, Goldenville quartzite fragments, or badly weathered feldspar crystals, with varying amounts of quartz grains. These exposures are stratified, as if by stream action, and locally show small cross laminations of different sized lenses of materials. They are clearly stream deposited.

Their shapes indicate rather limited travel, most fragments showing low roundness, with edges only slightly rounded; perhaps 1 in 10 fragments shows sub-roundness.

At all exposures seen by the writer, they lie directly upon the basement provided by the Halifax slates, and are in turn overlain by glacial debris. Their relation to the Windsor Group is not known. They are now exposed to erosion along the banks of Martins River, and seem to have been cut through by the river, in the same way that the river has cut through the underlying Halifax. Since they underlie the glacial debris, they are though by the writer to be pre-glacial, or perhaps late Tertiary. If they had been outwash from one glacier, and then overrun by a second advance, which carried beyond the limit of the first advance, they presumably would have been disturbed to the point where stratification was lost.

The only reference to such a bed, or similar beds, known to the writer, is by Goldthwait (1924, p. 101-102), who writes that a Mr. W. G. Frost calls these gravels the "Bridgewater Conglomerate" and that numerous exposures may be seen from Bridgewater to Halifax, always lying on the Halifax surface. Goldthwait goes on to point out that these beds seem always to be overlain by kame gravels, and the glacial debris at the Martins River exposure does indeed seem to be outwash deposit, formed ahead of the advancing ice front. If this is the case, the sharp break between the cemented gravels and the uncemented outwash above is hard to explain, since the line is sharp, and can be exposed with a little digging. In the one contact cleaned out along the Martins River, the overlying uncemented gravels lie on a rough surface, or unconformity, and this implies either two advances of the ice sheet, or a pre-glacial age for these cemented gravels.

CHAPTER III

GEOPHYSICAL WORK IN THE ANTIGONISH QUADRANGLES

During the summer of 1952, a gravity-meter and magnetometer survey was made along a narrow belt extending from Monks Head to the south-east beyond Antigonish in the Antigonish Quadrangles. This work was done by the Seismograph Service Corporation at the request of the Nova Scotia Government and the results of this survey have been published by Pohly (1952). A summary of this survey is presented here because it brought to light interesting data which bears upon the structural problems within the Antigonish Basin.

Magnetic highs were located a bit south of the large exposure of granite at Dunns Point, with a shoulder extending to the north-east towards the south end of Captain Pond. Another high was locateddirectly across the Harbour, extending northward from the mouth of the North River inlet. Another high was located on Williams Point, in a dog-leg shape, extending north-eastward in the direction of the igneous outcrops, and due south. All of these magnetic highs coincide with the location of igneous bodies of granite of grano-diorite, except the southern extension of the Williams Point high. Pohly has considered (ibid, p. 125) that this may indicate the southward extension of the Williams Point igneous mass, with the grano-diorite lying near the surface just west of the road bridge at South River. The surface geology at this magnetic high shows Windsor and Canso beds dipping eastward, and perhaps cut by the southward extension of the South Side fault. Probably this high, as well as the magnetic high at the inlet to the North River represent buried monadnocks on the pre-Horton, or pre-Windsor surface.

Residual gravity maxima coincide with the magnetic highs along the line of igneous outcrops from Dunns Point to Williams Point, and are explained by the presence of the igneous rocks. Three other gravity highs are present west of the igneous line which do not correlate with magnetic highs. These are located at the entrance of the West River into Antigonish Harbour, on the north-west shore of Williams Point, and about one half mile north-west of the North River inlet. This last may be associated with the magnetic high near the North River inlet. Fohly (ibid, p. 125) has pointed out that these must represent a density increase within the sediments, rather than from basement rocks, and points out the similarities with the Niagaran bioherms are known within the Windsor Group. The writer does not believe that such a development will be found at this location. These gravity highs occupy the site of what may have been the inlet and deepest pass into the south-east end of the Antigonish basin during Windsor times. It is possible that marine life developed thick beds at this point, and corals may even have been present to add to the deposits, but the writer does not feel that such a condition would lead to a measurable gravity high. In fact no definite answer is known for these gravity highs.

West of the igneous line, four gravity highs are present. Three of these line up along the Monks Head anticline and Monks Head fault. Just how far to the east of this line stations were occupied in determining gravity readings is not known, but likely, this represents the eastward limit of gravity-meter stations. The writer believes that these three highs represent the extra density of the Pennsylvanian beds which are present at the surface along the fault. They do not seem to indicate that the Monks Head fault is diapir in type, with abnormal flowage of salt into the axial region of the anticline, since additional salt in the anticline should produce a gravitational low.

The fourth gravitational high, lying between Monks Pond and Captain Pond does not seem to tie in with any surface geology, for at this high, the strata are dipping westward from the Monks Head anticline. The magnetic nose extending from the Dunns Point igneous area dies out before reaching the gravitational high.

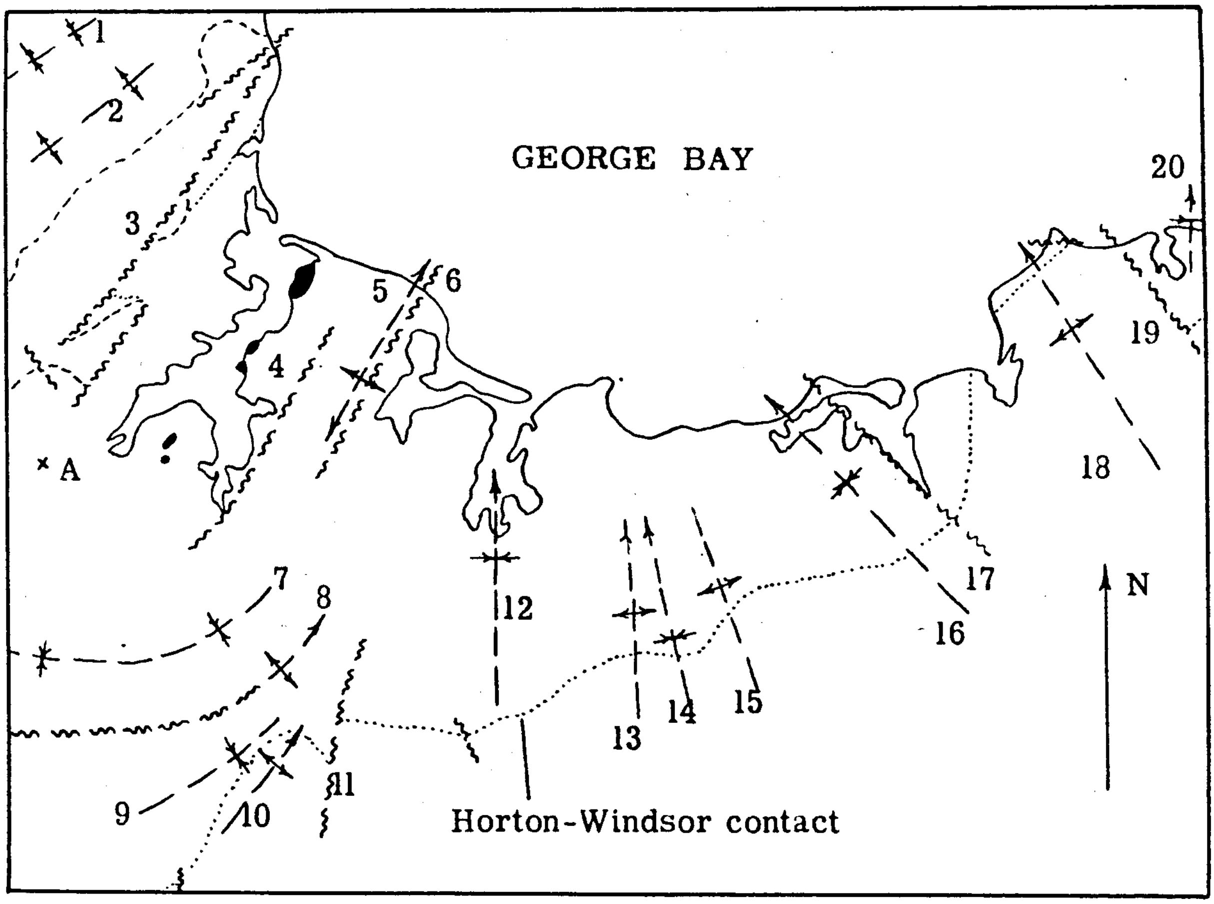
A distinct gravitational minimum coincides with the area around the drill holes which outlined a salt body in the South Side Antigonish Harbour area, and another smaller minimum located near the railroad trestle across South River may indicate another region underlain by salt.

STRUCTURAL HISTORY OF THE ANTIGONISH QUADRANGLES

The structural pattern with the Antigonish Quadrangles is based upon detailed field work in the western half of the map-area, and upon a rapid survey of the eastern half. Windsor exposures have been examined with care throughout the map-area, but the attitudes of the Windsor beds cannot be depended upon to give an accurate picture of regional structures, since Windsor beds have acted independently in response to forces applied to them.

The sketch map on the following page is designed to show the location of major structural features, and includes the location of major igneous bodies, the boundary between the Horton Group and older metamorphosed Paleozoic sediments, and the Horton-Windsor, or Horton-Canso boundary. Most of these features are mapped more accurately on the large geological map of this thesis, but included on this small map and not on the large map are several structures in the east half of the map-area which may later prove to be slightly out of place. These features include several gently rolling anticlines and synclines, the Bayfield Road A/C, the Afton S/C and A/C, the Tracadie S/C, the Rowman Head Fault, the Cape Jack A/C, and the Havre Boucher Fault and A/C. Of this group, only the Havre Boucher fault is included on the large map.

The structural history of this Carboniferous basin begins with the Acadian Disturbance, when the large block of Paleozoic metamorphosed sediments, which now make up the Pictou-Antigonish Highlands was uplifted, probably through fault action, leaving a depressed basin south-east of this higher land. Into the Antigonish basin were dumped over a mile of Horton conglomerates and sediments. Examination of the Horton beds (Sage, 1951) indicates that the streams which deposited this clastic wedge flowed eastward and southeastward from the Pictou-Antigonish upland, and northward from the Southern Upland, with the main source of sediments from the east. Two great alluvial fans appear to have met along a north-east line drawn through the center of the map



MAJOR STRUCTURES ANTIGONISH QUADRANGLES

1. Big Marsh S/C
2. Ogden Brook A/C
3. Crystal Cliffs Fault
4. South Side Fault
5. Monks Head A/C
6. Monks Head Fault
7. Beech Hill S/C
8. Pinedale Fault and A/C
9. Dunmore S/C
10. Glenroy A/C
11. Marydale Fault
12. Pomquet S/C
13. Bayfield Road A/C
14. Afton S/C
15. Afton A/C
16. Tracadie S/C
17. Bowman Head Fault
18. Cape Jack A/C
19. Havre Boucher Fault
20. Havre Boucher S/C

Igneous outcrops shown in solid black.

Figure 12

area. The Sugarloaf ridge was low lying at this time, allowing Horton beds to be laid down east of the Sugarloaf ridge.

In late Horton time, the first movement along the Crystal Cliffs fault took place, turning the Horton beds east of the ridge on their side, with steep dips into the basin now occupied by George Bay. Locally a basal sharpstone conglomerate of Windsor age is present along the western map-area. Following this fault activity, was the first invasion of the Windsor Sea, and into the basal limestones were washed large amounts of sand and silty material, to provide the laminations present in all exposures of the basal limestone. The deformed upper zone of the A_1 limestone in the Crystal Cliffs section is taken by the writer to indicate more activity on the Crystal Cliffs fault, causing slumping in the more steeply tilted limestone beds, and brecciation of some sections of this limestone to form the sharpstone limestone-conglomerate. Final movement along this fault is at least post-Lower Windsor, for gypsum beds in the North River area, which lie considerably below the Metamorphic highland, and in places aresepareted from the metamorphic rocks by the fault, contain no silt, or other indications that when formed, a ready source of silt and clay particles lay immediately beside them. Final movement is probably post-Windsor at earliest.

During B subzone time, the igneous bodies making up Williams Point and Dunn's Point, and the basement for the limestone deposit on Quarry Point, within Antigonish Harbour, must have been exposed above sea level, forming islands within the Antigonish arm of the Windsor sea. Sharp fragments of the igneous material, either grano-diorite from Williams Point, or granite from Quarry Point are included in the limestone beds. The shape of the fragments testifies to a mechanical weathering and rapid burial. The B_1 limestone originally completely buried these igneous peaks, and evidence for further burial under Windsor sediments is missing. For upper A subzone and lower B subzone times a lowering in the level of the Windsor sea is indicated.

This evidence is shown in the south-east Windsor sections where, in the Monastery Brook section, the B_2 limestone was apparently deposited unconformably on gypsum which overlaid the Ribbon limestone. The missing section may be faulted out, but it does not appear this way in the field. The general level of the Windsor sea seems to have been regained in the Antigonish area; but no post-Ribbon limestones are known to crop out at a point farther inland the basal Windsor.

At the end of Windsor time, the Tracadie-Havre Boucher region appears to have been subject to stresses, lowering it in relation to the western map-area, and at the same time imposing the anticlines and synclines upon the then present surface. The Canso beds were deposited unconformably over the entire south-eastern shore line, while they appear to be conformable with the Windsor in the West River and Beech Hill area.

The development of the Cape Jack anticline probably continued through Canso times but timing the Havre Boucher fault presents a problem. Only Horton beds along the Havre Boucher River are seen to be badly disturbed. The small outcrop of Windsor visible in the river does not indicate its attitude, nor whether deformed or not. And on top of the probable fault trace, the glacier has deposited a rather large esker. Windsor and Canso beds on Cape Jack are faulted, by what the writer takes to be a minor cross fault, associated with the larger Havre Boucher fault. Canso beds in a small syncline east of Havre Boucher have the same lithology as those at Barrio and Bowman Head, and show no increase in clastics. Presumably then the fault at Havre Boucher, which is not yet proved, but which seems probable, made its appearance after the deposition of the Canso, and likely belongs in the same time of deformation as the major features in the central part of the Antigonish basin.

Although little Pennsylvanian material is preserved in the Antigonish basin today, it presumably occupied a much larger area, and has since been removed by erosion.

The remaining faults and folds appear to have been formed at a period later than the deposition of Pennsylvanian beds. The age of the coarse material on the east end of Monks Head is not known, nor is the age of the small pair of coal seams on the edge of Pomquet Harbour. Since this Monks Head material is conglomeratic, the writerbelieves that it represents the beginning of either the Pictou or Cumberland Groups, and favors the former. This would make the coal seams Cumberland in age, and indicate that only a thin Riversdale Group was present in the Antigonish basin, unless the Canso-Riversdale boundary is set too high by this paper, and this also is likely.

The development of the Monks Head fault, the South Side fault and the Pinedale fault is therefore tentatively dated as being post-Cumberland, and a part of the Appalachian Revolution. Final movement of the Crystal Cliffs fault may be assigned to this period.

Block faulting of the basement is taken as the cause for the Crystal Cliffs fault. The south-eastern edge of the Sugarloaf ridge has been raised relative to the adjoining, Windsor-covered area. The Horton sediments north-west of this ridge have been compressed by this action, and thrown into the Ogden Brook anticline and the Big Marsh syncline. The sharp fold of the Big Marsh syncline indicates there was very little cover at the time of this deformation. Field work west of Antigonish may indicate an extension of the Crystal Cliffs fault as far as James River, with Windsor overlap hiding the fault surface exposure.

A second basement block is thought to have broken in post-Pennsylvanian times, this unit including the Williams Point, Quarry Point, and Dunn's Point intrusive masses; the main break was the Monks Head fault. The

South Side fault is minor compared with the Monks Head break, and its extension to Captain Pond is based on stratigraphy rather than direct evidence. As this second large block was elevated along its south-eastern edge, minor slices sheared off, causing the shuffled section at Monks Head, and flowage of the salt is likely, although not supported by geophysical work.

Another fault was developed en-echelon with the Monks Head fault. This is the Pinedale fault, which extends into an anticline, and differs from the Monks Head structure, where the fault and the anticline lie adjoining. The difference probably lies in the manner of formation, for the Pinesdale fault appears to be a true diapir, or piercement structure. The line of salt springs along the anticlinal end of this fault seems to bear this out.

One pair of faults does not tie in with other structures and this pair includes the Marydale fault and small fault on the south-east map border. Movement appears to have been lateral, rather than vertical. In the faulting, the Canso cover to the Windsor in the Pomquet River has been removed, and the Windsor has been thrown into a number of folds and faults, all of which trend at right angles to major structural lineations. This type of action is characteristic of the Windsor beds, and does not carry over into overlying Canso, or underlying Horton beds.

STRUCTURAL HISTORY OF THE MAHONE BAY - ST. MARGARET BAY AREA

The chief structural developments within this map-area have taken place well before the deposition of the thin patches of Windsor strata which are scattered along the shores of the two large bays. Such developments include, in historical order:

1. Folding of Meguma Series into tight anticlines and synclines.

2. Intrusion by a large granite batholith, which seems partially responsible for the folding of the Meguma beds.

3. Mineralization of fractures and anticlinal saddles of the Meguma Series with gold-bearing quartz, possibly an end phase of the granite intrusion.

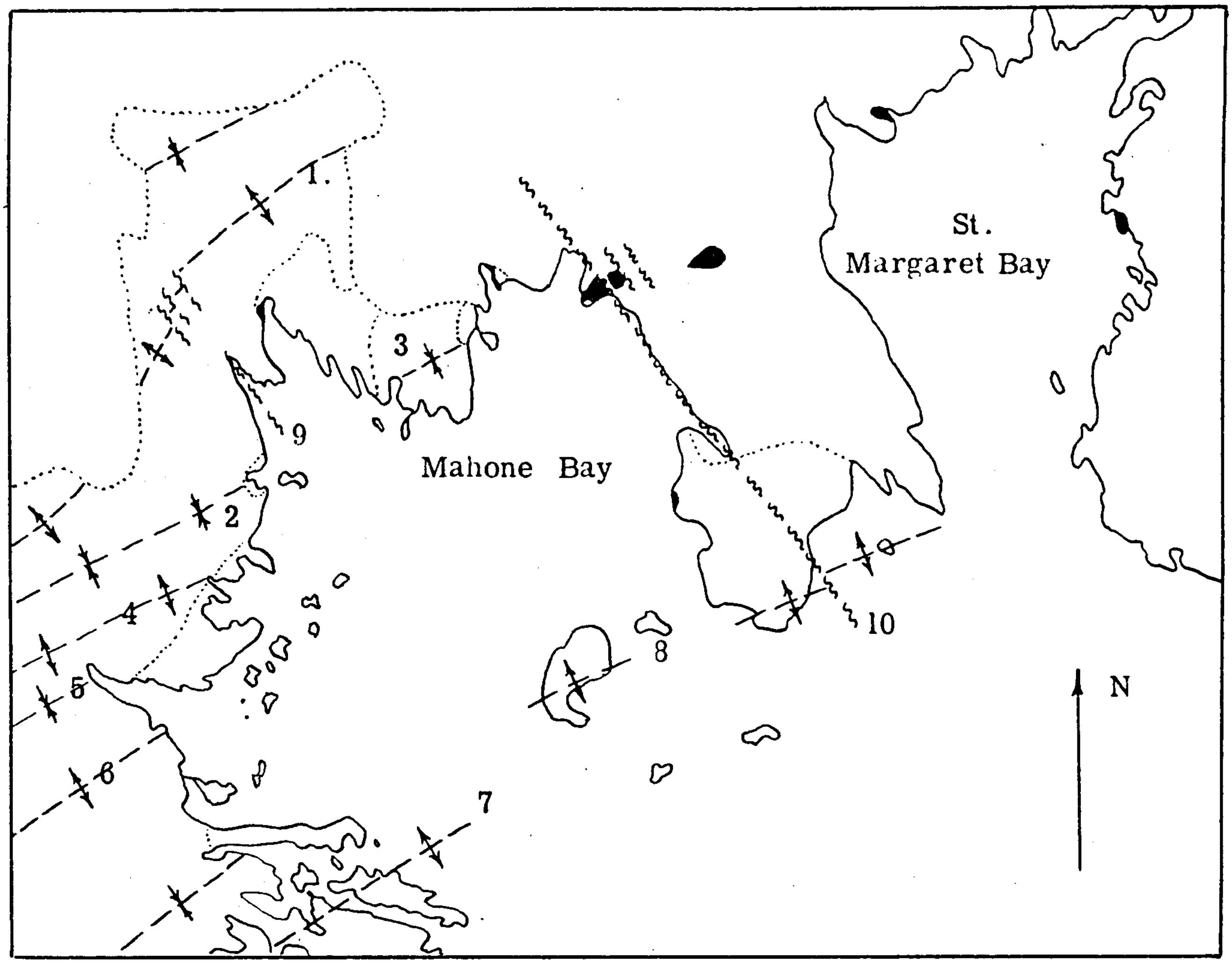
4. Uplift and erosion of pre-Windsor sediments.

Only two sets of faults have any bearing upon the Windsor problem in this area, and they may be termed the Gold River faults and the Deep Cove group of faults. The age of the Deep Cove fault, and the two minor faults shown east of it on the sketch map on the following page, is clearly post-Windsor, since these faults move the Windsor beds into three separate levels in the East River area. The Deep Cove fault also provides for considerable offset of the Tancook anticline.

It is not possible to date the Gold River fault system as being definitely post-Windsor, since no Windsor, or later strata are seen being cut by these faults. However, in view of offset of the Tancook anticline from the Long Island anticline, and a slight offset to the Goldenville-Halifax boundary just south of the road bridge across the Gold River, and minor offsets of the Gold River anticlinal axis, the movement of this fault system is comparable to that of the Deep Cove faults. In both areas, the eastern side of the fault has moved up relative to the western side of the fault. The northern dip of the axial planes of the folds accounts for the apparent lateral movement, except in the case of the Halifax-Goldenville contact, where the beds are dipping at about 70 degrees to the south, and lateral movement is necessary to account for the slight offset. Since these fault systems are parallel, and behave similarly, the writer believes that they were formed at the same time, that is, post-Windsor.

Examination of literature on these faults indicates that they cut the gold-bearing quartz veins, and are not therefore, part of that earlier mineralization, thought to be late Devonian.

No Horton beds are known in the area, and Windsor outcrops are plastered



MAJOR STRUCTURES MAHONE BAY - ST. MARGARET BAY AREA

1. Gold River A/C
2. Western Shore S/C
3. Chester S/C
4. Blockhouse A/C
5. Mahone Bay S/C
6. Rhodes Corner A/C
7. Long Island A/C
8. Tancook A/C
9. Gold River Fault
10. Deep Cove Fault

Windsor Group limestone outcrops shown in solid black.

Figure 13

directly upon Goldenville, Halifax, or Devonian rocks. Presumably this area was exposed to erosion until Windsor times, when it subsided relative to sea level and allowed the deposition of Windsor beds to overlap upon the low lying shores. That the main body of Mahone Bay, with its many drumlin-islands, is also underlain by Mississippian limestone, is evidenced by the vast number of limestone boulders found in the drumlins. East of the line of the Gold River faults these boulders are B subzone in age for the most part, with a few blocks of E subzone. West of the fault line the blocks are chiefly E subzone limestones. No limestones are present, as outcrops, or boulders, which can be assigned to either the C or D subzones; they either were not deposited within this map-area, or as the writer has already indicated, may possibly have been eroded from the eastern half of Mahone Bay following uplift by the various faults, while remaining buried and protected by E sub-zone limestones on the western half of Mahone Bay. The evidence is not conclusive for either case. However, if the Mahone Bay - St. Margaret Bay area is the site of the former inlet into the Windsor sea, C and D subzone fossils must be present somewhere in the region. In fact, the writer feels that their absence is strong evidence that they never were laid down in this area, despite the apparent movement on the Gold River faults.

CHAPTER IV

DISTRIBUTION, ECOLOGY AND RELATIONSHIPS OF WINDSOR FORAMINIFERA

The marine limestonesof the Windsor Group contain a large fauna of foraminifera. Ten genera of foraminifera have been briefly described in Chapter V of this thesis, without attempting to relate these forms to previously described species. Definite information concerning the distribution of these forms is not known at this time since foraminiferal collections are incomplete from many horizons and locations. The table below shows the distribution as it is now known for the Windsor Group.

	Faunal Subzones				
	A	B	C	D	E
Textularia sp.					x
Climacammina sp.					x
Ammodiscus sp.					x
Ammovertella sp.					x
Glomospira sp.			x		
Tetrataxis sp.					x
Haplophragmium sp.					x
Plectogyra sp.			x	x	x
Endothyra sp.					x
Millerella sp.					x
Nodosinella priscilla (Dawson)		x	x		

The distribution of these forms laterally within a single horizon is marked. In the oolitic beds, which seemingly were deposited in open and shallow seas, the foraminifera are scarce, and although a few fragments are seen to make up the nucleii of the oolites, complete specimens are rare. In beds of similar age, but laid down in protected regions, such as behind the igneous peaks in the Antigonish Quadrangles, or within the coralla of the colonial corals, numerous specimens are found, and over a hundred individuals may be present in a single thin section. These forms are definitely a facies fauna, and should be looked for in protected sites.

The only foraminifera which were collected from the type section at Windsor, Nova Scotia were found accidentally while making a thin section of a cup coral Caninia sp. Mud had filled the calice and preserved large forms of Endothyra and Plectogyra. The foraminiferal fauna present in the type section has yet to be studied, and probably a more varied distribution by faunal subzones will be found.

In studying the foraminifera it has been necessary to use thin sections entirely. Most forms average about .30 millimeters in large diameter, although Climacammina sp. may be slightly over 1 millimeter in length, and visible to the eye. Polished sections have not proved worthwhile and many specimens are not seen at all in a polished section. The ten genera described in this thesis represent about half of the forms thought to be present. Unnamed and unfigured forms belong to the two families AMMODISCIDAE and TEXTULARIIDAE.

It has been impossible to identify foraminiferal forms specifically and the identity of Haplophragmium is questionable. However, the Windsor Group forms are very close to forms from the Lower Carboniferous limestones described by H. B. Brady (1876), and from a comparison with Brady's figures in the 1876 publication, it is evident that the Windsor fauna is nearly identical with the Scotch fauna of the Lower Carboniferous limestones.

The specimens of Endothyra, Plectogyra and Millerella from the Windsor are also closely comparable with similar forms from the Chesteran type section in the United States. The forms found in the E subzone in Nova Scotia most closely resemble forms from the Paint Creek formation and the Glen Dean formation, of the type Chesteran, and on this basis the upper limit of the Windsor Group seems to be the approximate time equivalent of the Middle Chesteran.

In the Mahone Bay area, E subzone foraminifera are present in almost all the limey beds but are missing from sandy beds. They are found with Giganto-productus as well as with the reef-coral fauna, and die out at the same time as Gigantoproductus. It is thought by the writer that shoaling of this region in very Upper Windsor times caused a change in the salinity, with the water becoming brackish. Only algal growths are found in the upper six feet of E subzone in the Mabou Bay area, and they could well survive the brackish water and in fact, appear to have thrived in these waters.

E SUBZONE DEVELOPMENT OF CORALS AND GIGANTOPRODUCTUS.

From a study of the numerous E subzone limestone boulders in the Mahone Bay area, and from the Gaetz Cove limestone outcrop, it has been possible to reconstruct the uppermost twenty feet of the E subzone for the Mahone Bay area. This incomplete section has already been given in Chapter II of this thesis, and is summarized below:

(c) Algal zone . . . . 6'

(b) Gigantoproductus zone . . . . . . 10'

(a) Coral zone . . . . 4'

From the number of boulders containing Upper Windsor, E subzone fossils which do not fit into this scheme, there must be a portion of E subzone lying below the Coral zone, about which little is known. Thickness, fauna, general lithology can only be guessed at; the writer believes this to be an extension of the coral zone, with a brachiopod fauna, but containing many of the reef-coral fauna found in the (a) beds above; no reasonable guess as to the thickness of this missing section can be made.

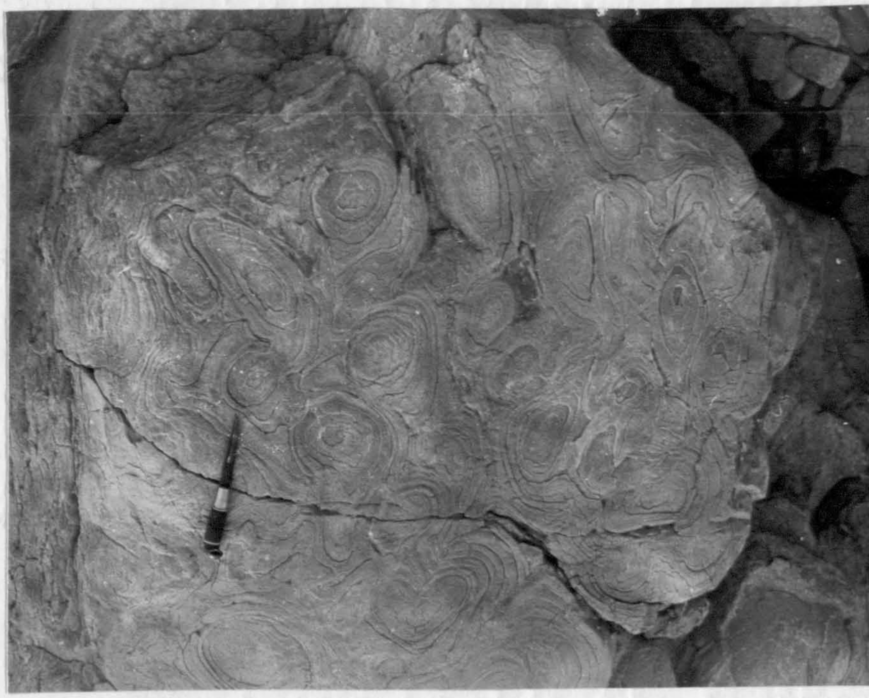
The boundary of the Gigantoproductus and Coral zones is not sharp, and the large brachiopods are found with the following corals: Lithostrotion sp., Koninckophyllum cf. interruptum, Thysanophyllum cf. orientale, Syringopora sp., Pseudoromingeria (?) sp., and Diphyphyllum (?) sp. The remainder of the corals from the E subzone of the Mahone Bay area are not found in boulders containing Gigantoproductus, but are associated with common forms of foraminifera, namely Endothyra, Plectogyra and Millerella which are also found in the Gigantoproductus zone. These corals not found with the Gigantoproductus presumably lie just below them.

The earliest forms of Gigantoproductus sp. are smaller than the forms which predominate the Gigantoproductus zone. They have thinner shells, are flatter, and roughly half the size of the large forms. They presumably are ancestral to *Gigantoproductus* sp. and may differ generically as well as specifically. The writer did not collect any material of this form which is well enough preserved to be studied for this type of information.

The large brachiopods in the *Gigantoproductus* zone are characteristically preserved in bands with many individuals, separated by bands with but few, or no individuals. These separate bands run from 2 inches to 12 inches or more in thickness, and are clear cut lines. Some thirty boulders were measured by the writer, and an attempt made to correlate these boulders one with another. The minimum number of bands into which all the measured boulders would fit was ten bands, with a stratigraphic thickness of about ten feet. The thickness of the *Gigantoproductus* zone could be substantially thicker.

The evidence for the algal zone comes from Gaetz Cove, where a few *Gigantoproductus* specimens were found at the base of the algal zone. Only 6 feet of algal material could be found by the writer. Thin sections were made of several specimens and no other forms of life were found. The absence of even the foraminifera is taken by the writer to indicate brackish water conditions, which followed the elevation of the sea bottom, and which seemingly were responsible for the extinction of *Gigantoproductus* sp.

Locally within the coral zone sandy beds have developed, and several large boulders representing the *Gigantoproductus* zone are sandy. Only *Lithostrotion* sp. of the corals was found in really sandy beds; whether this coral could tolerate the sandy waters, or whether this represents a freak of preservation is not known.



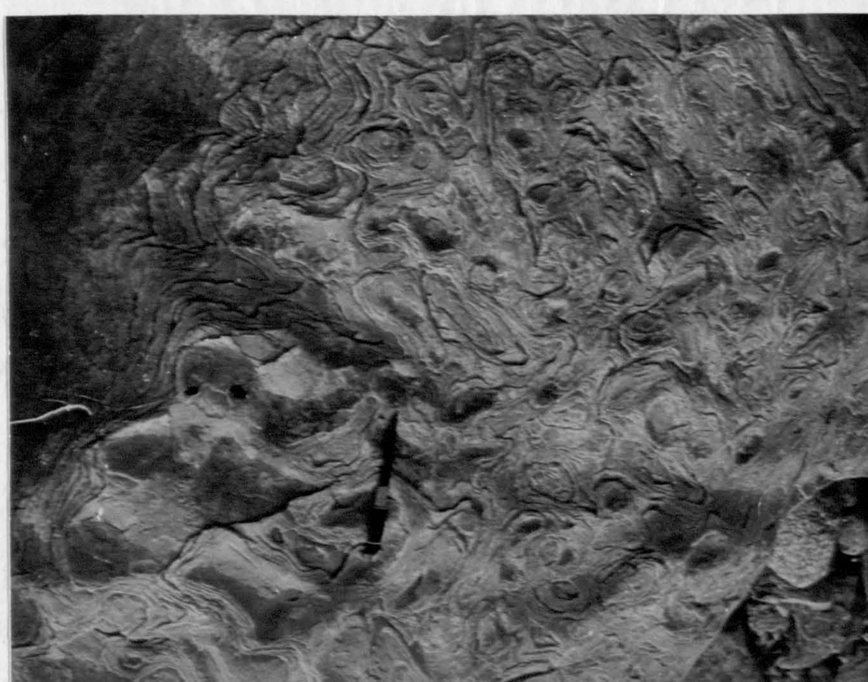


FIGURE 14

The two views show the weathered surfaces to two boulders from Gaetz Cove, Mahone Bay area. The knife shown in the prints for scale is 8 1/2 inches long. These beds belong to the Algal zone of the Upper Windsor B subzone, and represent the youngest beds of Windsor age in the Mahone Bay -- St. Margaret Bay area.

CORRELATIONS OF THE WINDSOR GROUP

Correlations within the Windsor Group are summarized on figure 11 on this thesis. Although faunal occurrences vary somewhat throughout the Windsor area, so that an individual fossil may not be strictly characteristic of a fixed set of faunal subzones, the fauna as a whole remains constant throughout the Windsor areas for certain subzones. Variations are based upon facies changes, with the more marine beds being present in the south-west part of the Windsor areas.

The only correlation within the Windsor Group which does not fit particularly well is that of correlating the A_2 limestone of the Antigonish Quadrangles and Cape Breton Island with the A subzone of the type section. The sequence of beds would be more comparable in the two areas if the A_2 were correlated with the Macumber limestone of the type section. However, there have been no fossil discoveries in the A_2 limestone from either Cape Breton Island or the Antigonish Quadrangles, and the writer feels that the present correlation, based upon Stacy's work on Cape Breton (Stacy, 1952), should stand until a fossiliferous A_2 limestone bed is found.

Correlations of the Windsor Group with strata outside of Nova Scotia have been worked out by Bell (1929, p. 71-74). On the basis of brachiopod comparisons, and by comparing the corals and bryozoan Tabulipora acadica Bell from the type section, Bell has shown that the E subzone of the Windsor Group is the correlative of the D_2 zone of the Lower Carboniferous series of Great Britain, and that the B subzone of the Windsor correlates well with the S_2 zone of the Avonian sequence in Great Britain.

Similar comparisons with the Mississippian type section indicate that the Windsor Group bears close affinities to the Meramecian and Chesteran series of this section (Bell, 1929, p. 73-74).

None of the fossils described in this thesis can be said to refute Bell's correlations, in fact the reef-coral fauna, and the foraminiferal fauna support these correlations, and perhaps allow an even closer tie in with the British Visean. The correlation of the Gigantoproductus zone offers the only problems.

Dorothy Hill (1937-1941, p. 3-32) has shown that three distinct fauna of Rugose Corals may be found in the Carboniferous. These she has called 1) The Cyathaxonia Fauna, 2) the Caninid - Clisiophyllid Fauna, and 3) the Reef-coral Fauna. The first fauna is not recognized in Nova Scotia, although one member which may be assigned to this fauna, Triplophyllites gmisdilleni var. minor, is found without other corals, in a zone of the Kennetcook limestone in the Windsor type section.

The second fauna, the Caninid - Clisiophyllid Fauna represents the fauna from seas with shallow waters, and well oxygenated bottoms which are reasonably free from terruginous matter. This fauna is present in Nova Scotia in both the C subzone and the E subzone and was located within the interior Windsor Sea. The maximum development of this fauna was in the type section, but a few members of this fauna are found in Cape Breton Island (Stacy, 1952) and even fewer members have been found in the Antigonish Quadrangles. The increase in detrital sediments appear to have retarded the northward spread of this fauna. Members of the Windsor Group of fossils which can be assigned to this fauna include the following:

Caninia juddi var. dawsoni

Diphyphyllum lambii

Koninckophyllum θ Vaughan

Koninckophyllum cf. interruptum

Bothrophyllum sp.

When compared with the faunal groups of the British Visean, these corals seemingly are equivalent to similar forms from Great Britain which are found in the upper D_1 zone (Windsor C subzone) and the upper D_2 or lower

D_3 zone of Garwood, (1912 p. 482) (Windsor E subzone).

The third fauna, the Reef-coral Fauna, is found in the Mahone Bay area in the E subzone of Upper Windsor. Two members of the Caninid - Clisiophyllid Fauna are associated with it. Corals which can be assigned to this fauna from the Mahone Bay area include the following:

Corwenia (?) sp.

Diphyphyllum (?) cf. lateseptatum

Lithostrotion sp.

Lonsdaleia cf. pictoense

Lonsdaleia sp.

Thysanophyllum sp.

When compared with the British corals, the Mahone Bay reef-coral fauna correlate with the upper D_2 and lower D_3 beds of the British Carboniferous.

The Windsor Gigantoproductus zone following as it does the reef-coral fauna, seemingly should correlate with other Gigantoproductus zones. The British Gigantoproductus zone appears near the upper limits of the D_2 zone (Garwood, 1912, p. 482) in the northwest of England, but Dixon (1911, p. 549) indicates the occurrence of this zone in the D_1 zone of the Visean in south-west Wales. In the United States the exact location of the Gigantoproductus zone is not clear, but Weller et al (1952, p. 115) indicate that these brachiopods are Meramecian in in age. From a comparison of the Nova Scotian Gigantoproductus with the collection in the United States National Museum, it is apparent that many species of these brachiopods exist, and it seems reasonable to presume that they may have lived at different times, and therefore cannot be correlated on a generic basis.

Considerably more work should be done on the foraminiferal fauna of the Windsor Group before it is used for correlation purposes. However, these forms are rather distinctive and seem most closely related to forms from the Lower Carboniferous of Scotland and England. The exact zoning of these European forms is not known to the writer. Another group of foraminifera is present in the type Chesteran of the Mississippi valley, and comparable forms to the Nova Scotian E subzone specimens are described and figured by Zeller, E. J. (1950) and Zeller, D. (1953). Similar specimens of Plectogyra sp. and Millerella sp. are found in the Middle Chesteran strata and the Windsor E subzone beds. Chesteran beds with these similar forms include the Paint Creek formation and the Glen Dean limestone.

FAUNAL DISTRIBUTION

The numbers which follow fossil names refer to the Windsor sections described in this thesis. These are as follows:

1. Mahone Bay - St. Margaret Bay Area.

3. West River section.

4. Milk Plant section.

5. Crystal Cliffs Section.

6. Quarry limestone and drill holes, South Side Antigonish Harbour.

7. Monks Head section, including the E_1 limestone of the Saw Mill section.

8. Pomquet River; only ostracodes have been found in these beds, with the exception of Linoproductus lyelli (Verneuil) and Composita dawsoni (Hall and Clarke) from the B_3 horizon.

9. Monastery Brook section; no fossils have been identified from limestones in this section.

The distribution of Foraminifera is omitted from this listing but given under a seperate heading, Distribution, Ecology and Relationships of Foraminifera. Ostracodes are abundant in subzones B, C, D, and E. Several species may be present but Paraparchites gibbus Bell is the only species known to the writer from these horizons.

A Subzone

Dielasma (?) sp. 5
Schizodus (?) sp. 5

B Subzone

Conularia planicostata Dawson 1, 6
Spirorbis caperatus McCoy 6
Septopora primitiva Bell 1, 6
Linoproductus lyelli (Verneuil) 6, 7, 8
Diaphragmus tenuicostiformis (Beede) 1
Pugnax dawsonianus (Davidson) 6
Romingerina anna (Hartt) 6

Continued on next page.

B Subzone fossils (continued)

Composita dawsoni (Hall and Clarke) 1, 6, 7, 8
Composita windsorensis Bell 8
Beecheria sp. 1, 6, 7
Sanguinolites parvus Bell 6
Grammatodon sp. 6
Leptodesma dawsoni (Beede) 6, 7
Leptodesma acadica (Beede) 6, 7
Aviculopecten lyelli Dawson 6, 7
Anematina (?) sp. 6
Anematina minuta (Bell) 7
Stegocoelia abrupta Bell 6
Stegocoelia compactoides Bell 7
Straparollus minutus De Koninck 1
Platyschisma (?) dubium Dawson 7

C Subzone

Linoproductus lyelli (Verneuil) 7
Linoproductus semicubiculus (Bell) 7
Ambocoelia sp. 7
Martinia galatea Bell 7
Pseudamusium debertianum (Dawson) 7
Edmondia sp. 7

D Subzone

Schellwienella sp. 7
Linoproductus lyelli (Verneuil) 7
Martinia galatea Bell 3, 7
Martinia thetis Bell 7
Bellerophon sp. 7
Diodoceras avonensis (Dawson) 7

E Subzone

See following page.

E Subzone

- *Caninia juddi var. dawsoni* (Lambe) 3
- *Dibunophyllum lambii* Bell 4
- *Bothrophyllum (?)* sp. 1
- *Koninckophyllum cf. interruptum* Nicholson and Thompson 1
- *Koninckophyllum* sp. 1
- *Lonsdaleia pictoense* (Billings) 1
- *Lonsdaleia* sp. 1
- *Lithostrotion* sp. 1
- *Diphyphyllum (?) cf. lateseptum* McCoy 1
- **Diphyphyllum (?) cf. furcatum* Thompson 1
- *Heterophyllia* sp. 1
- *Thysanophyllum cf. orientale* Thompson 1
- *Corwenia (?) sp.* 1
- *Syringopora sp.* 1
- *Pseudoromingeria (?) sp.* 1
- *Schuchertella sp.* 7
- *Schellwienella sp.* 1
- *Linoproductus lyelli* (Verneuil) 1, 7
- *Productus cyonensis* Bell 1, 3, 7
- *Pugnax sp.* 7
- *Camarotoechia atlantica* Bell 1, 7
- *Pugnoides (?) sp.* 3
- *Allorhynchus hartii* Bell 1 (Subzone doubtful)
- *Composita dawsoni* (Hall and Clarke) 1, 7
- **Spirifer cf. nox* Bell 1
- **Spirifer cf. adonis* Bell 1
- *Ambocoelia cf. acadica* Bell 7
- *Martinia galatea* Bell 1, 3, 7
- *Beecheria* sp. 7
- *Hortella gibbosa* Bell 1
- *Gigantoproductus* sp. 1
- **Edmondia hartii* Dawson 1
- *Schizodus cf. denysi* Beede 7
- *Spathella insecta* (Dawson) 7
- *Bellerophon sp.* 4
- *Bulimorpha (?) sp.* 7
- *Stegocoelia sp.* 7
- *Orthoceras sp.* 1

* Found in a single boulder on Goat Island, Mahone Bay, with *Gigantoproductus sp.*

LOCALITY INDEX

1-1, Kennetcook limestone, Windsor type section.

1-2, New Glasgow district, subzone doubtful, probably E.

1-3, B_1 limestone at Dingwall, Cape Breton Island.

1-33, E_1 limestone, West River Section, Antigonish County.

1-35, D_1 limestone boulder, West River Section, Antigonish County.

1-48, C subzone, Pomquet River Section, Antigonish County.

1-69, E(?) subzone, outcrop in stream bed which flows into Antigonish Harbour from south-west slope of Williams Point, Antigonish Co.

1-78, "Schizodus" limestone, E subzone, Hood Island.

1-C9, Boulders from Lynch Island, Mahone Bay.

1-C10, Boulders from Birch Island, Mahone Bay.

1-C12, Boulders from Rouse Island, Mahone Bay.

1-C13, Boulders from Goat Island, Mahone Bay.

1-C14, Boulders from north shore of Second Peninsula, Mahone Bay.

1-A-15, Quarry limestone, B subzone, South Side Antigonish Harbour.

1-60, E_1 limestone, Milk Plant Section, Antigonish County.

0-H-12, E Subzone, Hood Island.

0-14, Same as 1-C13, boulders from Goat Island, Mahone Bay.

0-27, East tip of Second Peninsula, Mahone Bay.

0-29, South-east tip of Second Peninsula, Mahone Bay.

0-90, Boulders from Saddle Island, Mahone Bay.

0-99, Redman Hill, St. Margarets Bay.

0-119, Same as 1-C14, Second Peninsula, Mahone Bay.

0-125, Same as 1-C9, Boulders from Lynch Island, Mahone Bay.

CHAPTER V

DESCRIPTION OF GENERA AND SPECIES

Bell's faunal descriptions in Memoir 155, Norton-Windsor District, Nova Scotia, 1929, include 129 species from the Windsor Group. Stacy (1952) has amended 8 generic or subgeneric names, i.e. _Fenestrellina_ (Bell's _Fenestella_), _Serpula_ (Bell's _Serpulites_), _Productus_ (Bell's _Diaphragmus_), _Linoproductus_ (Bell's _Productus_ in part), _Beecheria_ (Bell's _Dielasma_), _Grammatodon_ (_Parallelodon_)(Bell's _Parallelodon_), _Stegocoelia_ (Bell's _Murchisonia_), and _Flemingia_ (_Anematina_)(Bell's _Flemingia_).

In addition Stacy has described from Cape Breton Island five species new to the Windsor Group. An unidentified bryozoan, an unidentified tabulate coral, and three brachiopods, _Avonia_ (?) sp., _Shumardella_ (?) sp., and _Punctospirifer_ (?) sp.

Of these new changes many are based upon new taxonomic revisions. The dropping of Bell's _Diaphragmus_ in favor of Muir-Wood's (1928) _Productus_, as emended, by Stacy is incorrect. _Productus_ has a flaring trail and _Diaphragmus_ a stiff and non-flaring trail. The genus _Diaphragmus_ is not found in European beds and seemingly was not studied from specimens by Muir-Wood until after the 1928 paper. Bell's _Diaphragmus_ _tenuicostiformis_ (Beede) should be returned to proper usage.

In the following fossil description, 10 foraminifera are described for the first time for the Windsor Group. In addition, eighteen corals are listed and all but one figured. Of the eighteen species, ten are new for the Windsor Group, and new localities have been reported earlier in this thesis for many of the other corals. A nineteenth coral was reported by Lewis (1935, p. 135, _Koninckophyllum_ _cf._ θ Vaughan), and is not figured in this paper.

Two brachiopods are described and figured, including *Gigantoproductus* sp., and two gastropods are described.

PHYLUM PROTOZOA

Order FORAMINIFERA

Family TEXTULARIIDAE

Subfamily Textulariinae

Genus *Textularia* Defrance 1824

Textularia sp.

Plate I, figures 1, 2, 3, 4 (All figures x 70).

Horizon: E subzone, Upper Windsor; Localities 1-69, 0-99 (N.B.).

Description: Test free, tapering, biserial, compressed so that zigzag sutures lie on the flattened faces; early chambers and proloculum not seen, later chambers simple, about 6 chambers in one series; apertures, low, at base of inner margin of chamber, chamber wall thickened at the aperture.

Note: Localities are indexed in Chapter IV.

Genus *Climacammina* H.B. Brady 1873

Climacammina sp.

Plate I, figures 5,6,7,8 (All figures x 70).

Horizon: E subzone, Upper Windsor; Localities 1-69, 1-C13.

Description: Test free, biserial for about 4 chambers in a series, becoming uniserial, early chambers not seen, later chambers simple; chambers slightly bulging between sutures; apertures in biserial stage as in Textularia, in uniserial stage several terminal apertures are present, chamber wall thickened about multiple apertures. This is the largest foraminifera seen in the Upper Windsor, a few specimens reaching 1 mm. in length.

Family AMMODISCIDAE

Subfamily Ammodiscinae

Genus Ammodiscus Reuss 1861

Ammodiscus sp.

Plate II, figures 1,2,3,4,5,6,7,8. (All x 70).

Horizon: B and E subzones, Lower and Upper Windsor; Localities 1-69, 0-99, 1-C12, 0-H-12.

Description: Test free, planispiral, proluculum small, second chamber long, increasing in diameter, undivided; four or five complete whorls; aperture not seen but seemingly terminal.

Genus Ammovertella Cushman 1928

Ammovertella sp.

Plate II, figure 9 (x 70).

Horizon: E subzone, Upper Windsor; Locality 0-78.

Description: The only specimen figured forms the center of an oolite; proluculum and second chamber planispiral for one and a half whorls, remainder of second chamber bends back and fourth in the same plane, making four bends. Then winding off from rest of test; aperture terminal.

Genus Glomospira Rzehak 1888

Glomospira sp.

Plate II, figures 10, 11. (All x 70).

Horizon: C subzone, Upper Windsor; Locality 1-48.

Description: Test free, proloculum, and long, tubular, undivided second chamber winding about entire test in different planes; aperture at end of second chamber.

Family TROCHAMMINIDAE

Subfamily Tetrataxinae

Genus Tetrataxis Ehrenberg 1843

Tetrataxis (?) sp.

Plate III, figures 1,2,3,4. (All x 70).

Horizon: E subzone, Upper Windsor; Locality 1-69.

Description: Test free, proloculum succeeded by elongate chambers, comma-shaped in cross section, simple, which wind about test in roughly planispiral manner, tapering edge of chamber on ventral side; in cross section the chambers appear biserial, actually there are about four chambers to a whorl. This form seems to combine features of Trochammina and Polytaxis.

Family LITUOLIDAE

Subfamily Haplophragmiinae

Genus Haplophragmium Reuss 1860

Haplophragmium (?) sp.

Plate III, figures 5,6,7,8. (All x 70).

Horizon: E subzone, Upper Windsor; Locality 1-69.

Description: Test free, close coiled in early stages, uncoiling in tapering uniserial series, chambers simple; aperture in coiled part of test not known, terminal in uniserial portion of test, single aperture becoming multiple; chamber walls thickened by inner apertures of uniserial stage; about six chambers in uniserial portion of test.

Subfamily Endothyrinae

Endothyra or Plectogyra ?

Discussion: Three forms are found in Upper Windsor beds which may be called Endothyra Phillips 1846, and one of these clearly is not planispiral in coiling. These forms are also asymmetrical and are identified as Plectogyra Zeller 1950. The two planispiral forms differ in number of chambers to a whorl and in number of whorls in a test and possibly represent megalospheric and microspheric forms of Endothyra. A fourth form is found in the Upper Windsor E subzone, which is thought to be Millerella.

Genus Plectogyra Zeller 1950

Plectogyra sp.

Plate IV, figures 1,2,3,4. (All x 70).

Horizon: C, D, and E subzones, Upper Windsor; Locality of figured specimens 1-69.

Description: Test free, close coiled, involute and asymmetrical in cross section, axis of coiling not constant, final whorl in one plane, approximately three whorls in all; aperture simple, at base of apertural face, closedin last chamber of many specimens, open in others; chamber walls swelling between sutures, seven or eight chambers in the final whorl; conspicuous nodes built on floor of chambers, but not on floor of last chamber, and no hooks noticed in any chambers; early whorls usually thickened or calcite filled, final whorl largest of series.

Genus Endothyra Phillips 1846, emended

Plate IV, figures 5,6,7,8,9,11. (All x 70).

Horizon: E subzone, Upper Windsor; Locality 1-69.

Description: Test free, planispiral coiling, involute and nearly symmetrical in cross section; Two forms; megalospheric (?), large proloculum, two to two and one half whorls, with six or seven chambers to a whorl, low aperture at base of apertural face, final chamber closed, rest mostly open, with nodes on chamber floors of latter portion of last whorl. Microspheric (?), smaller proloculum, three whorls after proloculum, eleven or twelve chambers in final whorl, final chamber closed, nodes on chamber floors absent. In both forms the chambers bulge out between sutures and the final chamber is the largest.

Family FUSULINIDAE

Subfamily Fusulininae

Genus Millerella Thompson 1942

Millerella (?) sp.

Plate IV, figures 10 (x 70).

Horizon: E subzone, Upper Windsor; Localities 1-69, 1-c12, 1-C13.

Description: Test free, close coiling is planispiral becoming evolute in last whorl, three to three and one half whorls, thirteen or more chambers in the final whorl, last chamber depressed toward apertural end; apertural face of chambers at angle with outer wall of chamber, and not part of same curve, chambers flat between sutures and not bulging as in Endothyra; nodes and spines not seen on chamber floors, aperture in final chamber closed.

Discussion: The form figured for Millerella (?) sp. is from the Antigonish area and is nearly double the size of the Mahone Bay forms. The Antigonish form seemingly underlies the Mahone Bay forms stratigraphically. The smaller forms from the Upper Mahone Bay beds are without doubt Millerella and are not figured, and the larger form which is figured may well be Endothyra.

PHYLUM COELENTERATA

Class ANTHOZOA

Subclass TETRACORALLIA

Genus Triplophyllites Easton 1944

Subgenus Triplophyllites Easton 1951

Triplophyllites (Triplophyllites) enniskilleni var. minas (Dawson)

Plate V, figures 1a-3.

Zaphrentis minas Dawson, Acadian Geol., 2nd ed., 1868, p. 286, fig. 84a.

Zaphrentis minas Lambe, Ottawa Naturalist, Vol. XII, 1899, p. 254.

Zaphrentis minas Lambe, Geol. Surv., Canada, Cont. to Can. Pal., Vol. IV, pt. II, 1899, p. 128, Pl. VII, figs. 7, 7a, 7b.

Zaphrentis minas Dawson, Bell, W.A., Horton-Windsor District, Nova Scotia, Mem. 155, Geol. Surv. Canada, 1929, p. 90-91, Pl. I, figs. 1, 2, 2a-d, Pl. II, figs. 1, 1a, 2.

Zaphrentis enniskilleni var. minas Dawson, Lewis, H.P., Annals and Mag. of Nat. Hist., Vol. XVI, 10th Ser., 1935, p. 122-128, Pl. V, figs. 1a-1f, 2a-2c, 3, 4a-4e, 5a-5e.

Horizon: E subzone, Upper Windsor; Locality 1-1.

Description: Medium, simple, curved trochoid; calice shallow, circular, without calicular base or platform; epitheca thin, externally striated, sides rugose, corallum narrowing in late ephebic stage; about 30 long major septa, fused at inner ends except in late ephebic stage, cardinal septa reduced in ephebic stages, with well developed cardinal fossula on the concave side of the corallum, minor septa small, or represented by ridges, more conspicuous in counter quadrants; tabulae arched and incomplete, more strongly depressed on cardinal side of corallum, and slightly depressed to horizontal on alar side of corallum; dissepiments not present; axial region marked by fused septal ends and arched tabulae; stereozone present on middle or inner ends of septa in late ephebic stages.

Size: Large specimens up to 3 cms. in length, averaging about 2.5 cm. in diameter.

Remarks: Schindewolf (1938, p. 452) has restricted Zaphrenthis (corrected spelling of Zaphrentis) to corals with an open cardinal fossula, carinate or toothed septa and a wide zone of dissepiments. Easton (1944, p. 7-93) erected a new genus Triplophyllites to include zaphreutids without carinate or toothed septa and without dissepiments. In 1951, Easton established two sub-genera, Triplophyllites Easton, new usage, and Homalophyllites Easton 1944, emended, to include Triplophyllites with cardinal fossula on the concave side of the corallium, and on the convex side, respectively. Only forms assignable to the sub-genus Triplophyllites are known from the Windsor Group.

More detailed descriptions may be found in Lewis (1935) and Bell (1929).

Genus Caninia Michelin, in Gervais, 1840

Caninia juddi var. dawsoni (Lambe)

Plate V, figures 2a-f, 3.

Zaphrentis minas (partim) Dawson, Acadian Geol., 2nd Ed., 1868, p. 286.

Cyathophyllum dawsoni Lambe, Ottawa Naturalist, Vol. 12, 1899, p. 239.

Cyathophyllum dawsoni Lambe, Geol. Surv., Canada, Cont. Can. Pal., Vol. IV, pt. 2, 1901, p. 147, Pl. 12, figs. 4-4b.

Caninia dawsoni (Lambe) Bell, W.A., Horton-Windsor District, Nova Scotia, Memoir 155, Geol. Surv. Canada, 1929, pp. 91-94, Pl. II, figs. 3, 3a-c, Pl. III, figs. 1,2,3,4,5,5a,6,6a.

Caninia juddi var. dawsoni (Lambe) Lewis, H.P., Annals and Mag. Nat. History, Vol. XVI, 10th Ser., 1935, p. 128-132, Pl. VI, figs. 1a-e, 2a-d, 3a-e, 4a-d, 5a-d.

Horizon: E subzone, Upper Windsor; Locality 1-1, 1-35.

Description: Large, simple, curved trochoid, becoming cylindrical in some specimens, with constrictions and bends common; a few specimens double through lateral gemmation, rejeuvenescens common; calicular pit deep, with peripheral platform in cylindrical specimens, platform wining in trochoid forms, epitheca thick, marked by vertical striations and marked rugosities; about 43 long major septa present, extending about 2/3 distance to center of corallite, becoming amplexoid in late ephebic stages and tending to withdraw from axial region; a stereozone is present, with thickening confined to septa within tabularium, more common in cardinal quadrants; tabulae complete or nearly so, dome-shaped, and joined by supplementary tabulae in late stages; dissepiments crowded and showing no regular pattern, dissepimentarium variable in width but averaging 1/3 radius of corralite; no axial structure present.

Size: Large specimens up to 7.5 cms. in length, and 3.75 cms. in diameter.

Remarks: C. juddi var. dawsoni is more completely described by both Bell and Lewis. Specimens have been reported from only the Kennetcook limestone previously. A single poorly preserved specimen was found in a boulder about 1 mile south-east of

Antigonish, in a tributary to the West River. No other fossils were noted in this boulder but from field evidence it is presummed to be the E_1 limestone, which outcrops nearby.

Genus *Lophophyllum* Edwards and Haime, 1851

Lophophyllum avonensis Bell

Lophophyllum avonensis Bell, Horton-Windsor District, Nova Scotia, Mem. 155, Geol. Surv. Canada, 1929, p. 94-95, Pl. IV, figs. 4,5,6.

Lophophyllum avonensis Bell, Lewis, H.P., Annals and Mag. of Nat. Hist., Vol. XVI, 10th Ser., 1935, p. 133, Pl. VII, figs. 5, 6a-d.

Horizon: C and E subzones, Upper Windsor, Windsor type area.

Remarks: Bell and Lewis have described this coral in their papers. Specimens found by the writer rather closely fit the descriptions of *L. avonensis* Bell by Lewis, but not Bell's original description. The difference is in the tent shaped tabulae (broadly arched in Bell's description) and these specimens have been included under *Koninckophyllum*. Lewis (p. 133) does not mention tabulae shape for *L. avonensis* Bell but figure 6a, Pl. VII, clearly shows the tent shape so characteristic of *Koninchkophyllum*.

Genus *Dibunophyllum* Nicholson and Thompson 1876a

Dibunophyllum lambii Bell

Plate VI, figures 1a-g, 2.

Dibunophyllum lambii Bell, Horton-Windsor District, Nova Scotia Mem. 155, Geol. Surv. Canada, 1929, p. 95-96, Pl. IV, figs. 1, 1a-g, 2,3,.

Dibunophyllum lambii Bell, Lewis, H.P., Annals and Mag. of Nat. Hist., Vol. XVI, 10th Ser., 1935, p. 137-138, Pl. VII, figs. 7a-b, 8a-b.

Dibunophyllum lambii Bell, Stacy, M.C., Stratigraphy and Paleontology of the Windsor Group (Upper Mississippian) in Cape Breton Island, Nova Scotia, unpublished Ph.D. Thesis, 1952, p. 76-77, Pl. I, figs. 2-4, Pl. II, figs. 1-4.

Horizon: C and E subzones, Windsor type section; Uncertain subzone Cape Breton Island; E subzone, Antigonish Area; Localities 1-1, 1-60, 1-2.

Description: Medium to large, simple, curved trochoid; method of increase unknown; calicular pit shallow, without platfrom or boss; about 40 long, regular major septa, cardinal and alar septa continuous with medial plate in neantic stages but free and much reduced in ephebic stages allowing development of open fossula; minor septa short, reduced and irregular in ephebic stages; stereozone poorly developed on septa within tubularium; tabulae incomplete, forming inner zone of steeply dipping tabellae, which rise to meet medial plate, and an outer zone, of less steep dips where tabellae meet dissepiments; dissepiments arranged irregularly, five or six deep along periphery of corralum; axial region shows prominant medial plate until late ephebic stages, "spider-web" of tabellae, with a few septa extended as septal lamellae to support the "web".

Size: Average 2.5-3 cms. in length, about 2 cms. in diameter, with some specimens nearly double the length given here.

Remarks: A more complete description is to be found in Bell's paper. This coral seemingly invaded the Windsor interior seas, and has been reported from Cape Breton, Antigonish, the New Glasgow Area, as well as the type section. No specimens were found in the Mahone Bay-St. Margaret Bay area.

Genus Bothrophyllum Trautschold 1879

Bothrophyllum(?) sp. (Lewis)

Plate VI, figures 3a-c, 4.

Pseudocaninia sp. Lewis, H.P., Annals and Mag. of Nat. Hist., Vol. XVI, 10th Ser., 1935, p. 132, Pl. VI, figs. 6a-b.

Horizon: E subzone, Upper Windsor; Localities 1-1, 0-125.

Description: Simple, small, curved trochoid; calice shape and exterior surface not known; about 30 long major septa, extending to axial region and fused in early stages, remaining elongated until late development stage, minor septa making late and irregular appearance, never long; stereozone not known; tabulae seemingly incomplete and disrupted in axial region, but slightly arched across axis; dissepiments not present until ephebic stages, but well developed in late stages although irregularly arranged; axial structure formed by elongate septa and disrupted tabulae.

Size: Single specimen measured 4.2cm. in length and 1.3 cm. in maximum diameter.

Remarks: Lewis gives only a brief description of Bothrophyllum and includes two figures, which differ from the specimen here described by the fusing of septa into groups, rather than into a central group as the specimen figured in this thesis. In addition, the dissepiments of the specimen figured here appear much earlier and are better developed than Lewis' specimen. This thesis specimen differs from the <u>Corwenia</u>(?) sp. of this thesis in having neither medial plate nor dibunophyllid axial region, and in being a simple coral, rather than a colonial form.

The single corallum described is incomplete. Dorothy Hill (1937-1941, p. 104) has pointed out that <u>Pseudocaninia</u> is probably a synonym for <u>Bothrophyllum</u> Trautschold (1897, p. 128)

Genus <u>Koninckophyllum</u> Nicholson and Thompson 1876a

<u>Koninckophyllum cf. interruptum</u> Nicholson and Thompson

Plate VII, figures 1, 2a, 2b, 2c, 3a, 3b, 3c, Plate VII-A, figures 1,2.

<u>Lophophyllum (Koninckophyllum) cf. interruptum</u> Nicholson and Thompson, Lewis, H.P., Annals and Mag. of Nat. Hist., Vol. XVI, 10th Ser., 1935, p. 133-134, Pl. VII, figs. 3a-c, 4a-c.

Horizon: E subzone, Upper Windsor, Mahone Bay area; Localities 1-13, 0-118.

Description: Corallum large, compound, phaceloid becoming ceroid; peripheral increase, small corallites filling voids between large corallites; deep (?) calical pit not known; about 42 medium major septa at 15mm. diameter, extending from epithecal wale to about ½ radius, distal ends free at all times and proximal ends pulling away from epitheca in late stages, secondary septa about ½ length of major septa, but becoming reduced in late stages; tabulae incomplete, form low dome and produce styloform columella; dissepimentarium well developed, becoming lonsdaleoid in late stages, dissepiments concentrically arranged, with some tendency to herringbone; styloform columella present, seemingly discontinuous in late stages.

Size: Large corallites about 18mm. in diameter, corallum extending as much as 30cms.

Remarks: K. cf. interruptum Nicholson and Thompson is fully described by Lewis. This form is common in the Mahone Bay region, and found in close association with the lower beds of the Gigantoproductus zone, and with the Lithostrotion sp. figured in this thesis.

Koninckophyllum sp.

Plate VIII, figures 1a-d, 2a, 2b, 3a-d.

Horizon: E subzone, Upper Windsor; Locality 0-125.

Description: Medium, compound, phaceloid; calical pit not known, a single figured specimen shows a columella buried in mud in what seemingly is an early stage; increase by rejeuvenesence; 38-40 long major septa, minor septa about ½ length of major septa; incomplete tent shaped tabulae, with tabella rising in concentrated group to form columella, and less steeply dipping tabellae joining with dissepimentarium; dissepiments well developed, concentrically arranged, with herringbones and some chevrons formed by tabellae visible on axial side of minor septa; septal lamellae combine with tabellae to form axial structure.

Size: About 1.8cm. in diameter at calice end, length not known.

Remarks: These specimens are very close to K. cf. interruptum, yet are smaller, and do not develop the large bushy coralla of K. cf. interruptum as the latter appear in the Mahone Bay Area, and show a greater development of tabellae forming the axial structure than does K. cf. interruptum. Compared with Lophophyllum avonensis Bell, these Koninckophyllum sp. are larger, and show the columella and axial development.

The figured specimens of Plate VIII, were all in a single boulder with Corwenia(?) sp., Bothrophyllum(?) sp. (Lewis), and Heterophyllia sp.

Genus Lonsdaleia McCoy 1849

Lonsdaleia pictoense (Billings)

Plate VIII, figures 4a, 4b, 5a, 5b, Plate VIII-A, figures 1, 2.

Lithostrotion pictoense Billings in Dawson, Acadian Geol., 2nd ed., 1868, p. 285, fig. 83.

Lonsdaleia pictoense Lambe, Ottawa Naturalist, Vol. XII, 1899, p. 248.

Lonsdaleia pictoense Lambe, Cont. to Can. Pal., Vol. IV, pt. 2, 1901, p. 173, Pl. XIV, figs. 9, 9a.

Lonsdaleia pictoense Billings, Bell, W.A., Horton-Windsor District, Nova Scotia, Mem. 155, Geol. Surv. Canada, 1929, p. 96-97, Pl. V, figs. 4 and 4a.

Lonsdaleia pictoense (Billings), Lewis, H.P., Annals and Mag. Nat. Hist., Vol. XVI, 10th Ser., 1935, p. 139-140, fig. p. 139.

Horizon: E subzone, Upper Windsor, Mahone Bay area, Upper Windsor in New Glasgow region, subzone doubtful; Localities, 1-2, 0-125.

Description: Compound, small, fasciculate and phaceloid; increase by lateral budding; calicular pit without peripheral platform, calicular boss formed by lenticular columella; 19 or 21 long major septa, sometimes free at distal end, more commonly terminating at single tabula, proximal ends of septa withdrawn from epithecal wall, but generally in allignment with septal crest within dissepimentarium, cardinal and alar septa alone, or with an adjoining septum often extend to columella and divide corallite asymmetrically, that is, with one extra septa on one side of the plane of division, minor septa short; tabulae complete, rising up at center to form columella, supplemented by short tabellae at peripheral ends with tabulae turning down at ends and tabellae nearly horizontal, or flaring up, portions of septa within tabularium joined by a maximum of 2 tabula at one horizontal section, more often by a single tabulum; dissepimentarium narrow, essentially a single layer of concentric dissepiments pointing down towards center of corallite; lenticular columella, septa lamellae absent except for cardinal, alar and a single adjoining septa.

Size: Corallum fragmentary, true size not known; corallites 6-7mm. in diameter.

Remarks: The figured specimen differs from the holotype described by Bell in being smaller (holotype reaches 10mm. diameter), and in the smaller angle made by the tabulae as they rise to form the collumella, and thus show less congestion in the inner portion of the tabularium. The specimen figured in this thesis is from the E subzone while the holotype could be as low as C subzone. In view of the minor differences and poor condition of this thesis specimen, the writer considers it to be a variation of L. pictoense (Billings), if not specifically identical.

Lonsdaleia sp.

Plate IX, figures 1a-c, 2a-d.

Horizon: E subzone, Mahone Bay region; Locality 0-14.

Description: Medium, compound, phaceloid to cerioid; shallow calical pit; increase by lateral budding from the dissepimentarium; 24 major septa, withdrawn from epithecal wall and showing a few septal crest within the dissepimentarium, septa seemingly do not reach axial "spider web", no minor septa; stereozone present along peripheral ends of septa; tabularium divided into inner and outer zone, with inner tabellae rising to form axial structure, and outer tabellae more or less horizontal; dissepimentarium lonsdaloid, dissepiments elongate, lenticular, and dipping steeply down toward center of corallite; axial "spider web" dibunophyllid in character with a few septal lamellae apparent, but no medial plate or colummela is present.

Size: From 10mm. to 20mm at calice.

Remarks: Lonsdaleia sp. compares favorably with L. floriformis floriformis (Martin) although it is slightly larger and does not posess a medial plate at any sections figured in this thesis. This Nova Scotian specimen may well be another subspecies of Lonsdaleia floriformis, and not a new species.

Genus Lithostrotion Fleming 1828

Lithostrotion sp.

Plate X, figures 1, 2a-d, Plate X-A, figures 1, 2, Plate XI, figures 1, 2a, 2b, 3.

Horizon: E subzone, Mahone Bay: Localities 1-C9, 1-C12, 1-C13, 0-29.

Description: Small compound, fasciculate, phaceloid; increase by lateral budding; calicular pit without platform, lenticular columella exposed; 20 or 22 long major septa in ephebic stage, about 4 on each side extending to columella as septal lamellae, minor septa short; nearly complete tabulae curved down at peripheral ends, flaring up sharply in center to form columella, supplemented by short horizontal tabellae at peripheral ends, axial region free of tabellae; narrow dissepimentarium, with about 2 layers of concentric dissepiments, slightly bubble shaped; median plate absent, cardinal and alar septa occasionally divide corallite symmetrically, more often, 4 septal lamellae appear to support either side of axially-thickened, lenticular columella. Corallum bushy and cone-shaped, or with essentially parallel corallites.

Size: Corallites average 6.5mm. in diameter, form corallum 10-12cm. in diameter.

Remarks: Lithostrotion sp. is found in the upper coral zone in Mahone Bay, or in the lower zone of Gigantoproductus. It is found in both shaley and sandy limestones. This is the only species of Lithostrotion found in the Mahone Bay area by the writer, and can not be compared with Lithostrotion caespitosum which was reported by Faribault as having been found in the Mahone Bay Area, since no description of L. caespitosum from Nova Scotia is known.

The Lithostrotion figured in this thesis are slightly larger in size and number of septa than L. pauciradiale (McCoy) and smaller in similar characteristics than L. scoticum Hill (1937-41), but probably related closely to both.

Genomorph Diphyphyllum Lonsdale 1845

Diphyphyllum(?) cf. lateseptum McCoy 1849

Plate XII, figures 1a, 1b, 2a, 2b.

Horizon: E subzone, Mahone Bay; Locality 0-114

Description: Small, compound, fasciculate, phaceoid; calice shape and method of increase not known; about 20 long major septa extending well into axial region but not reaching columella or all ending in tabulate wall; minor septa about ½ to 2/3 length of major septa; tabulae dome shaped, rising in center to form columella and joined by supplementary plates to dissepimentarium; dissepiments concentrically arranged in two layers, peripheral, series globose and horse-shoe-shaped; columella formed by upturned tabulae, generally open lenticular in section, joined by cardinal and alar septal lamellae.

Size: Corallites average 4-4.5mm. in diameter.

Remarks: This form is very similar to D. lateseptum McCoy as figured and described by Hill (1937-41, p. 184, Pl. X, figs. 14 and 15) and differs only in more regular columella and seeming extension of cardinal and alar septa to form septal lamellae.

Diphyphyllum (?) cf. furcatum Thompson 1887a

Plate XII, figures 3a, 3b, 4a-d.

Horizon: Doubtful subzone, Upper Windsor, Mahone Bay; Locality 1-C13.

Description: Small colonial, fasciculate, dendroid; specimen figured shows lateral increase; calice unknown; 28 long major septa extending 2/3 radius of corallite from epithecal wall, slightly sinuous in early stages, distal ends free or ending in common tabulate wall; minor septa long, about 2/3 length of major septa; tabulae nearly complete, dome-shaped, turn down to meet lower tabulae, or extend downward to dissepimentarium, met by auxiliary tabulae which are nearly horizontal; thin persistant layer of dissepiments concentrically arranged; no axial structure.

Size: 10mm. is maximum diameter of specimen figured.

Remarks: This specimen resembles D. furcatum Thompson as described by Hill (1937-41, p. 185-186, Pl. X, fig. 16, Pl. XI, fig. 1) agreeing in everyway except size and number of septa. The Nova Scotian specimen is slightly larger and has 3-6 more septa.

Genus Heterophyllia McCoy 1849

Heterophyllia(?) sp.

Plate XIII, figures 1a, 1b, 2a, 2b.

Horizon: E subzone, Mahone Bay; Locality0-125.

Description: Compound, medium, fasciculate; exterior fluted longitudinally; calice and method of increase not known; about 33 long flexous major septa with short septa leaving on long septa, the septa unite as five groups near the center of the corallite; the alar septum makes one of these groups, minor septa short or absent, two groups of the 5, groups of major septa slightly separated, allowing development of cardinal fossula; tabulae long, arched, but seemingly not complete, rather are a series of curved plates depressed then elevated in the axial region and sweeping up in peripheral region to meet dissepimentarium; several layers of dissepiments present; no axial structure.

Size: The figured specimen averages 12mm. in diameter and is 3cm. long.

Remarks: This specimen differs from other Heterophyllia in the development of a dissepimentariums, and in the apparent depression of the tabulae in the axial region of the coralite. The vertical section figured here shows the depression of the tabulae in the younger stages and the elevation or doming of the tabulae in older stages. In transverse section the heterophyllid nature of the corallite shows clearly.

Genus Thysanophyllum Nicholson and Thompson 1876a

Thysanophyllum cf. orientale Thompson 1880

Plate XIV, figures 1a, 1b, 1c, 2, 3, Plate XIV-A, figure 1.

Horizon: E subzone, Upper Windsor, Mahone Bay Area; Locality C-90.

Description: Medium colonial, phaceloid, cerioid and approaching astraeoid; increase intermural; calice shows large axial pit without shelf or boss; about 30 short primary septa extending to epithecal wall in early stages and becoming lonsdaleoid in late stages, only primary septa extending into axial region; minor septa short or appear as septal spines in dissepimentarium; tabulae long but incomplete, passing in low crown across axis of corallite before joining next lower tabula on opposite side of axis; dissepimentarium well developed with 4-5 rows of blister-like dissepiments, arranged concentrically at outer margin, irregular or herringbone along inner margin; no axial structure.

Size: Large corallites usually reach 15mm. diameter, corallum extending up to 8cm. or more.

Remarks: The specimen figured was found in the lower Gigantoproductus zone. The lonsdaleoid character of this corallite is not as well developed as the specimens of T. orientale Thompson figured by Hill (1937-41, p. 162-163, Pl. VIII, figs 26-32), the number of major septa is slightly greater, and the corallites are seemingly smaller; otherwise the agreement is good.

Genus Corwenia Smith and Ryder 1926

Corwenia (?) sp.

Plate XIII, figures 3a-d.

Horizon: E subzone, Upper Windsor, Mahone Bay Area; Locality C-125

Description: Compound, medium phaceloid; method of increase not known; calicular pit present but shape unknown; about 38 long major septa extending well into inner tabularium, a few reaching a medial plate as septal lamellae, minor septa short; tabulae not known from vertical section, but steepen in axial region to form dibunophyllid "spider web"; dissepiments tending to herringbone at inner edge of dissepimentarium; sinuous median plate present, joined by a few septal lamellae.

Size: About 15mm. diameter at calice.

Remarks: When more material of this coral is found, it may prove to be closely allied to Corwenia rugosa (McCoy) 1849. Differences shown in the transverse sections are minor.

Subclass TABULATA

Family SYRINGOPORIDAE

Genus Syringopora Goldfuss 1826

Syringopora sp.

Plate XV, figures 1, 2, Plate XV-A, figure 1.

Horizon: E subzone, Upper Windsor, Mahone Bay; Locality 0-119.

Description: Syringopora with corallites about 2mm. in diameter separated from adjacent corallites by about 3mm., lateral prolanes common, 2 or 3 being formed close together in one plane. 28 to 30 small septal spines shown in transverse section. Tabular intersections circular to sub-triangular, and variable, but centers well centered. About 5 or 6 tabulae are shown in a single transverse section of a single corralite.

Tabulae shown in vertical sections are about 1.5 times diameter of corallite in length. Central tube occupied by gently arched, transverse tabulae.

Remarks: Affinities of this coral are not known. It is reasonably abundant in the upper part of the coral zone in Mahone Bay and belongs to the E subzone. Found 2 feet above Koninckophyllum cf. interruptum in one boulder.

Family AULOPORIDAE

Genus Pseudorominngerina Yabe and Sugiyama 1936 (?)

Pseudorominngerina (?) sp.

Plate XVI, figures 1, 2, 3, 4, Plate XV-A, figure 2, Plate XIV-A, figure 2.

Horizon: E subzone, Upper Windsor, Mahone Bay Area; Localities1-C12 and 0-27.

Description: Subramose colony, with individual corallites twisting and sub-parallel. Cylindrical corallites are about 3mm. in diameter, and divide to increase, but are not connected after division, or by stolons. Corallite walls are thick, ranging from ½ to

1/3 the diameter and display septal spines in an irregular manner, from none to as many as eight showing in a single transverse section of a corallite. Spines are deeply imbedded in corallite wall but do not protrude on exterior of corallite. Spines are arranged in longitudinal rows.

Tabulae are thin and scarce, mostly concave upwards, forming thin U in vertical sections. Generally only a single tabula seen in one corallite, or none visible.

Remarks: This specimen is probably a member of the tabulate family Auloporidae, and is found as fragments or in thick bushy colonies in the upper coral zone in Mahone Bay.

Family FAVOSITIDAE (?)

Genus Favosites Lamarck 1816

Favosites (?) sp. (Stacy)

Plate XV, figure 3.

Unidentified Tabulate Coral, Stacy, M.C., Stratigraphy and Paleontology of the Windsor Group (Upper Mississippian) in Cape Breton Island, Nova Scotia, p. 77-78, Pl. III, figs. 1-3.

Horizon: E subzone, Upper Windsor, Cape Breton Island.

Remarks: This small tabulate coral form from the E_1 limestone on Hood Island makes a hemispherical corallum about 4cm. in diameter and 3cm. high. The specimen collected by Stacy is too poorly preserved for definite generic identification, but is thought by the writer to be a member of the tabulate family Favositidae. The corallites are prismatic and tightly packed. This coral is not found in the Mahone Bay region, but should be found in more localities in the Windsor inland sea areas.

The figure of this thesis shows the corallum figured and described by Stacy.

PHYLUM BRACHIOPODA

Orders PROTREMATA-TELOTREMATA (undifferentiated)

Superfamily Productacea

Genus <u>Gigantoproductus</u> Prentice 1950

Plate XVII, figures 1a-e, 2, 3, Plate XVIII, figures 1, 2, 3, Plate XIX, figures 1, 2, Plate XX, figures 1, 2.

Horizon: E subzone, Upper Windsor, Mahone Bay, and North Shore of Minas Basin, near Pansboro; Localities, 1-C10, 1-C12, 1-C13, 1-C14, 1-C15, 0-38.

Description: Shell of large size, concavo-convex, length and width about equal, maximum width near hinge line with ears projecting slightly beyondhinge line; visceral cavity thin, averaging about 1cm. in thickness near center of shell and tapering anteriorly and posteriorly; large flairing trail present in well preserved specimens; spines and spine bases not seen on either valve.

Pedicle valve, nearly hemispherical, with rounded beak extending posterior to hinge line and slightly below plane of commissure; cardinal area not seen on specimens examined but may be present. The surface is marked by fine striae which increase by intercalation, and about 12 striae are present in a space of 1 centimeter. Concentric wrinkles may be present over the ears, and one or two irregular, radial folds common in well rounded specimens. The pedicle interior shows two large striate diductor impressions, a pair of large dendriti adductor impressions and a pair of small adductor, or occlusor, impressions anterior to the large adductor scars. A median depression is not well defined, nor are brachial hollows seen in these specimens. The shell is pseudopunctate and averages 1cm. in thickness over the central portion of the valve.

Brachial valve, concave, following closely the curve of pedicle valve and leaving a thin visceral cavity; exterior covered by five striae; low median septum on interior, with an auxillary central ridge separating adductor scars. Brachial processess low and rounded, extending laterally into low brachial ridges; extent of these ridges not known. Brachial eminences are slightly elevated. Brachial valve is from 2mm. to 8mm. thick. The cardinal process is not well exposed but four lobes are suggested.

Size: Width 10-14cm., length 10-14cm., heighth from plane of commisure to top of pedicle valve 4-5cm., trail may be as long again but generally masked in anterior direction.

Remarks: This form is extremely variable in the Mahone Bay area; some forms are nearly hemispherical with a stiff trail, and others are flattened with a flairing trail. These differences may well be due to the manner in which the specimen was preserved.

The writer was allowed to examine <u>Gigantoproductus</u> material in the National Museum in Washington, D.C. This collection included material from Western United States, Russia, Continental Europe and Great Britain. The Nova Scotian specimens figured here most closely resemble the specimens from Great Britain, and show only minor differences with <u>Gigantoproductus</u>

as figured by Davidson (1858).

Ecology: Gigantoproductus arrived in the Mahone Bay area near the end of E subzone time. Specimens are found with many of the corals, particularly Koninckophyllum and Lithostrotion. This period of first arrival follows a time when the E subzone limestone beds were becoming sandy. One sandstone boulder yielded the remains of many Gigantoproductus specimens varying from young to adult forms. These forms were preserved only as casts and molds but represent an ancient marine tragedy when bar sands slumped and buried a group of these large brachiopods. This early time of Gigantoproductus marks a time of shoaling seas. The colonial corals soon died off, and in the upper beds of the Nova Scotian Gigantoproductus zone corals are absent and foraminifera abundant. At least 10 separate beds are found in which Gigantoproductus is preserved in vast numbers. This represents a thanatacoenose assemblage, and changing salinities based on shoaling waters probably caused the extinction of the brachiopods. The black, pyritiferous limestones indicate lagoonal conditions unfavorable to brachiopods. Succeeding invasions of Gigantoproductus are noted. Lithostrotion, Koninckophyllum and Pseudoromingerina(?) accompanied the brachiopods on early invasions, but shortly, and for the upper three fourths of Gigantoproductus time, only foraminifera followed the large brachiopods. The period of Gigantoproductus was brought to a close by further shoaling, and the last record of life inthe Windsor Group is the algal limestone beds. These algae presumably lived in brackish water which excluded the other forms of marine invertebrate life, including marine foraminifera.

In Plates XIX and XX, four boulders are figured which indicate the manner of preservation of Gigantoproductus. The pictures are oriented with the top of the bed up. There is no preferred orientation to these shells, either in the areas of shell concentration, or where shells are not in contact with each other. If the animals lived with their concave side up, currents might flip some shells over while leaving some unturned, but if these brachiopods lived with their convex side up, probably none of them would be flipped over by currents. The evidence seemingly favors the "inverted" mode of living, that is, with the pedicle valve in contact with the sea bottom, and concave side up.

Superfamily RHYNCHONELLACEA

Genus Pugnoides Weller 1910

Pugnoides (?) sp.

Plate XXI, figures 1a-d.

Horizon: E subzone, Upper Windsor, Hood Is., and Antigonish, Localities 1-78, 1-33.

Description: Large rynchonellid, wider and higher than long, short hinge line, with strong fold and sulcus and few strong costae.

Pedicle valve, with strong triangular sulcus containing two well developed costae and two minor costae adjacent to the central portion of the sulcus. Three large and two minor costae on flat dorsal surface, well developed anteriorly but extending as fine markings out onto the beak. The beak is suberect, with a small circular foramen and projects slightly beyond the beak of the brachial valve. Interior not known.

Brachial valve, with strong fold bearing three costae. A single vestigial costa present on each flank of the fold, followed by two major costae and three minor costae on each ear. Costae run from the anterior edge and weaken towards the posterior, but are present over the beak. One new costa developed in figured specimen by intercalation. Interior not known.

Size: Lenth 12mm., width 18mm. and height 13mm.

Remarks: This brachiopod differs from the species of Pugnoides described by Bell (1929, p. 123, 124): it is nearly twice as large as Bell's specimen, and the costae extend to the posterior portion of the shell. Weathered portions of this species are common in the E_1 limestone on Hood Island and in the E_1 limestone in the West River section. It is associated with a number of rynchonellids, including Camarotoechia atlantica Bell in the Antigonish area. In the E_1 limestone of the Saw Mill section many specimens of Camarotoecia are present as molds, and numerous Pugnax sp. but the Pugnoides figured here has not been found.

PHYLUM MOLLUSCA

CLASS GASTROPODA

Genus Anematina Knight 1933

Anematina (?) sp.

Plate XXI, figure 3.

Horizon: B subzone, Lower Windsor, Antigonish Area, Dingwall, Cape Breton Island; Localities 1-3, O-A-15.

Description: Medium sized, high spired, turbinate, gastropod; pleural angle about 33 degrees; six whorls are seen on most specimens; ornamentation, fine growth lines and small nodes along the spireend of the last three whorls; the nodes are too small to be visible on the small early whorls; base gently rounded; aperture and umbilicus not known.

Size: 9-13mm. in length.

Remarks: Fragments and impressions of this gastropod are common in the B_1 limestone in the Antigonish and Dingwall areas, and are not known in other B subzone beds. In the 44 feet of core from the No. 1 drillhole at South Side Antigonish, impressions of this gastropod were numerous, and are easily identified.

Genus Bulimorpha Whitfield 1882

Bulimorpha (?) sp.

Plate XXI, figures 2a, 2b.

Horizon: E subzone, Upper Windsor, Antigonish Area; Locality C-W-15.

Description: Medium sized, moderately high-spired gastropod, fusiform; pleural angle measures about 50°; three or four whorls ornamented with growth lines, large body whorl; aperture not known; suggestion of a small umbilicus.

Size: 17mm. in heighth, maximum diameter 12mm.

Remarks: Because of the possible umbilicus this form may be assigned to the wrong genus. This gastropod agrees in general shell proportions with Holopea cf. proutana Hall as described by Bell (1929, p. 177). However, it is over twice as large and is Upper Windsor.

PLATES I - XXI

All figures of Foraminifera X 70

All figures of corals X 1.5 unless otherwise noted.

PLATE I

Textularia sp.

Figure 1. Vertical section.

Figure 2. Vertical section through apertures.

Figure 3. Vertical section.

Figure 4. Vertical section close to side of test, showing zigzag effect of two series of chambers.

Climacammina sp.

Figures 5, 6, 7. Vertical sections.

Figure 8. Vertical section showing multiple apertures.

PLATE I

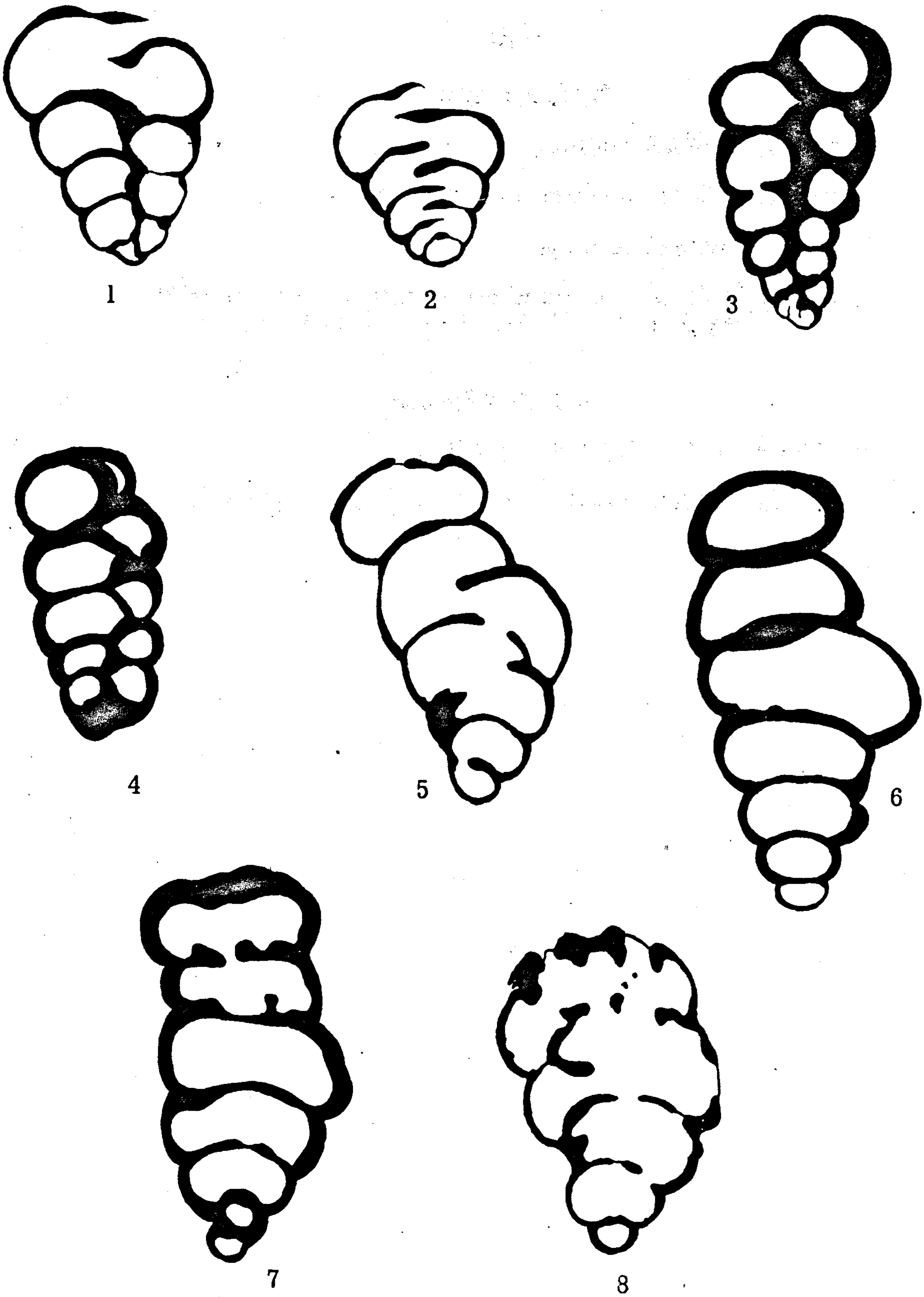


PLATE II

Ammodiscus sp.

Figures 1, 6, 7, 8. Sagittal sections, specimens from Antigonish, Redman Hill (St. Margaret Bay), Hood Island, and Rouse Island (Mahone Bay), respectively.

Figures 2, 3, 4, 5. Axial sections, all specimens from locality 1-69 in Antigonish area.

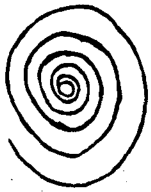
Ammovertella sp.

Figure 9. Transverse section of specimen from center of oolite, E subzone, Hood Island.

Glomospira sp.

Figures 10, 11. Sections of specimens from C_1 limestone, Hood Island.

PLATE II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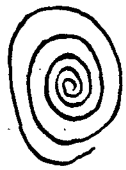
4


5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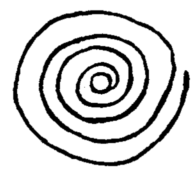
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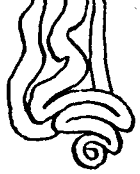
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PLATE XXI

Tetrataxis sp.

Figures 1, 2, 3, 4. Axial sections, all specimens from locality 1-69, Antigonish area.

Haplophragmium (?) sp.

Figures 5, 6, 7, 8. Vertical sections of specimens from locality 1-69.

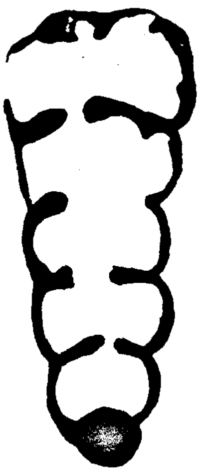
PLATE III

1

2

3

4



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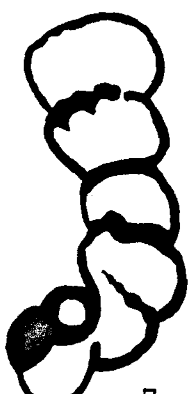

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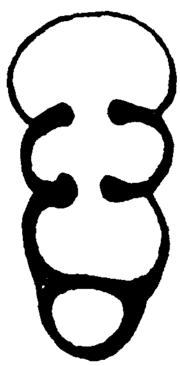

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PLATE IV

<u>Plectogyra sp.</u>

Figures 1, 3. Horizontal axial sections.

Figures 2, 4. Axial sections.

<u>Endothyra sp.</u>

Figures 5, 7. Cross sections of megalospheric (?) forms.

Figure 6. Axial section.

Figures 8, 9, 11. Cross sections of microspheric (?) forms.

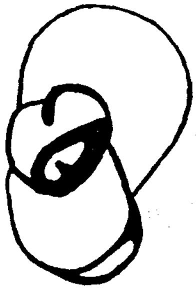
<u>Millerella (?) sp.</u>

Figure 10. Cross section.

All specimens figured on Plate IV from locality 1-69, Antigonish area.

PLATE IV


1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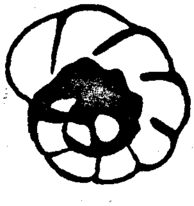
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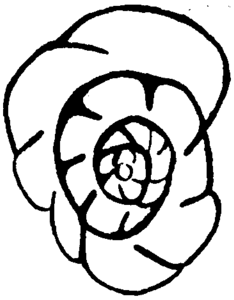
4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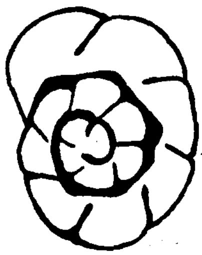
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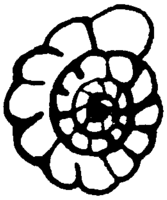
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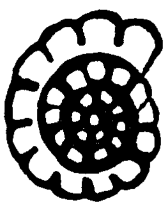
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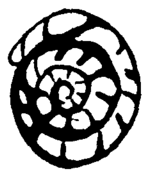
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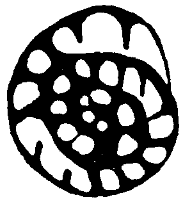
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PLATE V

Triplophyllites enniskilleni var. minas (Dawson)

Figures 1a, 1b, 1c, 1d, 1e. Series of transverse sections through corallum from Kennetcook limestone.

Caninia juddi var. dawsoni (Lambe)

Figures 2a, 2b, 2c, 2d, 2e, 2f. Series of transverse sections through corallum from Kennetcook limestone.

Figure 3. Vertical section through corallum from Kennetcook limestone.

PLATE V

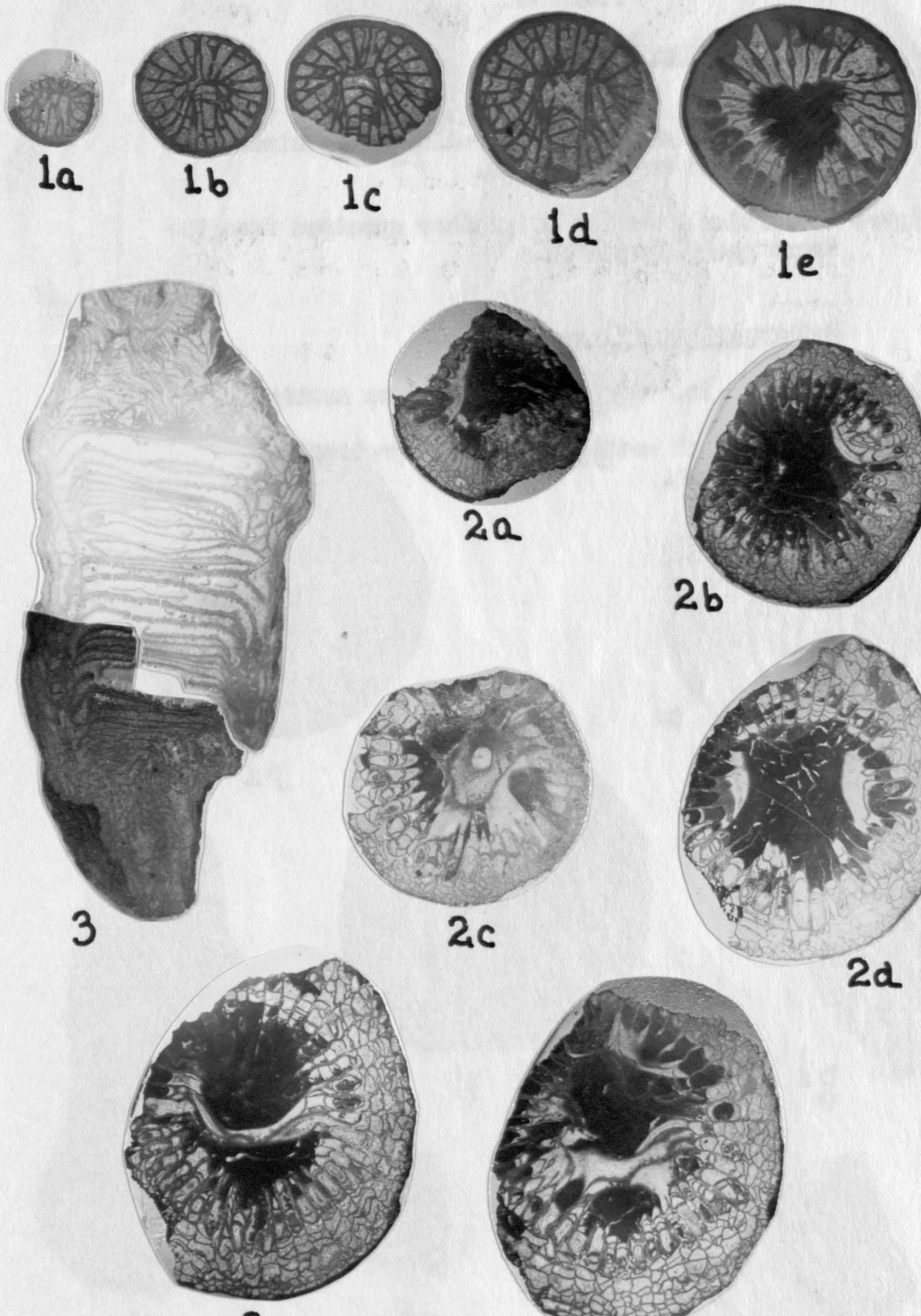


PLATE VI

Dibunophyllum lambii Bell

Figures 1a, 1b, 1c, 1d, 1e, 1f, 1g. Series of transverse sections through corallum of specimen from Kennetcook limestone.

Figure 2. Vertical section of another specimen from the Kennetcook limestone.

Bothrophyllum (?) sp. (Lewis)

Figures 3a, 3b, 3c. Series of transverse sections.

Figure 4. Vertical section of same corralite as figures 3a-c.

PLATE VI

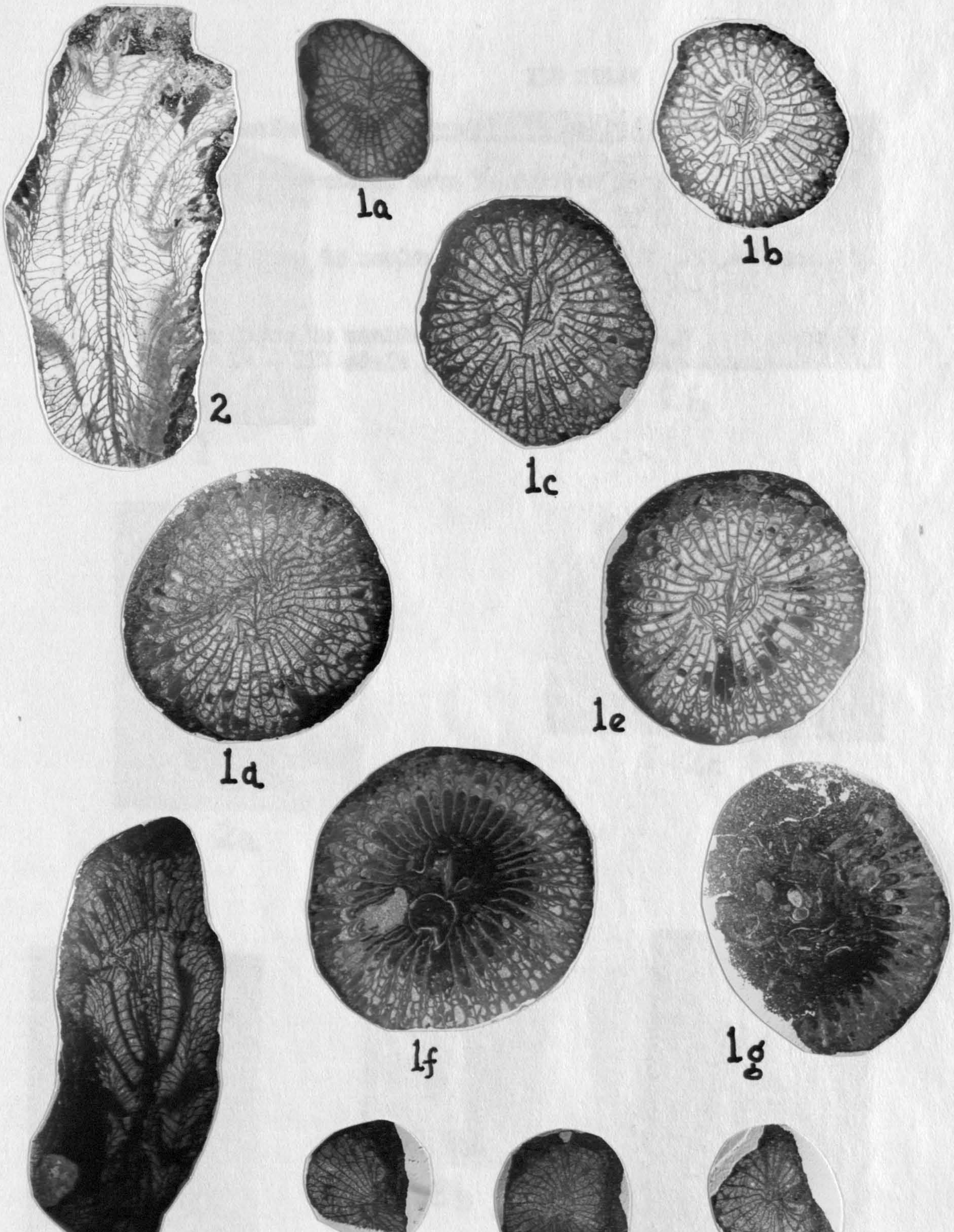


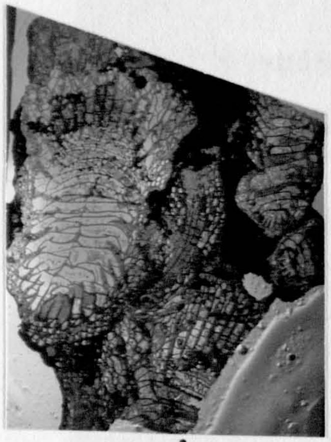
PLATE VII

Koninckophyllum cf. interruptum Nicholson & Thompson

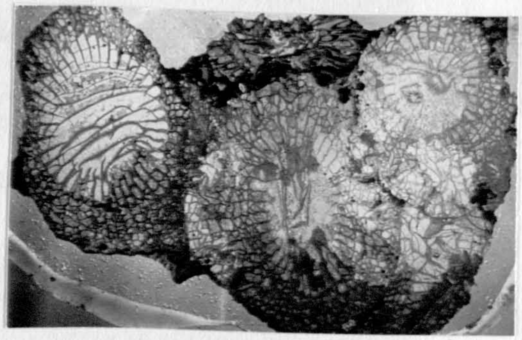
Figure 1. Vertical section of same specimen as figure 1, Plate VII - A.

Figures 2a, 2b, 2c. Transverse sections of part of same corallum.

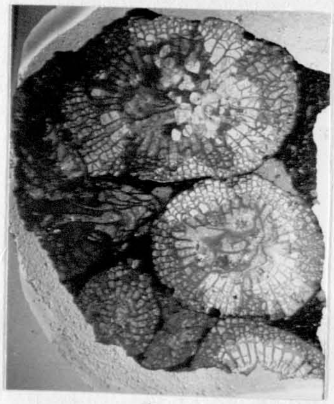
Figures 3a, 3b, 3c. Transverse sections of another corallum, same specimen as figure 2, Plate VII - A.



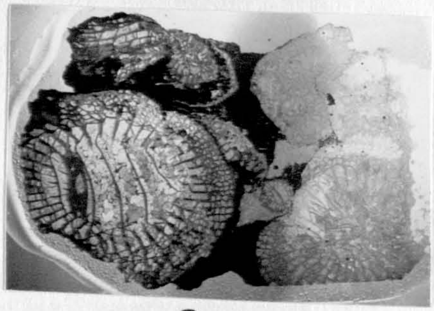
1



2b



2a



2c

3a

3b

3c

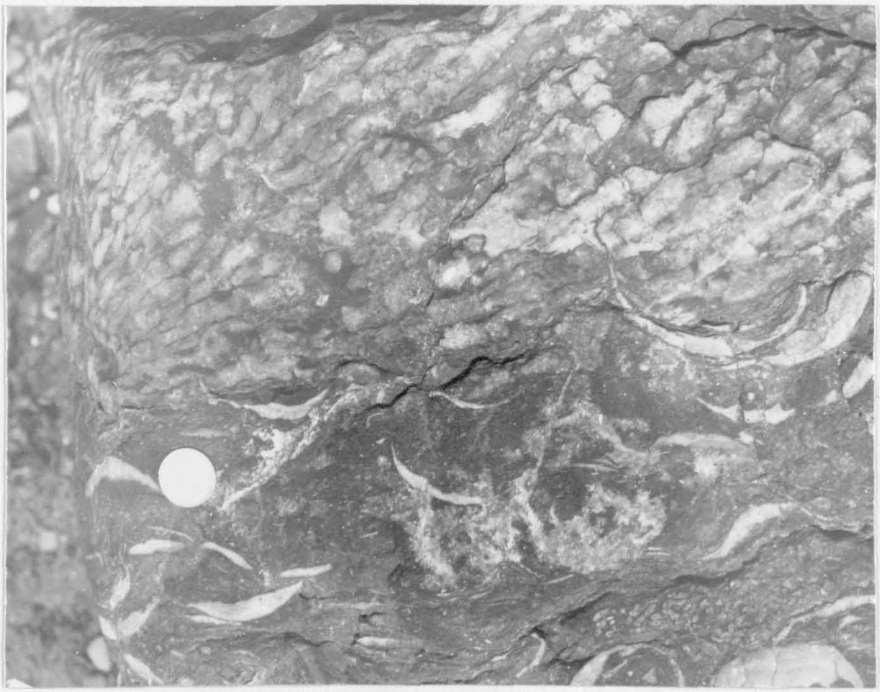
PLATE VII - A

Koninckophyllum cf. interruptum Nicholson & Thompson

Figure 1. Specimen from boulder, Goat Island, Mahone Bay, X 1.33

Figure 2. Specimen from boulder, north shore of Second Peninsula, Mahone Bay. Corallum is recrystallized. Note corallum of Lithostrotion sp. below larger corallum of Koninckophyllum. Silver quarter indicates scale.

1



2

PLATE VIII

Koninckophyllum sp.

Figures 1a, 1b, 1c, 1d. Series of transverse sections through corallite from boulder, Lynch Island, Mahone Bay.

Figures 2a, 2b. Vertical sections of a corallite from a different corallite, from boulder, Lynch Island.

Figures 3a, 3b, 3c, 3d. Series of transverse sections through same corallite as figures 2a-b.

Lonsdaleia pictoense (Billings)

Figures 4a, 4b. Vertical sections.

Figures 5a, 5b. Transverse sections. Specimen same as figure 4a-b, from Lynch Island. Same corallum also figured in Plate VIII - A, figures 1, 2.

PLATE VIII

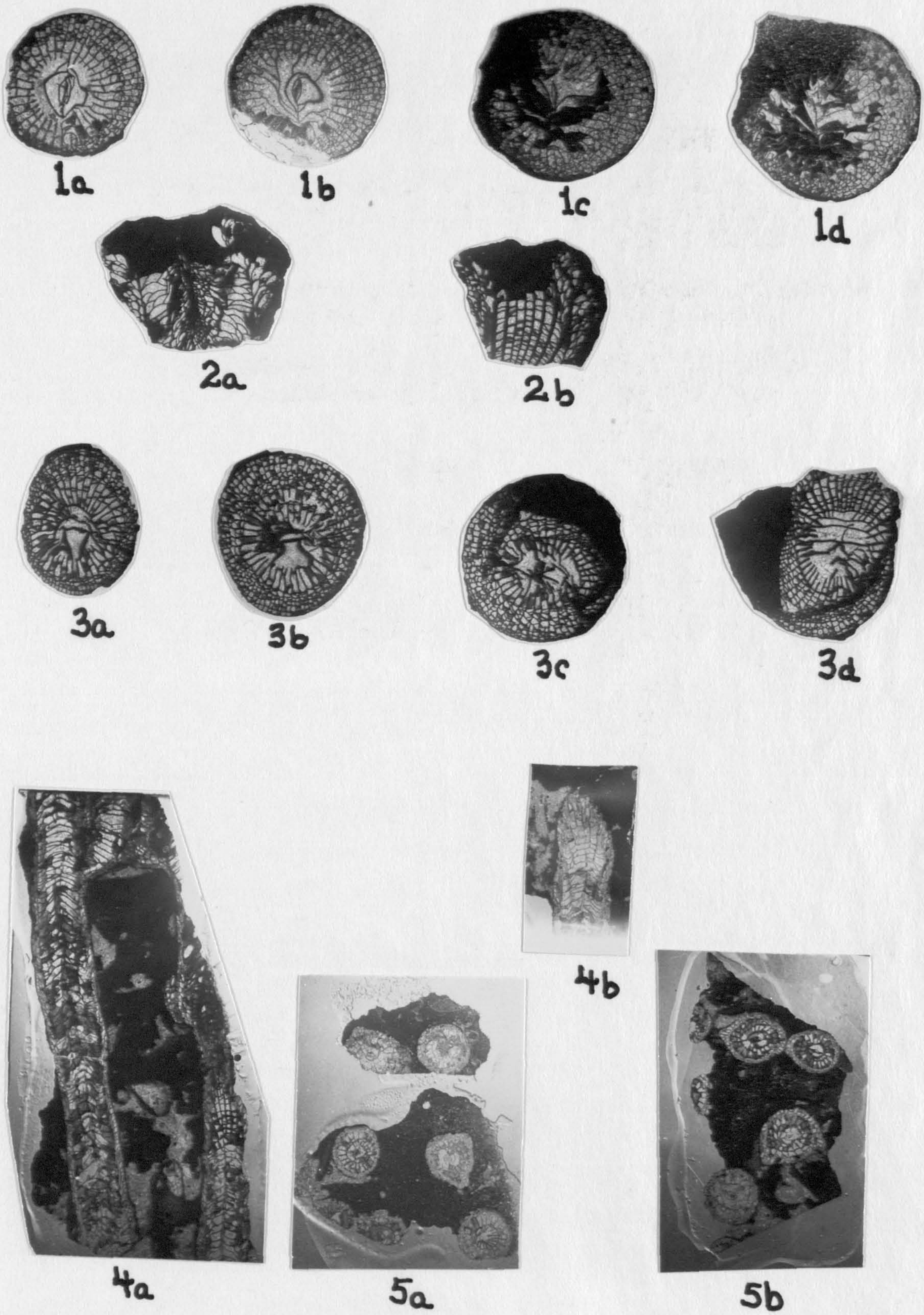


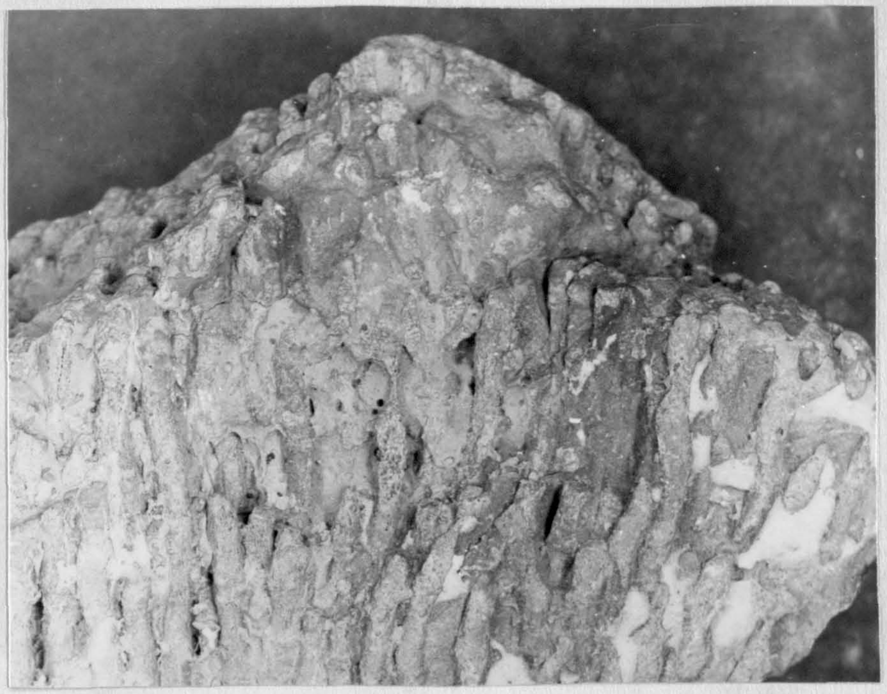
PLATE VIII - A

Lonsdaleia pictoense (Billings)

Figure 1. Top view of weathered corallum, X 2.

Figure 2. Lateral view of same corallum. This specimen is also figured on Plate VIII, figures 4a-b, 5a-b. Natural size.

1



2

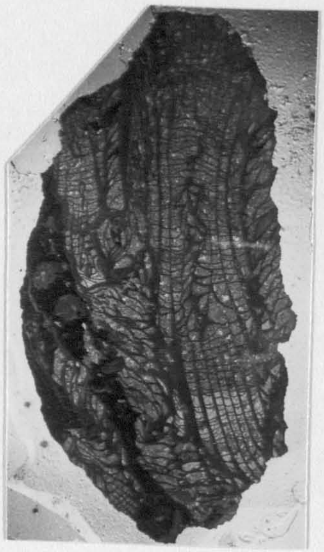
PLATE IX

Lonsdaleia sp.

Figures 1a, 1b, 1c. Vertical sections of single corralite.

Figures 2a, 2b, 2c, 2d. Transverse sections of same corallum as figures 1a-c. Specimen from boulder, Goat Island, Mahone Bay.

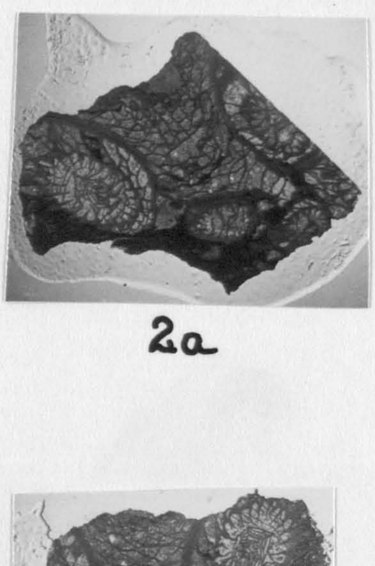
PLATE IX



1a

1b

1c



2a

2b

2c

2d

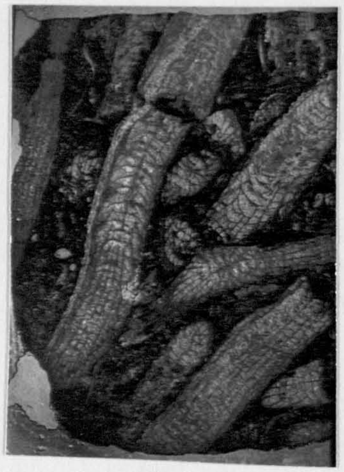
PLATE X

Lithostrotion sp.

Figure 1. Vertical section of corallum showing numerous corralites, specimen from Goat Island, Mahone Bay.

Figures 2a, 2b, 2c, 2d. Sections of corallum from Rouse Island, Mahone Bay. Same specimen as figure 1, Plate X - A.

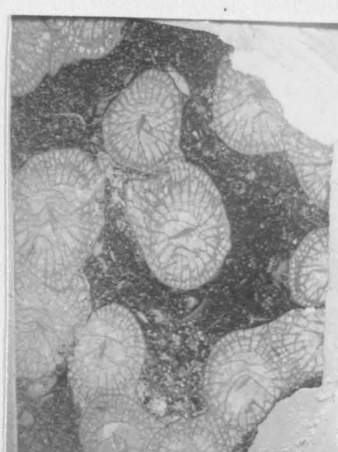
PLATE X



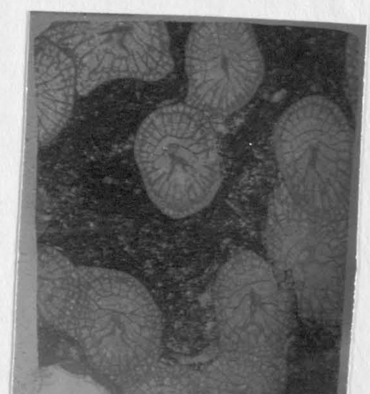
1

2a

2b



2c



2d

PLATE X - A

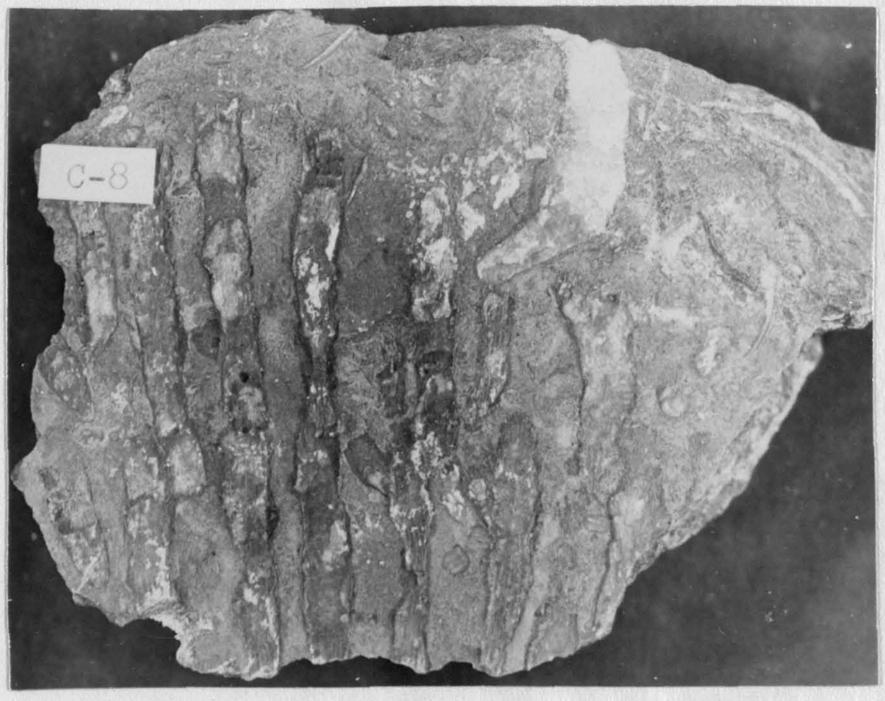
Lithostrotion sp.

Figure 1. Top view of cone-shaped corallum. Same specimen as figures 2a-d of Plate X. X 0.9

Figure 2. Side view of another corallum from Rouse Island. Note fragment of *Gigantoproductus*. Natural size.

PLATE X - A

1



2

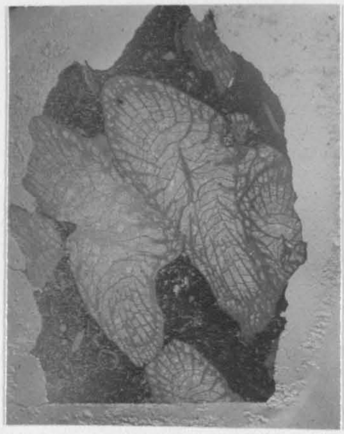
PLATE XI

Lithostrotion sp.

Figure 1. Oblique section.

Figures 2a, 2b. Transverse sections.

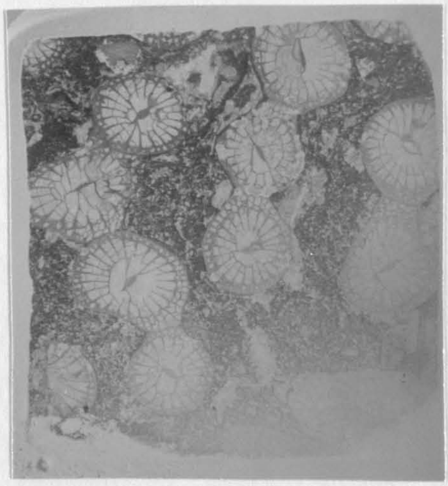
Figure 3. Vertical section. All figures on this Plate of the same corallum as figure 2, Plate X - A.



1

2a

3



2b

PLATE XII

Diphyphyllum (?) cf. lataseptum McCoy

Figures 1a, 1b. Transverse sections of corallum from boulder, north shore of Second Peninsula, Mahone Bay.

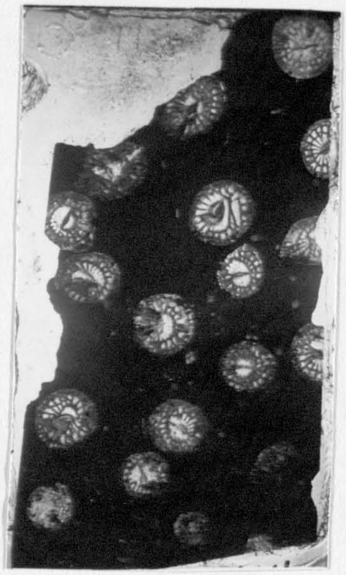
Figures 2a, 2b. Vertical sections of same corallum.

Diphyphyllum (?) cf. furcatum Thompson

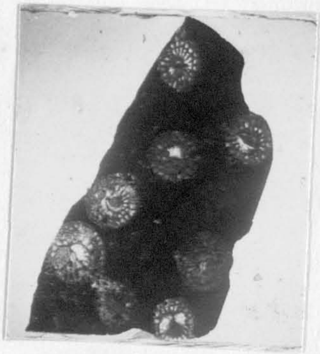
Figures 3a, 3b. Vertical sections of one corallite.

Figures 4a, 4b, 4c, 4d. Series of transverse sections through a budding corralite. Same corallum as figures 3a-b. From a boulder, Goat Island, Mahone Bay.

PLATE XII

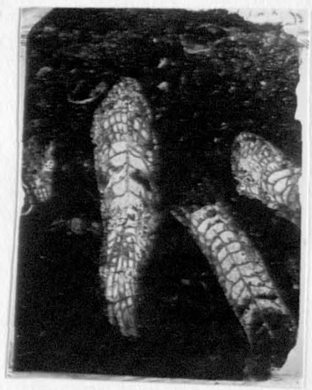


1a

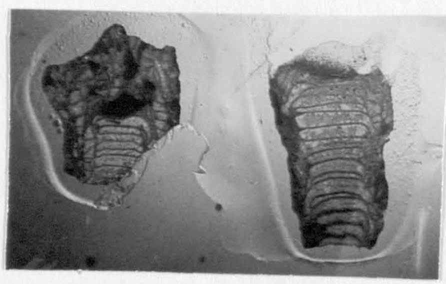


1b

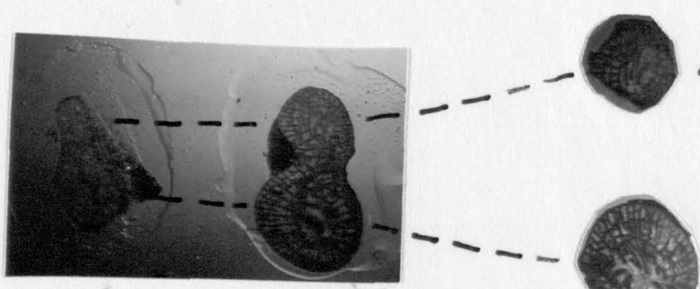
2a



2b



3a 3b



4a 4b 4c 4d

PLATE XIII

Heterophyllia sp.

Figures 1a, 1b. Transverse sections.

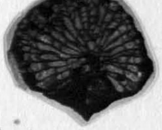
Figures 2a, 2b. Vertical sections through same corallite as figures 1a, 1b. Negative reversed on one view, both of same specimen from boulder on Lynch Island, Mahone Bay.

Corwenia (?) sp.

Figures 3a, 3b, 3c, 3d. Series of transverse sections of a corallite from Lynch Island Boulder, Mahone Bay.

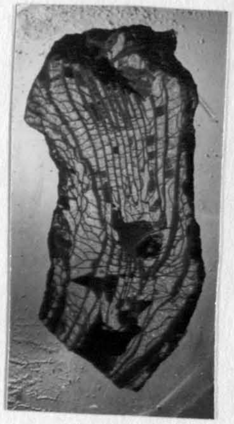
PLATE XIII

2a

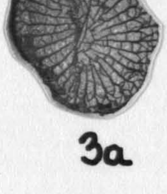


1a

1b



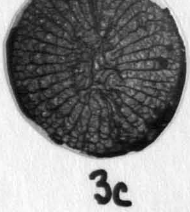
2b



3a

3d

3b



3c

PLATE XIV

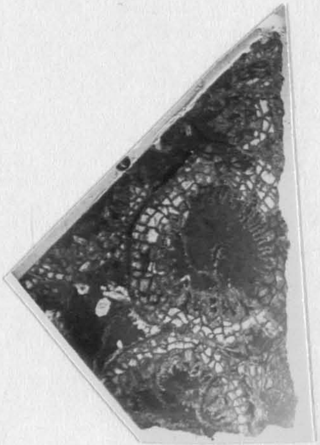
<u>Thysanophyllum cf. orientale</u> Thompson

Figures 1a, 1b, 1c, 2. Transverse sections.

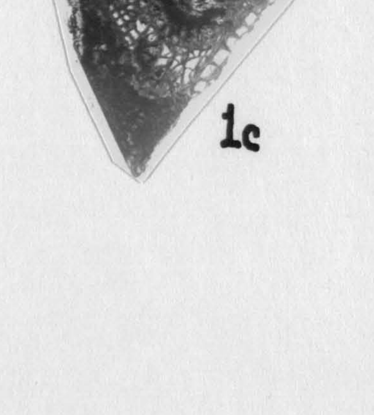
Figure 3. Vertical section. Specimen figured on this page and figure 1, Plate XIV - A from boulder, Saddle Island, Mahone Bay.

PLATE XIV

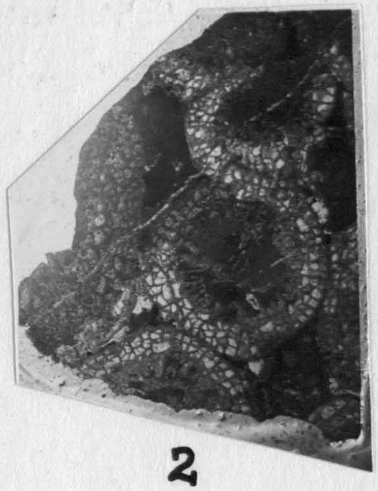
1a



1b



1c



2

3

PLATE XIV - A

Thysanophyllum cf. orientale Thompson

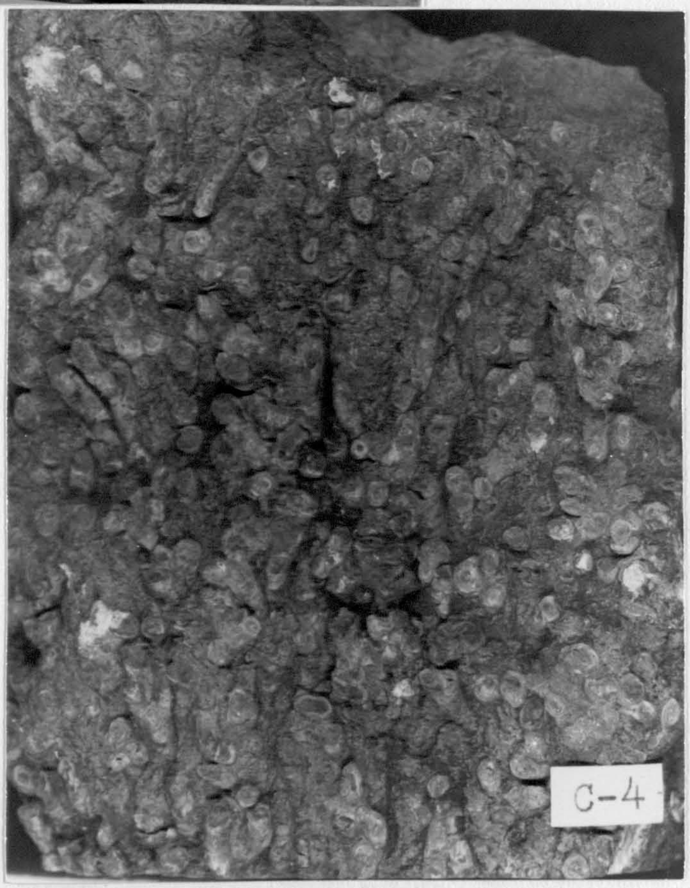
Figure 1. View of weathered corallum under valve of Gigantoproductus sp., X 1.5

Pseudoromingeria (?) sp.

Figure 2. View of weathered corallum from boulder, eastern end of Second Peninsula, Mahone Bay. Same specimen as figures 2, 3, 4, Plate XVI X 1.5

PLATE XIV - A

1



2

PLATE XV

Syringopora sp.

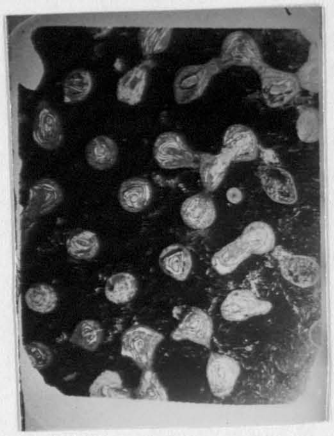
Figure 1. Transverse view of corallum.

Figure 2. Vertical view of same corallum. Both figures of same corallum as shown in figure 1, Plate XV - A. The specimen came from a boulder, Second Peninsula, Mahone Bay.

Favosites (?) sp. (Stacy)

Figure 3. Vertical section through a corallum. This specimen came from the Schizodus limestone, E subzone, Hood Island.

PLATE XV



1

2

3

PLATE XV - A

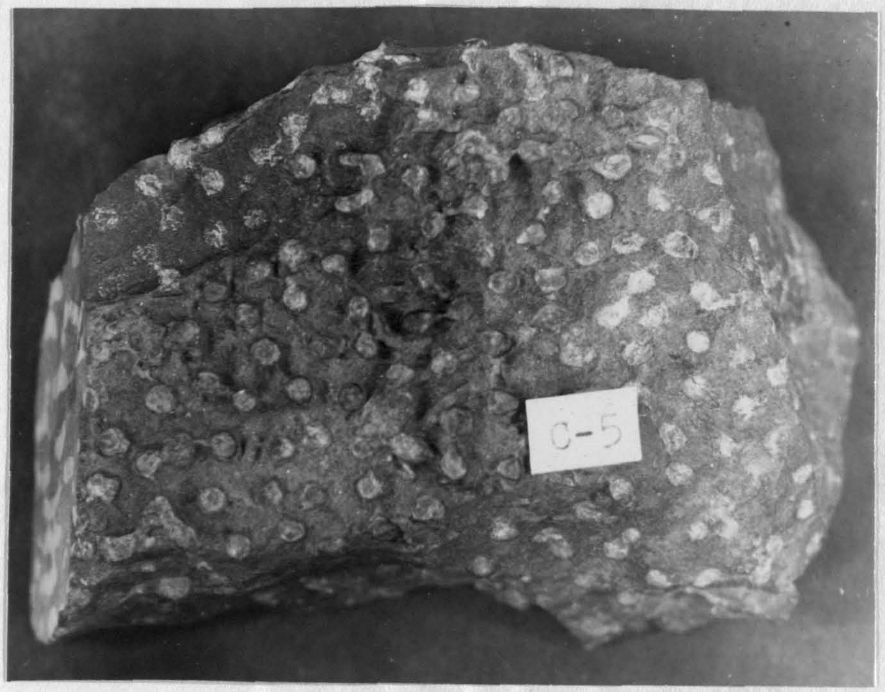
Syringopora sp.

Figure 1. Showing weathered surface of same specimen figured in Plate XV, figures 1, 2.
X 1.5

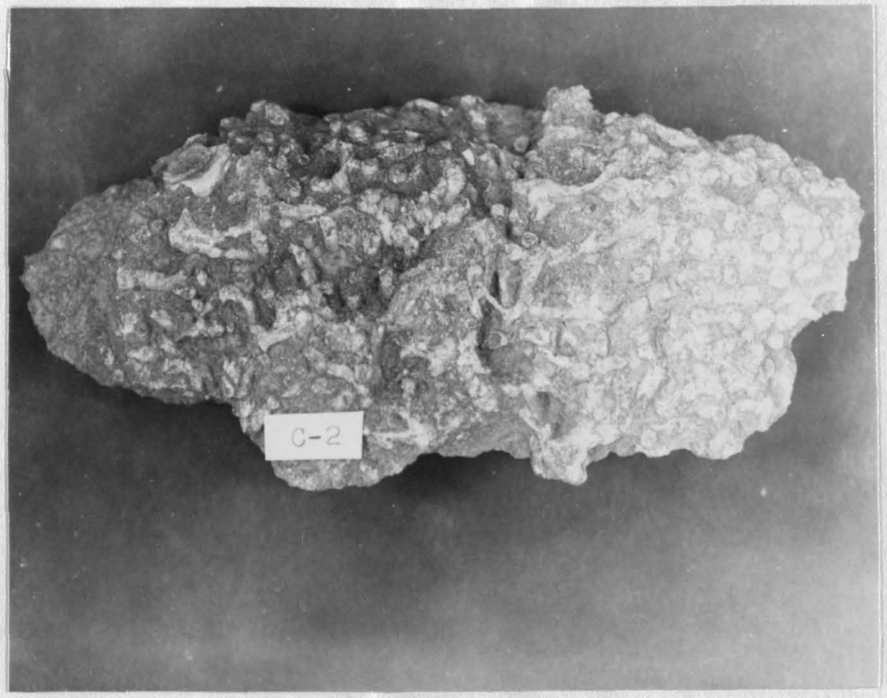
Pseudoromingeria (?) sp.

Figure 2. Weathered corallum. Same specimen as figure 1, Plate XVI. X 1.0

PLATE XV - A



1



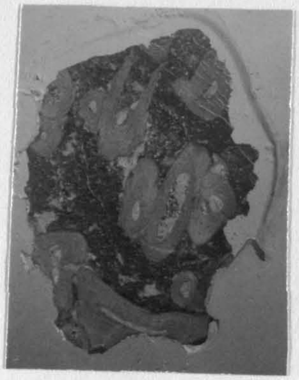
2

PLATE XVI

Pseudorominsgerina (?) sp.

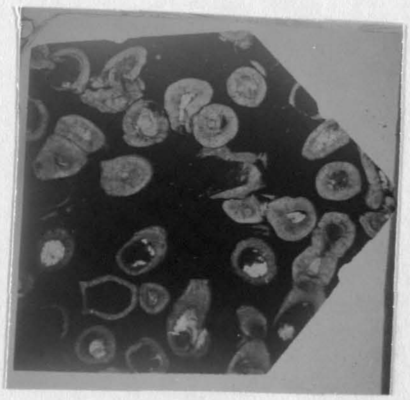
Figure 1. Section of corallum from boulder, Rouse Island, Mahone Bay, X 1.75

Figures 2, 3, 4. Sections of corallum from Second Peninsula boulder, X 1.75



1

2



3

4

PLATE XVII

Gigantoproductus sp.

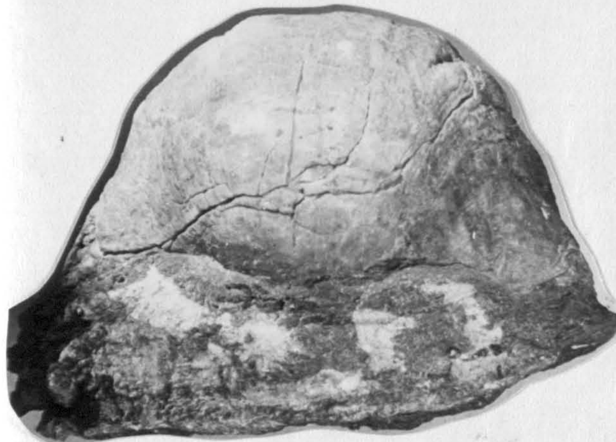
All figures on this plate X 0.8

Figures 1a, 1b, 1c. Posterior, pedicle and lateral views of a specimen showing stiff trail, radial folds and hemispherical shape.

Figure 2. Oblique view of pedicle valve of an incomplete specimen showing shape of ears.

Figure 3. View of pedicle valve of a low, wide specimen. Part of pedicle valve is broken away and the thick shell exposed.

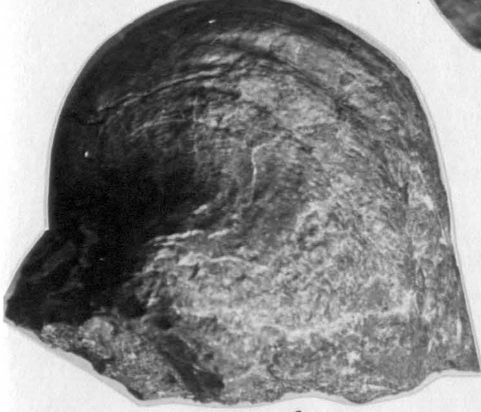
PLATE XVII



1a

1b

3



1c

2

PLATE XVIII

Gigantoproductus sp.

All figures on this plate X 0.8

Figure 1. Mold of pedicle valve.

Figure 2. Mold of fragment of another pedicle valve.

Figure 3. Mold of brachial valve.

Symbols used on overlay.

A - impression of adductor muscle.

D - impression of diductor muscle.

O - impression of auxiliary adductor,
or occlusor muscle.

C.P. - cardinal process.

M.R. - median ridge.

M.S. - median septum.

B.P. - brachial process.

B.E. - brachial eminences.

PLATE XVIII
Overlay

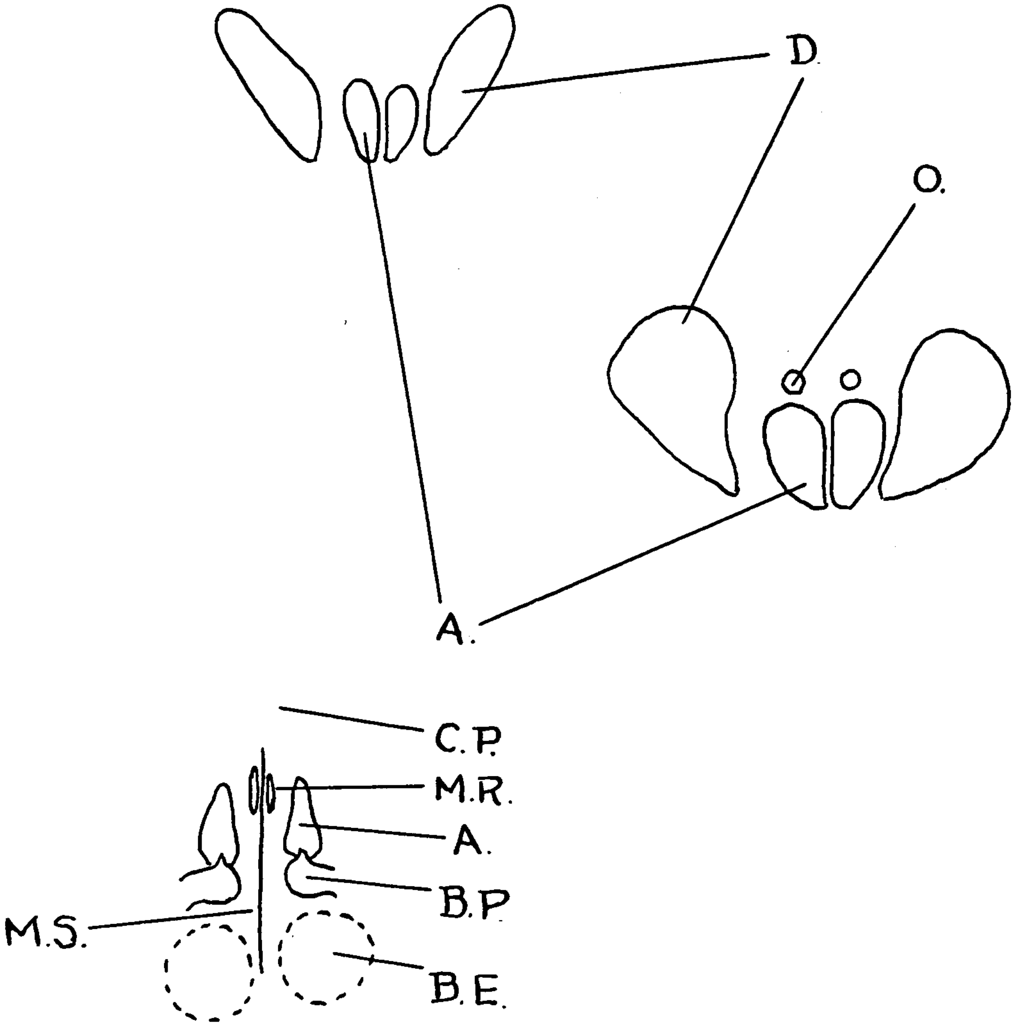


PLATE XVIII

Overlay

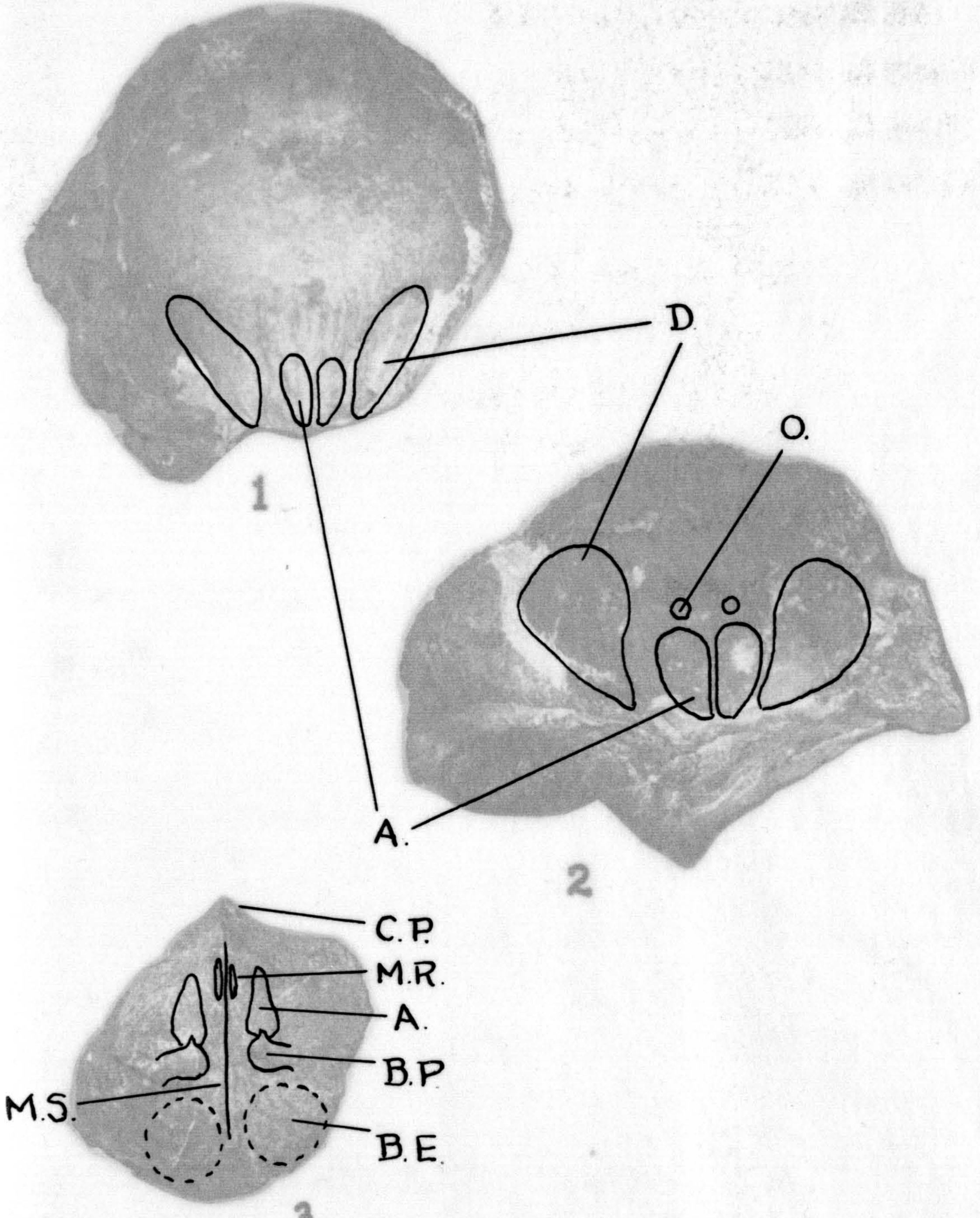
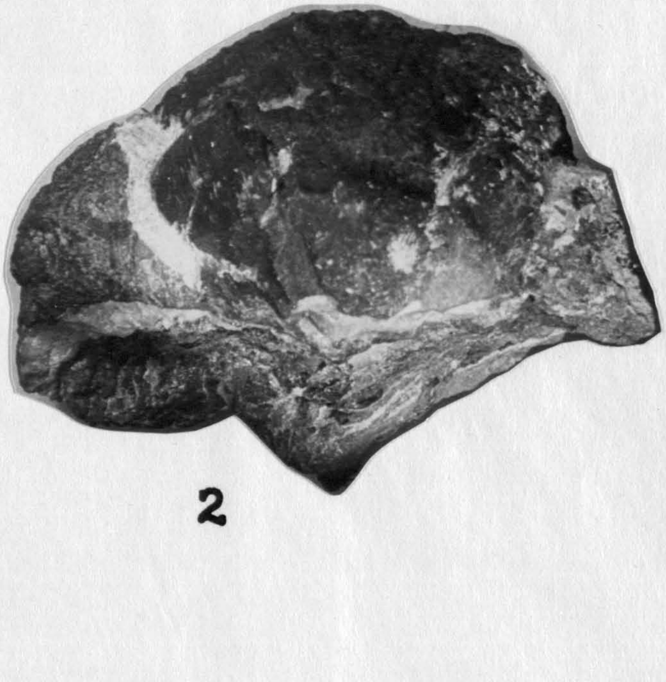


PLATE XVIII

1



2

3

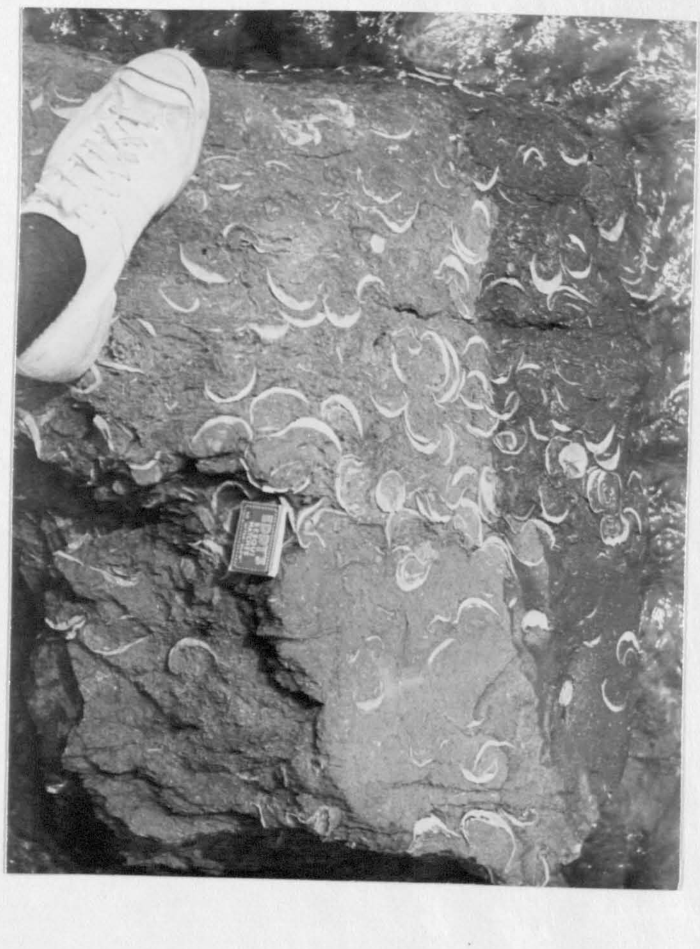
PLATE XIX

Gigantoproductus sp.

Figures 1, 2. Boulders from Rouse Island, Mahone Bay, oriented with top of bedding towards top of paper. Match box measures 2 1/4 x 1 1/2 inches.

PLATE XIX

1



2

PLATE XX

Gigantoproductus sp.

Figures 1, 2. Boulders from Goat Island, Mahone Bay, oriented with top of bedding towards top of paper. Match box is 2 1/4 x 1 1/2 inches.

PLATE XX

1

2

PLATE XXI

Pugnoides (?) sp.

Figures 1a, 1b, 1c, 1d. Posterior, anterior, pedicle and lateral views, all X 2

Bulimorpha (?) sp.

Figure 2a. Lateral view X 2.5

Figure 2b. Oblique view of apertural end X 2.5

Anematina (?) sp.

Figure 3. Lateral view X 2.5

PLATE XXI


1a


1b


1c


1d


2a


2b


3

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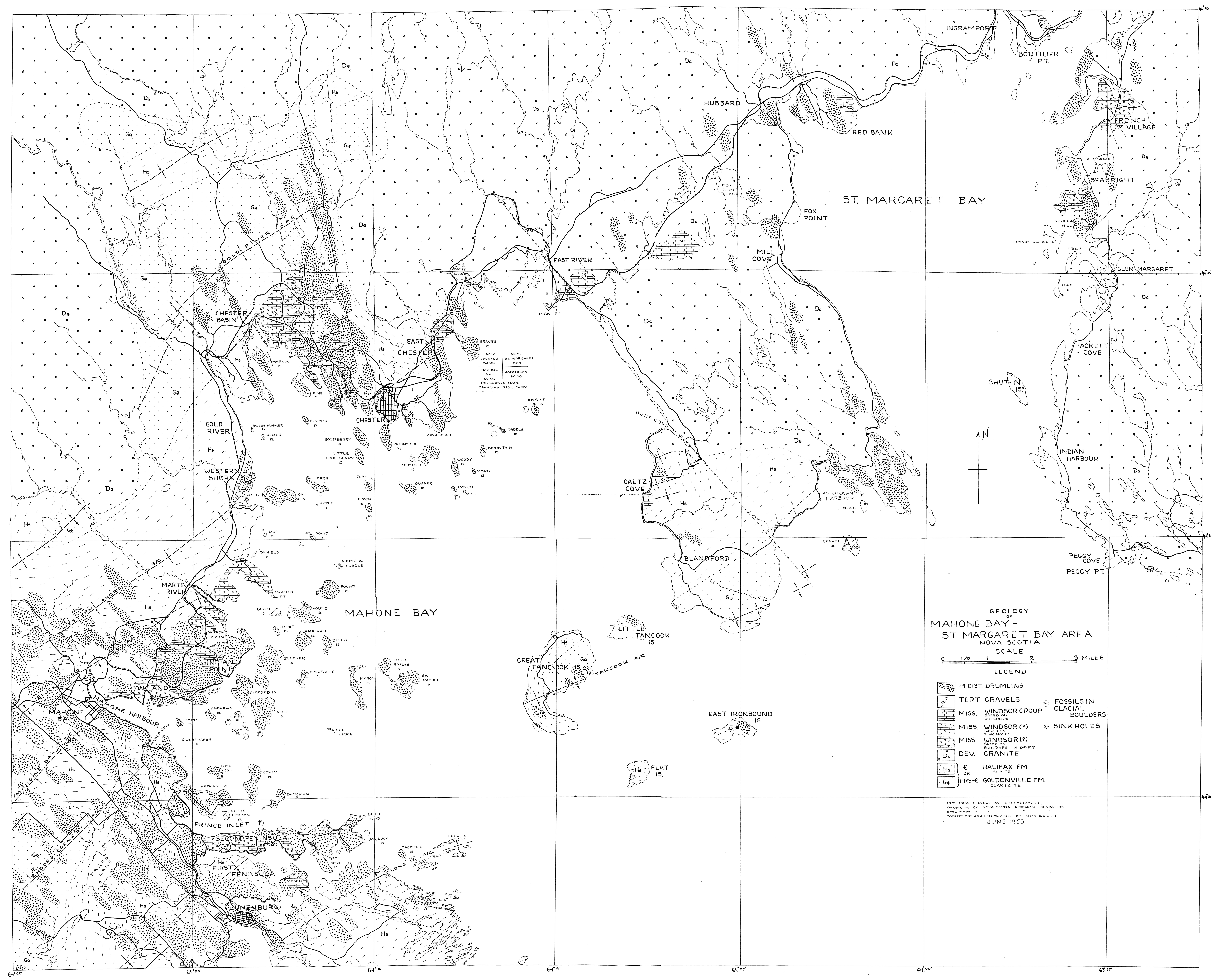
SECTIONS FOR ANTIGONISH QUADRANGLES


GEOLOGY OF
MAHONE BAY - ST. MARGARET BAY AREA
NOVA SCOTIA
SCALE
0 1/2 1 2 3 MILES
LEGEND
PLEIST. DRUMLINS
TERT. GRAVELS
MISS. WINDSOR GROUP BASED ON OUTCROPS
MISS. WINDSOR (?) BASED ON SINK HOLES
MISS. WINDSOR (?) BASED ON BOULDERS IN DRIFT
DEV. GRANITE
€ OR PRE-€ HALIFAX FM. SLATE
GOLDENVILLE FM. QUARTZITE
FOSSILS IN GLACIAL BOULDERS
SINK HOLES
PRE-MISS GEOLOGY BY E.R. FARIBAULT
DRUMLINS BY NOVA SCOTIA RESEARCH FOUNDATION
BASE MAPS " " " "
CORRECTIONS AND COMPILATION BY N McL SAGE JR
JUNE 1953
MAHONE BAY
ST. MARGARET BAY
INGRAMPORT
BOUTILIER PT.
HUBBARD
RED BANK
FRENCH VILLAGE
SEABRIGHT
FOX POINT
MILL COVE
EAST RIVER
GLEN MARGARET
HACKETT COVE
SHUT-IN IS.
INDIAN HARBOUR
PEGGY COVE
PEGGY PT.
CHESTER BASIN
EAST CHESTER
CHESTER
GOLD RIVER
WESTERN SHORE
GAETZ COVE
ASPOTOGAN HARBOUR
BLANDFORD
MARTIN RIVER
LITTLE TANCOOK IS
GREAT TANCOOK IS
TANCOOK A/C
EAST IRONBOUND IS.
FLAT IS.
INDIAN POINT
OAKLAND
MAHONE BAY
MAHONE HARBOUR
PRINCE INLET
SECOND PENINSULA
FIRST PENINSULA
LUNENBURG
NO. 87 CHESTER BASIN
NO. 71 ST. MARGARET BAY
NO. 88 MAHONE BAY
NO. 70 ASPOTOGAN
REFERENCE MAPS CANADIAN GEOL. SURV.
64°25'
64°20'
64°15'
64°10'
64°05'
64°00'
63°55'


GEOLOGY OF ANTIGONISH QUADRANGLES
NOVA SCOTIA
SCALE
0 1/2 1 2 3 MILES
PENN.
RIVERSDALE, PICTOU, & CUMBERLAND (?)
CANSO GROUP
WINDSOR GROUP
MISS.
UPPER HORTON
LOWER HORTON
PRESUMED HORTON
ORD.
BROWNS MT. GROUP
SEDIMENTARY
IGNEOUS
PRE-MISS.
BASIC DIKES & SILLS
DIABASE
GRANITE
GRANO-DIORITE
GYPSUM
SALT SPRING
DRILL HOLE
SINK HOLE
JUNE 1953
GEOLOGY BY N. McL. SAGE JR.
SEQUENCE OF WINDSOR LIMESTONES
ANTIGONISH QUADRANGLE
E1 SCHIZODUS
D3 (NO NAME)
D2 (NO NAME)
D1 GIANT RIPPLE
C3 COLUMNAR ALGAL
C2 (NO NAME)
C1 SMALL ALGAL
B3 1ST OOLITIC
B2 2nd OOLITIC
B1 QUARRY
A2 CANARY
A1 RIBBON
BASE OF WINDSOR
NOT TO SCALE
N
GEORGE BAY
MacISAAC PT.
CRYSTAL CLIFFS
JIMTOWN
MAHONEYS BEACH
DUNNS BEACH
MONKS HEAD
SOUTH SIDE
POMQUET IS.
POMQUET PT.
ANTIGONISH HARBOUR
WILLIAMS PT.
ANTIGONISH
POMQUET CHAPEL
POMQUET
POMQUET HARBOUR
BAYFIELD
SUMMERSIDE
TAYLORS ROAD
LOWER SOUTH RIVER
BAYFIELD ROAD
POMQUET FORKS
HEATHERTON
AFTON
TRACADIE
TRACADIE HARBOUR
QUARRY PT.
BOWMANS HEAD
MIDDLE HEAD
BARRIO HEAD
CAPE JACK
HAVRE BOUCHER
BLUE PT.
LINWOOD
BLACK BRIDGE
MERLAND
MONASTERY BROOK SECTION
BEECH HILL
ST. ANDREWS
MEADOW GREEN
GLEN ROY
PINEDALE
DUNMORE
MARYDALE
BEAULY
POMQUET RIVER SECTION
MILK PLANT SECTION
WEST RIVER SECTION
SAW MILL SECTION
COAL SEAM
THE SUGARLOAF
OGDEN POND
CAPTAIN POND
MONK POND
62° 00'
61° 45'
61° 30'
45° 45'
45° 30'
55'
50'
40'
35'
BASE MAPS 11 F/12 W½, E½
NOVA SCOTIA RESEARCH FOUNDATION