CANADA
DEPARTMENT OF MINES
HON. T. A. CRERAR, MINISTER; CHARLES CAMSELL, DEPUTY MINISTER

BUREAU OF ECONOMIC GEOLOGY
GEOLOGICAL SURVEY

MEMOIR 202

Contributions to the Study of the Ordovician of Ontario and Quebec

BY

A. E. Wilson, J. F. Caley, J. C. Sproule,
and V. J. Okulitch

OTTAWA
J. O. PATENAUDE, I.S.O.
PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
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PART I

A SYNOPSIS OF THE ORDOVICIAN OF ONTARIO AND WESTERN QUEBEC AND THE RELATED SUCCESSION IN NEW YORK

By Alice E. Wilson

INTRODUCTION

The aim of this synopsis is to give, as succinctly as possible, the present classification and nomenclature of the Ordovician of Ontario and western Quebec. There is a brief description of each formation, its relationship to the beds above and below, its type locality, and a few of the typical fossils are listed. A bibliography is appended which also holds titles of reports, papers, etc., dealing with related formations in New York and elsewhere.

Towards the latter part of the eighteenth century, Werner, of the Freiberg School of Mines, from the knowledge that he acquired in the immediate neighbourhood of Freiberg, made some sweeping generalizations, which were the first basis for a systematic classification of the relative age and origin of the rocks of the earth. Werner's classification was as follows:

3. Alluvial—loams, clays, sand, etc.
2. Floetz rocks—formed in part from sediments, and in part chemically.
1. Primitive—the first-formed rocks.

Later he found that all rocks did not come within this simple classification, and he introduced the term Transition rocks for the series that lies between the Primitive and the Floetz rocks.

For many years the Transition rocks were omitted in the study of the succession of formations. In the beginning of the nineteenth century, however, Sedgwick and Murchison vigorously attacked the problem of these Transition rocks. Murchison started in the south of Wales and worked down from the known base of the Old Red sandstone, in strata he termed the Silurian. Sedgwick started in the north of Wales and unravelled much of that complicated region. He called his system the Cambrian. Eventually it was found that Sedgwick's Upper Cambrian and Murchison's Lower Silurian coincided.

In 1879 Lapworth crystallized the recognition of the Lower Silurian as a separate system by proposing the term "Ordovician," reserving the term "Cambrian" for Sedgwick's Lower Cambrian.

FORMATIONS OF THE ORDOVICIAN

BEEKMANTOWN

The term " Canadian " was first employed by Dana (1875) to designate the basal member of his Lower Ordovician. He recognized in it two divisions, the heavy dolomitic phase that is now called Beekmantown and the Chazy rocks.

Ulrich (1911) limited the application of the name Canadian to the lower of Dana's two divisions, the Beekmantown. He recognizes a complete withdrawal of the sea after Ozarkian (Upper Cambrian) time. The next submergence he calls the Canadian, and he believes that prior to Chazy, or according to his conception earliest Ordovician time, another complete withdrawal of the sea took place. Thus he raises the Canadian to the status of a system practically on a par with the Ordovician. Ulrich considers the Quebec section as the type of the "Canadian" system. In the Canadian he includes Brainerd and Seeley's three upper divisions, C, D, and E. The section at Beekmantown, New York, he considers the type locality of the restricted Beekmantown. The Beekmantown of the southern Appalachians differs from that of the type locality. Ulrich, therefore, applies the term " Canadian " to all rocks formed between the two erosional intervals he describes, including both the New York and southern Appalachian representatives. Although he, and others, frequently interchange the terms Canadian and Beekmantown, he does not consider them exactly synonymous.

Clark (1934) considers that in southern Quebec a body of Upper Ozarkian occurs between the Cambrian and the Canadian. This Upper Ozarkian and Canadian he includes in the Beekmantown, thus placing the boundary between Cambrian and Ordovician at the base of the Upper Ozarkian. This use of the term Beekmantown makes it more comprehensive than the term Canadian.

The early definition of the Calciferous or Beekmantown included all beds between the well-defined Potsdam below, and the base of the less well-defined Chazy above. In eastern Ontario and western Quebec there are two phases of the Beekmantown—the Theresa, or " passage beds," and the overlying calcareous or dolomitic beds, to which Raymond has given the name of Beauharnois.

THERESA

The Theresa is a thin formation of alternating dolomites and loosely cemented sandstones. Raymond (1913) considers the sandy phase to be the reworked Potsdam sandstone with a calcareous cement. The lower dolomite layers contain considerable sand and grit, but higher up they become a purer, tough, bluish grey dolomite, weathering rusty in spots. These beds pass imperceptibly into the purer dolomite of the upper Beekmantown. The Theresa is very thin in the Ottawa valley, but increases in thickness at Smiths Falls and Brockville. In Ontario it can be traced along the western and northern edge of the Ordovician basin bounded by the Adirondacks, the Frontenac axis, and the Canadian Shield, and is there overlain by Beekmantown beds possibly correlatives of the Beauharnois strata. *Lingulepis acuminata* and rarely *Ophileta complanata* have been found in these rocks.

The Theresa was first described in New York state, the type locality being at Theresa, Jefferson county, New York, where the division attains a maximum thickness of 80 feet. In Emmons' "Report on the Second District of New York," he noted a succession of rocks near Depauville, New York, which he had not encountered elsewhere. At first he described them as the "Depauville Waterlime," thinking that the beds were above the Birdseye. Later, finding they lay below that member of the Black River, he included them in his Calciferous. His sections show that within the Calciferous he included two members. To the lower member Cushing (1908) gave the name "Theresa." He considered the Theresa in its most easterly phase as "passage" beds between the Potsdam sandstone and the overlying Beekmantown. Above the Theresa, Cushing found an unconformity, and for that reason, and, on account of the sandy nature of the formation, he considered the Theresa more closely allied to the Potsdam than to the Beekmantown. He stated that Ulrich and Ruedemann, in their work in the Champlain valley, came to the same conclusion.

In Ontario Logan recognized these beds as a separate phase and throughout the early Canadian literature they are spoken of as the "passage beds," and as lying above the Potsdam and below the typical Beekmantown. Raymond suggested that they represent the initial deposit of the advancing Ordovician sea rather than the final deposits of the Cambrian sea, and this interpretation has generally been adopted by Canadian writers. For further discussion of this *see* under Hoyt.

BEAUHARNOIS

Logan in his 1863 "Report on the Geology of Canada," traced the Calciferous (Beekmantown) into Quebec near Beauharnois. Raymond (1913) has given the name Beauharnois to the phase of the Beekmantown exposed there where it consists of dolomite and rather pure, blue-black limestone with a fauna allied to that of the typical Beekmantown. The thickness at Beauharnois has not yet been ascertained. The Beauharnois is overlain by the Chazy. The more typical fossils of the Beauharnois are *Hormotoma anna, Ophileta complanata,* and *Protocycloceras lamarcki.*

In the Ottawa valley and along the western margin of the Palæozoic basin, the Theresa is succeeded by heavy beds of rusty-weathering dolomite, in many places interbedded with heavy limestone beds. These upper Beekmantown strata have not yet been sufficiently studied to ascertain their relation to the Beauharnois. At Ottawa this upper Beekmantown attains a thickness of about 200 feet.

Raymond's (1913) revision of the Beekmantown as represented in Quebec and Ontario is:

Beekmantown {Beauharnois
Theresa

Clark (1934) considers the Beauharnois to be of middle Canadian age, and in southern Quebec recognizes above it a group of members belonging to the upper Canadian.

SILLERY

The Sillery (*See also* Deepkill) occurs in the lower valley of the St. Lawrence. Logan (1863) describes a thickness of approximately 2,000 feet of "red and green shales interstratified with greenish drab weathering sandstones, the shales prevailing. Higher up the sandstones exceed the shales, and appear as a well-marked series of fine- and coarse-grained rocks, frequently assuming the character of fine conglomerates with white coarse pebbles as large as peas."

The Sillery is Upper Cambrian or the oldest Ordovician formation in the St. Lawrence trough. It is succeeded by the Lévis. The type locality, Sillery cove, is on the north shore of St. Lawrence river a few miles above Quebec city.

Acrothele pretiosa (Billings) is the characteristic fossil.

The history of the unravelling of the age of the Sillery and the Lévis are closely intertwined. It is given under the Lévis formation.

LÉVIS

The Lévis, restricted, consists of black, grey, and greenish shales with bands of yellow weathering dolomites and beds of grey limestone conglomerates. The conglomerates, generally thin, are commonly lenticular masses. The exposures vary somewhat in the parts of the sections exhibited. The formation seems to attain a thickness of several thousand feet. Below it lies the Sillery.

The type locality is near Quebec city, but the formation is represented south of the St. Lawrence in the Eastern Townships and along the south shore of the St. Lawrence to Marsouin.

Logan (1866) placed the Sillery as being younger than the Lévis and described a general section as consisting of, in ascending order, the Lévis, Lauzon, and Sillery. Later two fossil forms were found in the Sillery, and were first considered of Upper Cambrian age. Further discoveries of fossils in the Lévis led to placing the Lévis above the Sillery. The Lauzon was never distinctly defined, and the name was soon abandoned, the strata being assigned to the Sillery. When graptolites were found associated with the two known Sillery fossil forms it was decided that there was no outstanding division between the Sillery and the Lévis. Logan estimated that the Lévis attained a thickness approximating 5,000 feet.

In 1888 Ells summed up the history of the rocks in Lévis district and showed that the Lévis is younger than the Sillery. He concluded, both from the relations of the rocks in the field, and from Lapworth's report on the graptolite content, that the Lévis is a part of the Beekmantown and that the Sillery belongs to the Cambrian.

The great difficulty in the interpretation of the Lévis strata has been that, besides being overturned, the Sillery and Lévis conglomerates bear pebbles with Cambrian fossils. Clark (1924) has clarified the situation by showing that there are five faunas carried by the Lévis and the Sillery, namely:

1. Lower Cambrian boulders in both Sillery and Lévis beds with such forms as *Obolella crassa* (Hall), *Salterella pulchella* Billings, *Olenoides ellsi* Walcott.

2. Upper Cambrian boulders in the Lévis conglomerates bearing such forms as *Agnostus canadensis* Billings and *Ptychoparia zenkeri.*
3. A limited fauna indigenous to the Sillery: *Obolella pretiosa* Billings and *Dichograptus ramulus* Hall.
4. A Beekmantown fauna in the Lévis conglomerates: *Elkania ida* (Billings), *Helicotoma miser* Billings, and *Maclonoceras metellus* (Billings).
5. An indigenous fauna of the Lévis shales with *Tetragraptus fructicosis* (Hall), *Didymograptus bifidus* (Hall), *Phyllograptus anna* Hall, and others.

PHILIPSBURG

The name Philipsburg has been given by McGerrigle (1930) to a series of rocks in the Eastern Townships of Quebec close to the border of Vermont. They were first studied by Logan who estimated they had a thickness of 4,860 feet. The series includes formations from the " Ozarkian " to the Trenton. The series is bounded both east and west by thrust faults which have considerably distorted some of the members. The lower part has been divided into seven members. The basal member, the Rock River, is 500 feet thick and consists of dark and light dolomites. Clark (1934) correlates this with the Potsdam. The six younger members Clark considers to be upper Ozarkian which he places in lowest Beekmantown. Strites Pond, 400 feet thick at the base of this group, is of light-coloured, pure limestones; above it comes the Wallace Creek succeeded by the Morgan's Corners, 150 feet and 200 to 250 feet thick, respectively, and both consist of dark dolomites with some thin, black limestones. These are followed by the Hastings Creek, consisting of 260 feet of pure limestones with some magnesian beds. Above this is the Naylor Ledge of massive, fine-grained limestone 30 feet thick. The uppermost division is the Luke Hill consisting of 160 feet of dark grey, thin-bedded limestones. Certain fossils in the Luke Hill and Naylor Ledge members suggest an older deposition than is exhibited by the members that underlie them. It is possible that the fossils in question have a greater range than was at first supposed.

The upper part of the Philipsburg series, according to Clark, consists of four limestone members which are named in ascending order, Solomon's Corners, St. Armand, Corey, and Basswood Creek. The definition, thickness, and type fossils of these rocks have not yet been published. Their age is indicated by Clark to be Upper Canadian and uppermost Beekmantown, representatives of the Lower and Middle Canadian being absent from the series. The Basswood Creek is overlain by the Mystic formation (Chazy age).

HOYT

The Hoyt consists of alternating dolomites and limestones, thick bedded, usually dark, many almost black. In the lower portion, particularly, there are often some oolitic beds. Throughout the section layers of vitreous sandstone occur but are more evident in the lower part. The type locality is the Hoyt quarry near Saratoga Springs, New York. Cushing (1914) found these beds with the Theresa below them to equal, approximately, in thickness the whole Theresa as developed farther west. He considered them as taking the place of the upper part of the Theresa and as representing an offshore phase of the sedimentation of Theresa time. *Lingulella acuminata* and *Cryptozoons* are found throughout. Above the Hoyt lies the Little Falls dolomite.

The Hoyt is generally considered Upper Cambrian. It is included here because of the relationship with the Theresa. If, as Cushing says, it represents the upper Theresa then the Theresa is also Cambrian, but the Theresa at Saratoga and the Theresa of Theresa, New York, and eastern Ontario, may not be equivalents.

DEEPKILL

The Deepkill shales were originally included in the shales of the "Hudson River Group." In 1902, Ruedemann described an exposure of Beekmantown shale in Rensselaer county, New York. It contained a fauna that included most of the Lévis forms, and to it he gave the name, "Deepkill shales." The formation has a maximum thickness of 200 to 300 feet and consists of an alternation of thin limestones, sandy shales, grits, and siliceous and black, graptolite shales. The Deepkill beds have been divided into three major zones, which, listed from uppermost to lowermost, are as follows:

(*c*) *Diplograptus dentatus* and *Cryptograptus antennarius* zone.
(*b*) *Didymograptus bifidus* and *Phyllograptus anna* zone.
(*a*) *Tetragraptus* zone.

Ruedemann considered the Deepkill to represent a southern extension of the Lévis trough and from the work done up to that time Ruedemann recognized that both the upper and lower Deepkill zones were present at Lévis. The middle zone he compared with the exposures at Ste. Anne.

Clark (1924) has shown that the divisions of the Lévis do not quite correspond with those of the Deepkill. The fauna of the uppermost division of the Lévis and that of the highest division of the Deepkill are closely related, but the range and the prevalence of certain fossils and the association of forms are somewhat different from that found at Deepkill.

CHAZY

The Chazy includes practically every type of sedimentary rock and the study and differentiation of the horizons of the Chazy have almost given the term group significance. The Chazy was first described in the early New York reports from Champlain valley near Chazy, New York, where, according to Raymond (1906), one section is 890 feet thick without exposing the top.

The Chazy of Champlain valley was divided by Brainerd and Seely (1896) into three members, lithological features being employed as a basis of the division. Cushing (1905) recognized these divisions and proposed for them the names Day Point, Crown Point, and Valcour, in ascending order. Raymond (1906) made a detailed study of the fauna and indicated that in a general way the lithological divisions corresponded with the faunal divisions, but he revised the boundaries between them, in order that the basis of division might be applied outside of Champlain valley.

AYLMER

To the phase of the Chazy exposed along Ottawa valley, Raymond (1912) has given the name Aylmer. The type section is at Aylmer, Quebec, about 12 miles above Ottawa, and the division attains a thickness of 150 to 200 feet. The Aylmer consists of shales with interbedded, fine-grained sandstone lenses of varying thickness and varying extent. In the vicinity of Ottawa city both shales and sandstones are grey-green, farther up the river they have become a deep red. Around Montreal and in the lower Ottawa and St. Lawrence regions the shales are overlain by a thick limestone. This limestone thins out toward the west, becoming very impure, and contains towards the top some layers of rusty-weathering dolomite. *Camarotoechia plena* is the characteristic fossil. In some places a number of cystids are associated with this brachiopod. The lower beds exposed at Chazy, New York, are unrepresented in the Ottawa-St. Lawrence region.

MYSTIC

Clark (1934) has given the name Mystic to certain limestone and conglomerate beds in the Philipsburg region in southern Quebec. They succeed the Basswood Creek member of the Philipsburg series Upper Beekmantown, and are in turn overlain by the Stanbridge slate of Trenton age. Details as to thickness and fossil content have not yet been published.

BLACK RIVER

The Black River was at first considered to be a lower part of the Trenton. It is a distinctive and very persistent group and is widely distributed over New York and eastern Canada. In the past the term Black River has been indiscriminately used both for the upper portion of the group and for the group itself. In the last fifteen years the group has been differentiated into several members and the term Black River has been reserved for the group name only. The three main members recognized in the Canadian section are, in ascending order, Pamelia, Lowville, and Leray.

PAMELIA

Cushing (1910) describes the Pamelia at the type locality Pamelia, New York, as consisting of two parts having a combined maximum structure of 150 feet. The lower part has a sandy base above which it consists of alternating blue, black, and grey limestones with shaly partings. The upper part is composed of lighter grey limestone with dolomite. Cushing found that the same succession extends across the St. Lawrence to Kingston. The lower, rather fine conglomerate layer, called Rideau beds by Ami (1902), which rests directly on the Precambrian in that area, Cushing considered to be the base of the Pamelia. Raymond (1911) correlated certain beds at Ottawa with the Pamelia in New York, and with the succession at Kingston. In Ottawa valley the Pamelia is approximately 70 feet thick. The lower part is composed mainly of impure sandstone layers, with considerable shale and a few, thin, dark grey or black limestone bands. The upper division consists of interbedded limestone, shale, and dolomite with a white sandstone layer at the base. Several forms of *Tetradium* with *Bathyurus acutus* and several zones of ostracods characterize the Pamelia.

In Ottawa valley the Pamelia rests on thin, impure limestone and dolomites of the upper Chazy. In the Kingston region it lies directly upon the Precambrian. The Pamelia is followed by the Lowville in all known localities.

According to Raymond (1913) the Pamelia is more closely allied to the Black River than to the Chazy.

LOWVILLE

The term Lowville was introduced to replace the older term, Birdseye, and the town of Lowville, New York, was designated as the type locality. Clarke and Schuchert (1899) limited the Lowville to the part of the section that exhibits the feature due to the presence of tubes of *Phytopsis tubulosa,* and which had given rise to the descriptive name of Birdseye. These authors employed the term Black River for the overlying beds. Later the term Leray was introduced by Cushing (1910) to designate the Black River strata succeeding the restricted Lowville of the type locality. Bassler (1932) and several others have continued to treat the Leray as being an upper part of the Lowville.

The restricted Lowville (Schuchert and Clarke, 1899) consists of light grey limestones and shales interbedded with fine-grained limestone full of the tubes of *Phytopsis tubulosa.* At the base the formation is thin-bedded, but towards the top the fine-grained material in some cases attains a thickness of 1 to 3 feet.

In Ottawa valley the Lowville is from 20 to 25 feet thick. Like the Pamelia it becomes thicker to the south, reaching a maximum of 60 feet in New York state. *Tetradium cellulosum* is exceedingly abundant in some layers. The Lowville has been recognized west of the Frontenac axis, but has often been combined with the Leray above, or in some cases even the Lower Trenton has been included with it, so that its exact thickness is not known.

LERAY

The Leray limestone at its type locality, Watertown, New York, is described by Cushing (1910) as consisting of dark grey, heavily bedded limestone with layers of black chert nodules. Above the Leray is the so-called 7-foot tier which locally has been called the Watertown. It is like the Leray but carries a greater amount of chert and an abundance of cephalopods, some of which are found in the Leray below. In Ontario the Leray is a heavy-bedded, dark grey limestone weathering rubbly. It occasionally has shaly partings. The chert is much less prominent in the northern exposures.

Cushing states that the Leray is 13 feet thick at the type locality. It thickens somewhat to the north, reaching approximately 30 feet. *Columnaria halli, Doleroides pervetus ottawana,* and Actinoceroid cephalopods are characteristic forms. The Leray has been found both east and west of the Frontenac axis in Ontario.

The term Coboconk was given by Johnston (1912) to the Leray beds in central Ontario west of the Frontenac axis.

G. Marshall Kay (1929) gave the name Glenburnie to a couple of feet of argillaceous limestone that lies between the Watertown and Leray in a section near Glenburnie, Frontenac county, Ontario. The majority of the fossils cited are bryozoan. The other forms appear in the top of the Leray as recognized at Ottawa.

G. Marshall Kay (1929) proposed the term Chaumont to include the Watertown, Glenburnie, and Leray as exhibited in the Watertown-Kingston area.

TRENTON

The word Trenton was originally used to designate rocks both older and younger than is now the practice. The type locality is at Trenton Falls, New York, and was described in some detail by White (1896) and by Prosser and Cumings (1897). The later investigations have proved that a complete section of the Trenton is not present at the type locality nor in its vicinity. The term as now employed is generally used to designate a group, consisting of various members. This group attains a thickness of approximately 600 feet in Ontario and consists of shale and limestone.

ROCKLAND

The Rockland consists of heavy-bedded, dove-grey, somewhat crystalline limestones, interbedded in some localities with shale beds 4 to 10 inches thick. Towards the top the beds become thinner and break into platy fragments.

Above the Rockland lies the Hull, and below it the Leray. Between undoubted Rockland and undoubted Leray there is a zone in which the Black River forms mingle with the early Trenton forms.

Orthis tricenaria, Rafinesquina alternata, Ceraurus pleurexanthemus, and an abundance of *Dalmanella rogata* are prevalent in the Rockland. The division attains an average thickness of about 35 feet. It is found throughout the eastern part of Ontario. The type locality is Rockland, near Ottawa (Raymond, 1914).

HULL

The name Hull was given by Raymond (1914). The type locality is Hull, Quebec, where a lower part of the member is represented by thick- and thin-bedded, blue limestones with a considerable amount of chert. These beds are particularly noted for their crinoids. They pass upward into massive, coarse-grained, blue-grey limestones which hold some *Tetradium*, but otherwise comparatively few fossils. In the neighbourhood of Hull and Ottawa the two phases combined are 90 to 100 feet thick. The Hull lies upon the Rockland and is overlain by the Sherman Fall.

SHERMAN FALL

The Sherman Fall consists of dark grey or in some cases brownish weathering, grey shales with thin, impure, dark grey limestone bands. It is estimated that it attains a thickness of about 100 feet at Trenton Falls, New York. In Ottawa valley the member is approximately 25 feet. Raymond (1913, 1916) adds to these beds the next zone which he originally separated as Cystid beds. If this is included the total thickness would approximate that of the type section. There are features, however, that suggest a closer correlation of the Cystid beds with the beds above them. The abundance of *Prasopora* is characteristic of the Sherman Fall member, which, however, is replete with fossils from every phylum.

Raymond (1913) used the term "Prasopora beds" to designate these beds as represented at Trenton Falls, New York. G. Marshall Kay (1929) has adopted the name Sherman Fall as suggested by J. J. Galloway in place of "Prasopora beds" and defined the limits of the beds to be designated by the term.

COBOURG

The Cobourg was first named Picton (Raymond, 1914) from the town Picton, Ontario, but the name being preoccupied was subsequently changed by Raymond (1921) to Cobourg and the vicinity of Cobourg was substituted as the type locality. The Cobourg rests on the Sherman Fall and is overlain by the Collingwood. Its total thickness is several hundred feet. The lower part consists of thin to thick beds of grey limestone alternating with thin bands of shale. These measures grade upwards into the upper part which is composed of heavier beds of muddy grey, rusty-weathering, more impure limestone.

Rafinesquina deltoidea occurs throughout the strata. *Hormotoma trentonensis* and *Trochonema umbilicatum* are abundant in the upper part of the Cobourg.

The Cobourg has generally been included in the Trenton group, but possibly is in part or whole of Utica age (*See* Utica).

LORETTE

The Lorette beds were described by Raymond (1912) as belonging to the basal Trenton as exposed at Montreal and Quebec. The type locality is at Lorette, just west of Quebec city. The formation there rests on Precambrian. A fine-grained conglomerate at the base is followed by thin-bedded, blue-grey limestone, which toward the top becomes thick bedded and dark grey. The Lorette is approximately 90 feet in thickness at the type locality where it is succeeded by typical Middle Trenton beds. The limestone carries numerous fossils. *Trinucleus* and an early form of *Parastrophia* are present. The upper part of the Lorette appears to correspond to the Rockland, the lower part may be older.

FARNHAM

The name Farnham was given by Dresser (1910) to a series of graphitic, argillaceous, and in places calcareous, slates, with at their base, a conglomerate. The slates have yielded few fossils and their age is somewhat doubtful. They have, however, generally been regarded as of Lower Trenton age.

STANBRIDGE

The Stanbridge slates occur in Philipsburg district, Quebec. Clark (1934) considers them to represent the Trenton and (?) possibly the Utica. They overlie the Mystic.

LACOLLE

The Lacolle is a conglomerate occurring near Lacolle, Quebec. It overlies and holds boulders of Beekmantown dolomite and is overlain by the Stony Point. Clark (1934) considers it to be probably of Upper Trenton age.

STONY POINT

The Stony Point (Clark, 1934) is a shale. It overlies the Lacolle in the vicinity of Lacolle and is overlain by the Iberville. It contains a graptolite fauna.

MAGOG

The Magog slates occur in the Memphremagog quadrangle, Quebec. They consist of a thick series of carbonaceous mudstones, and according to Clark (1934) contain graptolites of Trenton age.

TOMIFOBIA

The Tomifobia is a series of graptolitic slates and dark limestones occurring east of lake Memphremagog, Quebec (Clark, 1934).

UTICA

Raymond (1913) recognized two divisions in the Utica of Ontario and Quebec, the Collingwood and the Gloucester. He more recently (1916) has suggested, however, that the Collingwood is probably younger than the typical Utica in New York and correlates the Upper Cobourg with the typical Utica.

COLLINGWOOD

The name "Collingwood" was introduced by Raymond (1912) for the fine-grained, dark limestones alternating with dark, rusty-weathering shales that lie upon the uppermost Cobourg and are succeeded by the typical black shales of the Gloucester. The Collingwood grades imperceptibly into the Gloucester and the boundary between them has been arbitrarily placed at the last appearance of the Collingwood horizon marker *Ogygites canadensis*. At Ottawa the thickness is regarded as less than 50 feet. In the Georgian Bay region a thickness of limestones has been found containing the typical *Ogygites canadensis* and lying above the Upper Cobourg beds. The Collingwood has been distinguished as far east as Montreal. It outcrops in Ottawa valley, and on the north shore of lake Ontario and northwest around the southern margin of Georgian bay in Collingwood region.

Raymond (1913) originally classed the Collingwood as Lower Utica, considering the dark graptolite-bearing shale above it to be typical Utica. In 1916 Raymond correlated the Collingwood with the Frankfort above the typical Utica of New York. In 1921 he correlated the Collingwood with the Utica of New York, thus lowering it in the scale. He considered the Utica, however, as a shaly phase of the Trenton, not a separate unit. In 1922 he again raised its position. Ulrich (1913) considered the Collingwood an independent late invasion of the Trenton from the northeast. Ruedemann (1925) concludes that the Collingwood is an upper zone of the true Utica.

GLOUCESTER

The Gloucester consists of fissile, carbonaceous, black shales. The Gloucester was so named by Raymond (1916) to indicate the upper phase of the "Utica" as it is known at Ottawa. No exposure shows a good section, but it is estimated to be something over 100 feet in thickness. It is characterized by an abundance of graptolites and *Triarthrus*. The Gloucester has not been recognized as such elsewhere. It is underlain by the Collingwood, and is succeeded by a representative of the "Lorraine." Parks (1928) correlates the upper Gloucester with the Blue Mountain of Georgian bay. Ruedemann (1925) places the Gloucester in the topmost Utica, correlating it with the Deer River and Atwater shales. The Deer River shales he considers the top of the Utica and the Atwater shales as equivalent to the Frankfort shales.

BLUE MOUNTAIN

The Blue Mountain is composed of soft, blue-grey shales, sparingly fossiliferous. Outcrops are not numerous, but the formation is estimated to be about 200 feet thick at Georgian bay. It contains a varied fauna in which there are some graptolites and a characteristic trilobite *T. spinosus rougensis*. It is underlain by the Collingwood shale and succeeded by the basal member of the Dundas (Lorraine) formation, from which it is only separated faunally by the lack of the appearance of the *Triarthrus*. The type region is along the south shore of Georgian bay. Parks (1928) correlates it with the upper Gloucester at Ottawa.

IBERVILLE

The Iberville is a graptolite-bearing shale occurring in the Lacolle quadrangle, Quebec. It overlies the Stony Point. Clark (1934) suggests its correlation with the Utica.

LORRAINE

The Palæozoic region of southern Ontario and western Quebec is divided in two by the Precambrian area of the so-called Frontenac axis which extends southeasterly from the Canadian Shield and crosses the St. Lawrence in the Thousand Islands district. The Upper Ordovician east of the Frontenac axis has been classified by Foerste (1924) as follows:

Richmond
Lorraine

The Upper Ordovician west of the Frontenac axis was divided by Foerste as follows:

Richmond
Maysville—Wekwemikongsing
Eden —Sheguiandah

Parks in his study of the Toronto region recognized a stratigraphic unit which he named Dundas and divided into four members, the succession being:

Richmond

Dundas { Credit, Humber, Danforth, Rosedale }

The Rosedale and Danforth combined correspond to the Eden (Sheguiandah) of Foerste.

The term Lorraine was originally proposed by Emmons to include in New York all the Upper Ordovician shale from, and including, the Utica. In eastern Ontario and western Quebec the Lorraine has not been subdivided and the term has been used to designate the strata succeeding the Utica and succeeded by the Richmond. In Ottawa valley the Utica passes very gradually upward into the Lorraine by the intercalation of thin, somewhat dolomitic bands. The black shales gradually give place to grey shales which in turn give place to more arenaceous shales. Both interbedded shales and the dolomite bands weather rusty, and are fossiliferous. Farther east in Quebec Logan (1863) describes the Lorraine as alternating layers of bluish and grey argillaceous and calcareous shales with a sand content, in some cases interstratified with thin limestone layers.

In Ontario one well at Vars showed a thickness of 510 feet. Apparently the thickness increases eastward. Johnston (1933) reports a well from Yamaska county, Quebec, showing a thickness approximating 3,000 feet.

"LORRAINE"

The Lorraine of eastern Ontario and western Quebec succeeds the Utica and is followed by the Richmond. Some of the typical fossils of this "Lorraine" are *Zygospira erratica, Pholidops* cf. *truncata, Cryptolithus.*

DUNDAS

In the Toronto region above the Utica there is a thickness of nearly 600 feet of grey shales, limestones, and sandstones. These beds have been divided on the basis of their fossils into an upper group of Richmond age, and a lower of Lorraine or Maysville age. To the lower part Parks (1925) has given the name Dundas.

The Dundas is mainly a greyish blue shale weathering lighter. It varies from a dense, blue, argillaceous shale to a yellowish, silty, or argillaceous shale. Its fossil content partakes of the features of the Maysville rather than of the Lorraine of New York.

The Dundas has been recognized along the south of Georgian bay and at Toronto and west of it. There are features in the Lorraine of eastern Ontario that suggest a correlation with some phases of the Dundas.

The members of the Dundas are given below. The fossil content of these members has been worked out in considerable detail by Dyer (1925) and Miss Fritz (1926).

ROSEDALE

The Rosedale (Parks, 1925) is the basal member of the Dundas formation. It consists of blue shales with a few hard bands of argillaceous shales. Only the upper 10 feet has been exposed at Rosedale, Toronto, the type locality, but it has a thickness of about 25 feet in the Meaford section. It has also been found in Credit valley. *Whitella impressata* and *Mastigograptus gracilis* are characteristic forms.

DANFORTH

The Danforth (Parks, 1925) member of the Dundas is of blue, green, and dark grey shales with more of the hard bands of limestone than occur in the Rosedale below, and a few sandy layers. It occurs above the Rosedale and is succeeded by the Humber at Meaford, at Toronto, and in Credit valley. It has a maximum thickness of 68 feet. *Hallopora onealli danforthensis* is a characteristic form.

HUMBER

The Humber (Parks, 1925) member of the Dundas is composed of bluish grey shales. It is more massive than the two preceding members. The shales are interbedded with occasional silty bands. Hard limestone and sandy layers are intercalated. The highly fossiliferous limestone bands are characterized by an abundance of *Zygospira erratica* and by the presence of *Rafinesquina mucronata torontonensis*. The member attains a maximum thickness of 282 feet in the Lake Ontario region, but decreases to 91 feet at Meaford.

CREDIT

The Credit (Parks, 1925) member of the Dundas follows the Humber in the Toronto and Credit Valley region. It is succeeded by the Richmond. It consists of interbedded shales and limestones, the limestones becoming dominant at the top. It contains numerous bryozoans of which *Stigmatella sessilis crassa* is characteristic. It attains a maximum thickness of 457 feet.

CHRISTIE

The Christie (Fritz, 1926) is the uppermost member of the Dundas as it is exposed near Georgian bay. It consists of greyish blue shales with numerous, hard bands. The latter are highly fossiliferous. It contains an abundance of bryozoans. Although the Christie occupies the same relative position as the Credit at the top of the Dundas at Toronto and in Credit valley, the fossil content differs considerably. It attains a known thickness of 67 feet. The Christie overlies the Humber member of the Dundas and is followed by the Richmond. It is characterized by *Dekayia meafordensis, Hallopora onealli creditensis, Byssonychia vera plana,* and *Calymene meeki.*

SHEGUIANDAH

The Sheguiandah consists of thin, interbedded layers of limestone and soft, argillaceous, brown-black shales. It occurs on Manitoulin island where it succeeds the Collingwood shales and is followed by the Wekwemikongsing. The thickness is something more than 100 feet. Characteristic fossils are *Byssonychia vera, Cryptolites carinatus, Calymene granulosa, Hallopora onealli sigillarioides.*

Foreste (1924) correlates these beds with the Eden of Mississippi valley which is in turn correlated in a general way with the Frankfort of New York state and the basal Dundas of central Ontario.

WEKWEMIKONGSING

The Wekwemikongsing (Foerste, 1916) of Manitoulin island resembles the Humber member of the Dundas formation with which it has been correlated. It is composed of indurated, fine-grained, argillaceous limestones, 2 to 4 inches thick, interbedded with argillaceous shales. They weather brown and have a rough, sandy appearance. Neither the base nor the top has been definitely defined, but the formation is estimated as about 40 feet in thickness. It is underlain by the Sheguiandah and followed by the Richmond. It contains besides a bryozoan fauna, *Diplograptus foliaceus vespertinus, Zygospira modesta, Byssonychia radiata, Pholadomorpha pholadiformis,* et cetera.

RICHMOND

In eastern Ontario (east of the Frontenac axis) and in western Quebec the Lorraine passes imperceptibly upwards into the Richmond. Foerste (1924) classified the strata as follows:

Richmond {Queenston
Unnamed}

The Richmond beds below the Queenston have been described as holding a Waynesville fauna. The greatest described thickness of these beds is on Nicolet river, Quebec. They consist of alternating argillaceous shale and thin limestones characterized by *Zygospira kentuckiensis, Pholadomorpha pholadiformis, Pterinea demissa,* and *Lophospira bowdeni.*

In the Georgian Bay region Foerste (1924) subdivided the Richmond as follows:

Richmond {Kagawong
Meaford}

In the region about Toronto the Richmond has been subdivided as follows:

Richmond {Queenston
Meaford}

MEAFORD

The Dundas (Lorraine) rocks of Ontario are followed by the Meaford, in turn followed by the Queenston in the Toronto region, and by the Kagawong on Manitoulin island. Foerste (1924) correlates the Meaford with the Waynesville, Ohio. At the type locality on the south of Georgian bay the Meaford has been subdivided by Miss Fritz (1926) into the Erindale and Vincent. Foerste believes this exposure reveals beds lower than on

Manitoulin. In Credit valley, Dyer (1925) has divided the Meaford into the Erindale, Streetsville, and Meadowvale.

The Manitoulin beds are characterized by the presence of *Hebertella insculpta* and *Catazyga headi.*

ERINDALE

The Erindale (Fritz, 1926) is the lowest member of the Meaford, at Meaford, Georgian bay, and in Credit valley (Dyer, 1925). It is not distinctly separated from the Dundas beds below it, the line being drawn mainly from the gradual faunal change. The beds consist of shales and limestones at the base, the limestones increasing upward. A bryozoan reef of compact crystalline limestone occurs in Credit valley. The maximum thickness of 83 feet is found at Meaford. The typical forms are *Strophomena varsensis, Catazya headi, Whiteavesia pholadiformis, Pterinea demissa,* etc.

VINCENT

The Vincent (Fritz, 1926) on Georgian bay succeeds the Erindale. It consists of thin-bedded, arenaceous limestones in places strongly ripple-marked, interbedded with unfossiliferous layers of blue-grey shale. It is 25 feet in thickness. It is characterized by a bryozoan reef, containing *Bythopora vacua* and *Cyphotrypa stidhami.*

STREETSVILLE

The Streetsville member of the Meaford is exposed in Credit valley (Dyer, 1925). It passes from argillaceous limestones separated by narrow bands of shale into several layers of massive limestones. It is about 20 feet in thickness. The Erindale precedes it and the Meadowvale follows it. *Ischyrodonta miseneri, Homotrypa streetsvillensis, Columnaria halli,* and *Bythopora meeki* are characteristic forms. One bryozoan reef is replete with *Stromatocerium huronense.*

MEADOWVALE

The Meadowvale (Dyer, 1925) member of the Meaford lies above the Streetsville in Credit valley and is succeeded by the Queenston. It is absent from the Meaford, Ontario, section. At its base is a *Columnaria* reef which is followed by shales interbedded with limestones that higher up become arenaceous. The member is 30 feet in thickness. It is characterized by *Columnaria alveolata, Hebertella occidentalis,* and *Zygospira modesta.*

KAGAWONG

Foerste (1924) places the Kagawong, in Manitoulin island, above the Meaford. It contains a coral reef followed by more arenaceous material. The lower part of the Kagawong appears to be correlative with the Meadowvale of Credit valley. The upper part differs from it. *Strophomena vetusta, Ceraurus marginatus, Leperditia caecigena,* and *Primitia lativia* are typical of the Kagawong.

QUEENSTON

The top of the Richmond of Canada is represented by the Queenston. The type section is at Queenston, Ontario, where the formation lies below the Medina red shales. It occurs in isolated patches in Quebec and eastern Ontario. It caps the Meadowvale in Credit valley, and is found at the top of the Meaford section. On Manitoulin island it is lacking, but Foerste (1924) considers that it is, in part at least, represented by the Kagawong. It is generally unfossiliferous, but a few ostracods have been found in it, *Drepanella richardsoni canadensis*, and *Drepanella? striatomarginata*.

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PART II

THE ORDOVICIAN OF MANITOULIN ISLAND, ONTARIO[1]

By J. F. Caley

INTRODUCTION

This paper describes the stratigraphy and palæontology of the Ordovician strata occurring along the north, and to some extent, east, shores of Manitoulin island. This island is in lake Huron, close to the north shore. It is approximately 80 miles long and 20 miles wide. Geologically it occupies a position on the southern rim of the Canadian Shield and is composed, for the most part, of Ordovician and Silurian sedimentary rocks resting upon an irregular floor of Precambrian rocks.

The rocks of the north shore of lake Huron, with the Ordovician and Silurian strata on Manitoulin and the adjacent islands, were studied by geologists over a century ago. In 1821, John J. Bigsby,[2] of the British Army Staff in Canada, classified the rocks of Drummond, Cockburn, Fitz-William, and Manitoulin islands and the northern peninsula of Michigan, calling the succession the "Limestones of the Manitoulin Range," and differentiating the Ordovician strata as the "Limestones of the Isles of the North Shore."

Alexander Murray in the Geological Survey, Canada, Report of Progress for 1847-48, described the strata of the main shores and islands of lake Huron, the first strictly geological account of these rocks. The Ordovician strata recognized on Manitoulin island were described under the headings of Trenton limestones, Utica slate, and Lorraine shales.

In 1865 and 1867, Robert Bell, in the Report of Progress for 1863-66, recognized the Trenton group, Utica formation, and Hudson River group.

In 1898, Bell,[3] in his report on the French River sheet, included an account of the eastern portion of Manitoulin island. He presented the following section as representing a section across the island from north to south.

	Feet
Chocolate marls and fine sandstones (Chazy?)	100
Trenton group	320
Utica formation	60
Hudson River formation	250
Clinton formation	177
Niagara formation	405
Guelph ? formation	100
Total thickness	1,412

[1] The work on which this account is based was carried out with the aid of a scholarship from the National Research Council.

[2] Bigsby, John J.: "Geological and Mineralogical Observations on the Northeast Portion of Lake Huron"; Am. Jour. Sci., vol. 3, 1st ser., pp. 254-272 (1821).

[3] Bell, Robert: "Geology of the French River Sheet"; Geol. Surv., Canada, Ann. Rept., vol. IX, pt. I (1898).

There seems to have been little or no further work done on the island until about 1912. During the intervening period, the Ordovician strata of Ohio, Kentucky, and Indiana had received much attention from various American geologists who made more or less detailed subdivisions, especially of the Upper Ordovician strata, and obtained remarkably complete faunal lists.

In 1912, Foerste[1] described all the Ordovician rocks on Manitoulin island. Later[2] he presented a shorter account of his studies. In 1916 Foerste[3] described the Upper Ordovician formations of Ontario and Quebec, essentially a continuation of the preceding but adding a number of stratigraphic sections and having a fuller treatment of the fauna. In 1924 he[4] extended the description of the faunas and introduced the term Meaford for the Lower Richmond or Waynesville beds. Foerste's results are shown in the following table:

Time scale	Formation	Correlation
Richmond..................	Kagawong................. Meaford...................	Whitewater and Saluda Waynesville
Maysville..................	Wekwemikongsing..........	Fairmount or Bellevue
Eden......................	Sheguiandah...............	Southgate and Fulton

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Finally, the writer takes this opportunity of expressing his gratefulness to Mr. H. G. Way for assistance in measuring sections in the field.

GENERAL GEOLOGY

Manitoulin island is at the northern extremity of the Palæozoic plain, which extends from the Canadian Shield southward into the United States. The topographic features of the island are directly related to the almost horizontal attitude of the underlying Ordovician and the final result of erosion has been the production of a succession of steps with north-facing escarpments and gently sloping floors in direct conformity with the low south dip of the underlying strata. These steps are especially well devel-

[1] Foerste, A. F.: "The Ordovician Section in the Manitoulin Area of Lake Huron"; Report from Ohio Naturalist, Dec. 1912.

[2] Foerste, A. F.: Geol. Surv., Canada, Inter. Geol. Cong., Guide Book No. 5, 1913.

[3] Foerste, A. F.: "Upper Ordovician Formations of Ontario and Quebec"; Geol. Surv., Canada, Mem. 83 (1916).

[4] Foerste, A. F.: "Upper Ordivician Faunas of Ontario and Quebec"; Geol. Surv., Canada, Mem. 138 (1924).

oped in the Silurian rocks, but have also formed in the Ordovician, particularly where resistance to erosion has varied due to changes in lithology.

At Sheguiandah, these features are interrupted by Precambrian quartzite hills that rise considerably above the general level of the immediate vicinity. The hills represent the higher topographic features of the Precambrian surface upon which the Palæozoic strata lie, and indicate the degree of relief that prevailed prior to the deposition of the sediments.

Glacial striæ occur in only a few places in the Ordovician strata. They appear to be confined chiefly to the hard limestones, although at one locality they were observed in the Collingwood shale. They indicate movement of the ice in a general direction a little west of south: south 30 degrees west, south end of Strawberry island; south 30 degrees west, lot 21, con. XII, Howland tp.; south 55 degrees west, at Sheguiandah.

About one-sixth of the total area of Manitoulin island is underlain by Ordovician rocks. In general, they form a narrow, arcuate belt that occupies the north shore of the island and extends to within 14 miles of its western boundary. The strata have a gentle southerly dip away from the Precambrian, which lies immediately to the north. The exposures, though relatively abundant, are isolated. The best outcrops are at various localities along the north shore where they range from a few feet to 40 feet in thickness. Smaller exposures occur in stream beds and road cuts.

An accurate determination of the thickness of the Ordovician strata is difficult. Since the Precambrian floor is irregular the thickness of the Ordovician deposits necessarily varies from place to place. None of the available records of wells drilled in the eastern part of the island reaches the Precambrian, therefore the thickness of strata between the oldest exposure and the Precambrian surface is not obtainable. A composite section constructed from the measurement of exposures, chiefly in the vicinity of Little Current and Kagawong, shows about 400 feet of strata. Of this, the lower 72 feet is Trenton, leaving about 328 feet for the section above the base of the Collingwood shale.

This section increases in thickness toward the southeast. On Georgian bay the total thickness above the base of the Collingwood shale as given by Parks[1] and Fritz[2] amounts to about 589 feet.

These Ordovician rocks include limestones, shales, clays, and conglomerates. Most of the stratigraphic divisions are quite distinct, although there appears to be no lithological feature by which the Sheguiandah and Wekwemikongsing formations can be distinguished.

The limestones occur chiefly in the Trenton and Richmond formations and are argillaceous, magnesian, or dolomitic, weathering from dark grey to buff. The individual beds vary from a few inches to more than 2 feet in thickness. The shales comprise the larger portions of the Sheguiandah, Wekwemikongsing, and Collingwood formations, and are soft, clayey, brown, blue, or green, as in the Sheguiandah; partly fissile, grey, and thinly bedded as in the Wekwemikongsing; or hard, carbonaceous, brownish to black, and evenly bedded as in the Collingwood formation.

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[1] Parks, W. A.: "Faunas and Stratigraphy of the Ordovician Black Shale and Related Rocks in Southern Ontario"; Trans. Roy. Soc. Canada, vol. XXII (1928).

[2] Fritz, M. A.: "The Stratigraphy and Palæontology of the Workman's Creek Section of the Cincinnatian"; Trans. Roy. Soc. Canada, vol. XX (1926).

The Ordovician rocks of Manitoulin island show a regional dip of approximately 35 feet a mile in a direction a few degrees west of south, forming a gentle monocline dipping into the Michigan basin. In the vicinity of Sheguiandah, the general attitude of the strata is interrupted by the presence of a number of quartzite ridges which protrude through the Ordovician sediments. On the south side of the main ridge at Sheguiandah, and in contact with it, both the Trenton and Collingwood rocks show dips varying from 3 to 18 degrees. These strata were deposited against the flanks of the quartzite with a certain initial inclination, the magnitude of the inclination depending upon the slope of the surface of deposition. This initial dip, however, would be increased by settling of the sediments during lithification. This modification of the regional dip is not discernible for more than a few hundred feet from the quartzite contact.

STRATIGRAPHY

The following table indicates the classification and correlation of the Ordovician of Manitoulin island as here proposed.

Classification and Correlation of the Ordovician of Manitoulin Island

Manitoulin island				Georgian bay	Toronto Credit river	Ohio	New York
Time scale	Formation	Zone	Thickness				
Richmond	Kagawong	*Cyrtodonta ponderosa*	(Feet) 12	Queenston		Whitewater and Saluda	
		Maple Point *Stromatocerium* biostrome	2+				
			31				
		Stromatocerium biostrome (Mudge bay) *Beatricea undulata*	5± 30				
		Columnaria biostrome (Gore bay)	5		Meadowvale (Member)		
	Meaford	*Rhynchotrema perlamellosum* *Hebertella occidentalis* *Platystrophia clarkesvillensis*	43	Meaford	Erindale (Member)	Waynesville	
		Catazyga headi *Hebertella insculpta*	10				
Maysville	Wekwemikongsing		75	Dundas	Humber (Member)	Fairmount	Pulaski
Lorraine	Sheguiandah	*Dalmanella fultonensis lorrainensis*	71	Blue Mountain		Economy	Whetstone Gulf
		Lophospira abbreviata	6				
Eden		*Glossograptus quadrimucronatus* *Climacograptus manitoulinensis*	18+				
Utica	Collingwood		22±	Upper Collingwood			Utica
	Cobourg	Disconformity *Rhynchotrema increbescens*	32	Lower Collingwood Cobourg			
Trenton	Trenton	*Prasopora simulatrix orientalis*	40				

TRENTON

These beds have only a small distribution on Manitoulin island; they occur at Little Current in the railway cut at the south end of the bridge, along the shore from here to a point about one mile to the west, and along the main street in the western part of the town. They are also exposed at Sheguiandah, in contact with the Precambrian quartzite, and in the quarry on the shore about 1½ miles northeast of the village.

The strata consist chiefly of impure, arenaceous to magnesian limestones, varying from dark to light grey in colour, weathering buff. The beds are from a few inches to 1½ feet thick, with many thin ribbons of grey or greenish, arenaceous shale.

The thickest and most continuous section of Trenton is exposed at Little Current where about 72 feet of these strata occur between lake level and the overlying Collingwood shale.

The uppermost beds on Cloche island, about 2 miles north of Little Current, contain the genera ***Receptaculites, Gonioceras,*** and ***Maclurea,*** indicating an horizon near the top of the Black River formation. Assuming a constant dip of 35 feet a mile, there would be about 80 feet of Trenton below the lowest strata exposed at Little Current.

An examination of records of wells on the east part of Manitoulin island shows that the drill penetrated 137 feet of the Trenton.

The contact of the Trenton with the underlying Black River formation is not exposed on Manitoulin island. At Sheguiandah, the Trenton limestone is in contact with the Precambrian quartzite. The lower 3 feet of the formation is a cobble-limestone, containing quartzite fragments varying from pebbles of half an inch to boulders upwards of one foot in diameter, the latter occurring closer to the contact.

The Trenton-Collingwood contact on Manitoulin island is apparently disconformable. It is exposed at two localities in Little Current and in the village of Sheguiandah, and in the quarry immediately to the northeast. At Little Current the surface of the Trenton is quite irregular and is covered by a thin veneer of loose, ferruginous, yellow, limy material that may represent a weathered surface of the limestone. At Sheguiandah, on the east side of the road leading to Little Current, the irregular surface of the Trenton contains fragments of Precambrian quartzite, and the upper 6 to 15 inches of the formation consists of a rotten, impure, cavernous limestone, indicating a weathered zone. About one-quarter of a mile north of this contact, where the road cuts the quartzite ridge, the Collingwood shale lies directly upon the Precambrian quartzite. In the quarry, the uppermost Trenton bed is a hard, crystalline, grey limestone which presents an irregular surface and contains quartzite pebbles projecting into the overlying Collingwood shale. This bed has suffered truncation and shows a decrease in thickness from 27 to 2 inches in a distance of 70 feet.

In other areas, as for example on Georgian bay, the interval between the Trenton formation and the base of the Collingwood is occupied by the Cobourg formation. On Manitoulin island this formation is either absent or represented by not more than 30 feet of basal beds.

From the foregoing observations it seems probable that a break exists in the geological column on Manitoulin island, represented elsewhere by the greater part of the Cobourg formation, and that the Collingwood sea transgressed over an eroded Trenton surface.

The Trenton rocks of Manitoulin island appear to be broadly divisible into two palæontological zones. An examination of the fauna shows that although the majority of the species range throughout the entire section, certain forms seem to be confined to definite horizons.

Zone of the Prasopora simulatrix orientalis. The lower 40 feet of the section is characterized by an abundance of *Prasopora simulatrix orientalis* which appears to be confined to this zone.

Zone of Rhynchotrema increbescens. The upper 32 feet of the section is not as fossiliferous as is the lower part. Although most of the species occurring here have been observed in the lower zone, nevertheless a predominance of *Rhynchotrema increbrescens* seems to be characteristic.

A critical examination of the fauna collected from the Trenton of Manitoulin island reveals a complete absence of all the forms diagnostic of the Cobourg formation. Such typical Cobourg species as *Ogygites canadensis, Cyclospira bisulcata, Hormotoma trentonensis,* and *Rafinesquina deltoidea,* and many common but less typical Cobourg forms, are wanting. Only about 15 per cent of the species identified from Manitoulin island have even been recorded from the Cobourg formation of Georgian Bay area, and, further, only about 20 per cent are common to the Cobourg of Ontario as defined by Sproule.[1]

About thirty species of Trenton Byyozoa have been identified from the island. Of these, four species have been recorded from the Cobourg formation of Georgian bay; six species from the Decorah of Minnesota; six species from the Prosser of Minnesota; and the remainder are known to occur in the Trenton of Ontario and elsewhere. The most abundant single species is *Prasopora simulatrix orientalis.* The bryozoa, taken collectively, indicate an age ranging from late Black River to Upper Cobourg.

A comparison of the fauna of the Manitoulin Trenton with that of the Rockland beds as given by Wilson[2] shows the following species to be common to both areas:

Streptelasma corniculum Hall
Dekayella praenuntia Ulrich
Prasopora simulatrix orientalis Ulrich
Rhinidictya fidelis Ulrich
Camarella panderi Billings
Rhynchotrema increbrescens Hall
Zygospira recurvirostris Hall
Ctenodonta nasuta Hall
Hormotoma gracilis Ulrich
Liospira vitruvia Billings
Actinoceras bigsbyi Billings

The Rockland beds are placed at the base of the Trenton in Ottawa valley and conformably overlie the Black River Leray. None of the above fossils listed as common to both the Manitoulin Trenton and the Rockland beds is confined to the latter, and it is a significant fact that *Prasopora simulatrix orientalis, Rhynchotrema increbescens,* and *Zygospira recurvirostris* are especially abundant in the " Prasopora beds " at various localities in Ontario.

[1] Sproule, J. C.: *See* part III of this memoir.
[2] Wilson, A. E.: "The Range of Certain Ordovician Faunas of the Ottawa Valley with Description of Some New Species"; Geol. Surv., Canada, Mus. Bull. 33 (1921).

When a comparison of the Manitoulin fauna is made with that of the "*Prasopora* horizon" as listed by Wilson[1] from Cornwall it is seen that approximately 53 per cent of the fauna of that horizon is present also on the island. In considering the value of this fact in correlating the Manitoulin beds with those of the above horizon, it must be kept in mind that the most prolific species on the island are *Prasopora* sp. and bryozoa, forms not specifically determined by Wilson but listed as "undetermined." Miss A. E. Wilson has kindly furnished the writer with a list of fossils collected from the "*Prasopora* horizon" at various localities in central Ontario. An analysis of this list shows that about 45 per cent of the species are common to those of the Manitoulin Trenton. Further, the most abundantly occurring forms, *Prasopora* sp., *Rhynchotrema increbescens,* and *Zygospira recurvirostris,* are also the most abundant on the island.

The weight of the foregoing evidence, especially the absence of typical Cobourg fossils, the abundance of *Prasopora* sp., and the general similarity of the fauna, seems to indicate a correlation of at least the lower 40 feet of the Manitoulin Trenton with the "*Prasopora* beds" of central and eastern Ontario.

It is doubtful whether the upper 30 feet of the pre-Collingwood limestones should be correlated with the above-mentioned "*Prasopora* beds." The lithology is essentially similar to that of the underlying 40 feet, the fauna, however, is extremely sparse and non-diagnostic, and, in view of the fact that no specimens of the genus *Prasopora* have been observed in these strata, they are here separated from the underlying beds which contain that genus in abundance and referred provisionally to the basal beds of the Cobourg formation.

Faunal List of the Trenton

Genera and species	Localities				
	Main street, Little Current	Railway cut, Little Current	Light-house, Little Current	Trotter's dock, Little Current	Quarry at Sheguiandah
HYDROZOA					
Tetradium fibratum Safford	x	x	....	....	....
ANTHOZOA					
Streptelasma corniculum Hall	x	x	x	x	....
BRYOZOA					
Mesotrypa maculosa sp. nov.	x	x	....	x	....
Mesotrypa infida Ulrich	....	x	....	....	....
Mesotrypa angularis Ulrich and Bassler	x	....	....	x	....
Homotrypa crenulata sp. nov.	....	x	x	....	....
Homotrypa subramosa Ulrich	....	x	x	....	....
Homotrypa cf. *similis* Foord	....	x	....	....	....
Homotrypa cf. *subramosa* Ulrich	....	....	x	....	....
Homotrypa callosa Ulrich	....	x	....	....	....

[1]Wilson, A. E.: "Ordovician Fossils from the Region of Cornwall, Ontario"; Trans. Roy. Soc. Canada, vol. XXVI, 1923.

Faunal List of the Trenton—Continued

Genera and species	Localities				
	Main street, Little Current	Railway cut, Little Current	Light-house, Little Current	Trotter's dock, Little Current	Quarry at Shegui-andah
BRYOZOA—*Concluded*					
Euridictya multipora (Hall)	x	x	x		x
Rhinidictya neglecta Ulrich		x			
Rhinidictya neglecta canadensis Ulrich		x			
Rhinidictya sp. indet		x	x		x
Rhinidictya fidelis Ulrich		x			
Dekayella trentonensis Ulrich	x	x			
Dekayella praenuntia echinata Ulrich			x		
Monticulipora arborea Ulrich	x	x	x	x	
Monticulipora manitoulinensis sp. nov			x		
Monticulipora sp			x		
Callopora multitabulata Ulrich		x		x	
Monotrypella? dubia sp. nov		x			
Prasopora simulatrix orientalis Ulrich		x		x	
? *Prasopora* sp. indet					x
Calloporina crenulata Ulrich		x		x	
Batostoma sp. nov		x			
Cf. *Batostoma winchelli* Ulrich	x				
Homotrypa minnesotensis Ulrich		x			
Hemiphragma ottawaensis Foord		x			
Eridotrypa mutabilis minor Ulrich			x		
Anaphragma sp				x	
Escharopora subrecta Ulrich					x
BRACHIOPODA					
Rhynchotrema inæquivalve Castelnau		x			
Rhynchotrema increbescens Hall	x	x	x	x	x
Dalmanella testudinaria Hall		x		x	
Strophomena sp. indet		x			
Strophomena incurvata (Shepard)			x		
Lingula sp. indet	x				
Zygospira recurvirostris Hall					x
Camarella panderi Billings			x		
Hebertella borealis Billings					x
PELECYPODA					
? *Ctenodonta nasuta* Hall		x			
Ctenodonta sp. indet	x		x		
Vanuxemia inconstans Billings		x			
Vanuxemia cf. *inconstans* Billings		x			
Vanuxemia sp. nov		x			
Vanuxemia sp. indet		x			
Cyrtodonta sp. nov	x	x			
GASTEROPODA					
Hormotoma gracilis Hall	x	x	x	x	
Bellerophon sp. indet	x	x			
Fusispira sp. indet		x		x	x
Fusispira subfusiformis (Hall)	x				
Helicotoma planulata Salter	x		x		
Hormotoma cf. *salteri* Ulrich					x
Lophospira sp. indet	x				x
Liospira vitruva Billings			x	x	
Maclurea nitida (Ulrich and Scofield)			x		
Carinaropsis sp. indet			x		

Faunal List of the Trenton—Concluded

Genera and species	Localities				
	Main street, Little Current	Railway cut, Little Current	Light-house, Little Current	Trotter's dock, Little Current	Quarry at Sheguiandah
CEPHALOPODA					
Orthoceras sp. indet.		x	x	x	x
Spyroceras sp. indet.	x	x			
Spyroceras bilineatum (Hall)	x				
? *Ormoceras* sp. indet.		x			
Cycloceras undulostriatum (Hall)	x				
Actinoceras bigsbyi Billings			x		
Endoceras sp. indet.			x		
TRILOBITA					
Isotelus maximus Locke		x			
Bumastus sp.	x	x	x		
OSTRACODA					
Leperditia canadensis loukiana Jones		x			
Leperditia sp. indet.		x	x		
ANNELIDA					
Eunicites trentonensis sp. nov		x			

COLLINGWOOD FORMATION

The chief exposures of Collingwood strata occur at the following localities: (1) at Little Current, at the top of the hill on the Sheguiandah road, and in a ditch beside the public school; (2) in the farmyard on lot 21, con. XII, Howland tp.; (3) along the Little Current-Sheguiandah road; (4) at Sheguiandah, where they occur between Bass lake and Sheguiandah bay; and (5) in the quarry situated about 1½ miles northeast of Sheguiandah. Smaller exposures occur: near the shore on lot 13, con. XII, Howland tp.; on the south end of Strawberry island; and where the Little Current-Sheguiandah road cuts the quartzite ridge immediately north of the latter village.

The strata consist of black and brownish, thinly bedded, carbonaceous shales with some thin, siliceous, limestone bands at the base.

The total thickness is difficult to determine, since nowhere is the upper limit of the formation exposed. The thickest section occurs at Sheguiandah, where 16 feet of the shale has been measured along the stream connecting Bass lake with Sheguiandah bay. In the farmyard on lot 21, con. XII, Howland tp., about 13 feet is exposed.

It is very difficult to separate the Collingwood from the overlying Sheguiandah formation by an examination of the debris from bore-holes. In the records compiled by well drillers these two are usually logged as a single unit under the term Utica. However, in the Report of the Ontario Bureau of Mines, volume XV, pages 72-73, are the logs of four wells drilled about 2 miles southeast of Wekwemikongsing in which the black shale, as distinguished from the overlying dark shale or grey shale, is given as varying from 9 to 22 feet in thickness.

The nature of the Collingwood-Trenton contact has been described on a previous page. Immediately north of Sheguiandah where the road cuts the quartzite ridge the Collingwood is seen to lie directly upon the Precambrian quartzite, from which it dips southward at an angle of 18 degrees. Between the post office and the Government dock at Sheguiandah, the black shale exhibits dips of from 5 to 18 degrees away from the flanks of the quartzite. The actual contact is not exposed at this locality, but it is believed that the shale lies directly on the quartzite as in the previous case.

The upper limit of the Collingwood is nowhere exposed on Manitoulin island.

An effort to distinguish palæontological zones in the Collingwood has been unsuccessful. The formation as a whole is very fossiliferous, but the fauna is limited both in numbers and species. Although most of the forms obtained range throughout the entire section, there are some that appear to be more abundant at certain horizons than at others. For example, *Triarthrus canadensis* is fairly common about 12 feet above the base of the formation; *Serpulites isolatus* and *S. serratus* were found first at about 10 feet above the base, and then again near the top of the formation; and *Primitia ulrichi* was obtained only from the lower one foot of the shale.

The black shales on Manitoulin island are correlated with the Collingwood formation at its type locality at Ottawa, and with the Upper Collingwood on Georgian bay. The formation on Manitoulin is entirely shale except for a few, thin, siliceous limestone beds at the base; at Ottawa and on Georgian bay, intercalations of limestone occur throughout. However, the fauna is essentially similar at all three localities. It has been found that 60 per cent of the species identified from the island occur at Ottawa, and 70 per cent are recorded from Georgian bay.

Fauna of the Collingwood Formation

Species	Little Current	Lot 13, con. XII, Howland tp.	Sheguiandah	Strawberry island
GRAPTOLITOIDEA				
Climacograptus cf. *rougensis* Parks	....	....	x	....
Climacograptus sp.	....	....	x	....
Climacograptus prolificus Parks	....	x	x	x
Glossograptus quadrimucronatus (Hall)	....	....	x	x
Glossograptus quadrimucronatus inequispinosus Ruedemann	x	....	x	x
Leptograptus flaccidus (Hall)	....	....	x	....
Diplograptus sp.	x	x	x	....
Diplograptus cf. *montis* Parks	....	x	....	....
Mastigograptus sp	....	x	....	....
Desmograptus cancellatus Hopkinson	x	....	....	....

Fauna of the Collingwood Formation—Concluded

Species	Little Current	Lot 13, con. XII, Howland tp.	Sheguiandah	Strawberry island
VERMES				
Serpulites isolatus Parks	....	....	x	....
Serpulites serratus Parks	....	....	x	....
BRYOZOA				
? *Paleschara beani*	....	x	....	....
BRACHIOPODA				
Leptobolus insignis Hall	x	x	x	x
Dalmanella emacerata Hall	x	x	x	....
Schizocrania filosa Hall	x	x	x	....
Lingula obtusa Hall	....	....	x	....
Lingula curta Hall	....	....	x	....
Lingula progne Billings	x	x	x	....
Lingula cobourgensis Billings	x	x	....	....
Rafinesquina deltoidea Conrad	....	x	....	....
Rafinesquina alternata (Emmons)	....	x	....	....
Zygospira modesta Hall	....	....	x	....
Cf. *Dinorthis* sp. indet	....	....	....	x
PELECYPODA				
Ctenodonta pulchella (Hall)	....	x	x	....
Modiolopsis sp. indet	....	x	....	....
CEPHALOPODA				
Geisonoceras tenuistriatum Hall	x	x	x	x
CONULARIDA				
Conularia trentonensis latior Ruedemann	....	....	x	....
TRILOBITA				
Triarthrus canadensis Smith	....	x	x	x
Triarthus eatoni Hall	x	x	....	....
Calymene cf. *senaria* Conrad	....	....	x	....
Isotelus gigas DeKay	....	....	x	....
Ogygities canadensis (Chapman)	x	x	....	....
OSTRACODA				
Primitia ulrichi (Jones)	....	....	x	....

SHEGUIANDAH FORMATION

DISTRIBUTION

The Sheguiandah formation is exposed discontinuously at about 3 miles south of Little Current on the Sheguiandah road, and also at Tamarack point. The strata consist of soft, thinly bedded to fissile shales and clay-shales, green, brown, and dark grey in colour. The thickness of strata between the lowest exposure and the top of the formation as here defined is approximately 95 feet.

The contact with the underlying Collingwood shale is not exposed and, as previously stated, the two formations cannot be separated in well borings with any degree of accuracy. About 2½ miles south of Little Current, the road to Sheguiandah turns directly southward. A short distance north of this bend occurs the last exposure of the black Collingwood shale. About 1,500 feet farther south the soft shales of the Sheguiandah formation make their appearance and hence the contact between the two formations must be in this interval.

The contact between the Sheguiandah and Wekwemikongsing formations presents some difficulty. The two formations are essentially a single lithological unit. On Georgian bay the contact between the Blue Mountain and overlying Dundas formation is drawn at the horizon where the genus *Triarthrus* ceases to appear. The topmost part of Sheguiandah formation, as defined by Foerste,[1] consists of about 20 feet of interbedded clay-shale and thin, crystalline limestone bands which do not contain remains of this genus. It is, therefore, proposed to include this 20 feet of strata in the Wekwemikongsing rather than in the Sheguiandah formation. As thus defined, the top of the Sheguiandah formation will be drawn at the horizon where *Triarthrus* ceases to appear. This level occurs at about the first limestone band.

The Sheguiandah formation is only sparsely fossiliferous. Great thicknesses of the shale appear to be barren or to contain only fragmentary remains. The following zones have been recognized.

Zone of Glossograptus quadrimucronatus and Climacograptus manitoulinensis. The lower 18 feet of the formation is characterized chiefly by the occurrence of the above-mentioned species. Little else occurs here except *Leptobolus insignis* and *Geisonoceras tenuistriatum.*

Zone of Lophospira abbreviata. Immediately above the foregoing zone, about 6 feet of shale are characterized by an abundance of *Lophospira abbreviata.* This form seems to be confined to this horizon and is associated chiefly with *Dalmanella fultonensis lorrainensis.*

Zone of Dalmanella fultonensis lorrainensis. The remaining 71 feet of the formation yield the bulk of the fauna, with an abundance of *D. fultonensis lorrainensis* at various horizons.

Immediately below the top of the formation is an abundance of *Hallopora* sp. These are poorly preserved and do not admit of positive specific identification. *Triarthrus,* also, was found only in the upper few feet of the shale.

The Sheguiandah formation, as defined above, is correlated with the Blue Mountain formation on Georgian bay. The lithology is essentially similar in the two areas except that the blue colour of the shales on Georgian bay is replaced by a more grey and brownish colour in the Sheguiandah formation. About 50 per cent of the species found in the Sheguiandah are common to the Blue Mountain. About 20 per cent occur in the Gloucester at Ottawa and 17 per cent in the brown Gloucester shales on Rouge river east of Toronto.

Although the fauna of the Sheguiandah shales is thus seen to be in essential agreement with that on Georgian bay, there are, nevertheless,

[1] Foerste, A. F.: Geol. Surv., Canada, Mem. 83, p. 94.

striking differences. According to Parks[1] various species of the genus *Triarthrus* seem to be the best diagnostic fossils of the Gloucester and Blue Mountain series. The only representative of this genus in the Blue Mountain is *T. spinosus rougensis*. On Manitoulin island this species is apparently absent and *T. canadensis* is the sole representative of the genus. This latter species, although lacking on Georgian bay and at Ottawa, is present in the brown Gloucester shales on Rouge river.

Since the Sheguiandah shales are in general more brownish than blue, and contain *Triarthrus canadensis* and not *T. spinosus rougensis*, they may represent, at least in part, the horizon of the Rouge River beds, but the weight of palæontological evidence seems in favour of a closer correlation with the Blue Mountain formation.

Fauna of the Sheguiandah Formation

Species	Localities, Howland township			
	Lot 16, con. XII	Lot 13, con. XII	Lot 12, con. XII	Lot 11, con. XII
GRAPTOLITOIDEA				
Climacograptus manitoulinensis sp. nov.			x	
Glossograptus quadrimucronatus (Hall)		x		
Mastigograptus cf. *gracillimus* (Lesquereux)				x
BRYOZOA				
Bythopora parvula (James)	x			x
Bythopora arctipora Nicholson	x			
Aspidopora areolata Ulrich	x			x
BRACHIOPODA				
Lingula sp.	x			
Dalmanella fultonensis lorrainensis Ruedemann			x	
Zygospira cincinnatiensis Meek	x		x	
Leptobolus insignis (Hall)	x		x	
Orbiculoidea lamellosa Hall	x			
VERMES				
Cornulites progressus Ruedemann	x			x
PELECYPODA				
Cuneamya scapha brevior Foerste				x
Ctenodonta filistriata Ulrich			x	
GASTEROPODA				
Lophospira cf. *abbreviata* (Hall)			x	x
Lophospira sp.			x	
Archinacella sp. indet.				x
CEPHALOPODA				
Geisonoceras tenuistriatum Hall			x	
Orthoceras sp. indet.				x

[1] Parks, W. A.: Trans. Roy. Soc. Canada, vol. XXII, p. 59 (1928).

Fauna of the Sheguiandah Formation—Concluded

Species	Localities, Howland township			
	Lot 16, con. XII	Lot 13, con. XII	Lot 12, con. XII	Lot 11, con. XII
TRILOBITA				
Calymene meeki Foerste	x	....	....	x
Odontopleura sp.	....	....	....	x
Cf. *Homotelus stegops* (Green)	....	....	....	x
Triarthrus canadensis Smith	....	....	....	x
OSTRACODA				
Aparchites minutissimus Ruedemann	....	....	x	....

WEKWEMIKONGSING FORMATION

Strata belonging to this formation are best exposed on Gorrel point, Clay cliff, below Kagawong falls, and about 3 miles south of Little Current on lot 11, con. XI, Howland tp. The rocks are chiefly of thinly bedded, fissile shales and soft clay-shales dominantly dark grey but presenting also shades of green and brown. In the lower part of the formation the shales are interbedded with numerous, thin, coarsely crystalline limestone bands. These are lacking toward the middle of the section. At the top several beds of medium-grained, siliceous limestone occur; they vary from 2 to about 10 inches in thickness.

The formation has a thickness of about 75 feet. The definition of the lower limit has already been discussed. The upper boundary may be seen only at one locality. About 300 feet down stream from the foot of Kagawong falls occurs about 13 feet of soft, bluish shale with thin, siliceous limestone bands. Immediately above this exposure, and in the stream bed, a hard, crystalline limestone bed appears containing *Hebertella insculpta*. This is followed by more argillaceous strata containing *Catazyga headi*. Since nowhere on Manitoulin island have these two species been found below typical Richmond strata, their appearance is here used to designate the base of the Richmond. Thus the above-mentioned 13 feet of blue shale represents the top of the Wekwemikongsing formation.

It has not been possible to establish definite palæontological zones in the Wekwemikongsing strata. Although as a whole the formation is not very fossiliferous, the section exposed at Clay cliff has yielded a goodly number of bryozoa, at least four species of which are new to science.

A great deal of difficulty is encountered in attempting to correlate the Wekwemikongsing strata of Manitoulin island. Lithologically, and to a certain degree faunally, the formation resembles the Dundas as exposed at Toronto, and on Workman brook, and is regarded by the writer as the equivalent of the Humber and Christie members of that formation.

The fauna of the Wekwemikongsing is not evenly distributed throughout the formation. At Gorrel point there are many feet of shale practically devoid of fossils or containing fragmentary remains. A glance at the faunal list will show that a large percentage of the forms has been identified from a section of about 26 feet exposed at Clay cliff in Cape Smyth area. It follows that the correlation of the entire formation will of necessity rest largely upon the fauna identified from that section. About 40 per cent of the species occur in the Humber member at Toronto. A somewhat lower percentage is common to that member on Workman creek. The typical species of the Humber member, however, are about equally common to all three areas.

The most prolific fossils in the Wekwemikongsing strata are the bryozoa, of which some thirty species have been identified. Of these, both *Dekayella granulosa* and *Hallopora onealli creditensis* have been reported from the Christie member on Workman creek. *Arthropora shafferi, Bythopora arctipora, B. gracilis, Chiloporella flabellata,* and *Hallopora onealli creditensis* occur in the Humber member at Toronto. The remainder, exclusive of the new species, have all been recorded from the Lorraine of New York or the Maysville of Ohio valley.

Pelecypods are next in abundance. In the Humber member, both at Toronto and on Georgian bay, these forms are the most prolific. More than 70 per cent of the Manitoulin species occur in the Humber member at Toronto.

Approximately 60 per cent of the brachiopods identified from the island occur at Toronto, and 50 per cent at Workman creek.

The remainder of the Wekwemikongsing fauna is non-diagnostic, consisting of long-range species, or of species reported from members of the Dundas other than those mentioned above.

The bryozoa of the Wekwemikongsing formation range from Southgate to Bellevue of the Ohio classification. There is, however, a large proportion of Fairmount forms, indicating a position somewhere in the Lower and Middle Maysville. *Arthropora shafferi* and *Bythopora gracilis* occur from the McMicken to the Bellevue; *Amplexopora septosa, A. septosa maculosa, Arthropora cleavelandi, A. cincinnatiensis, Bythopora arctipora, B. parvula,* and *Hallopora subplana* occur in both the McMicken and Fairmount, and *Peronopora vera* ranges from the Southgate to the Fairmount.

Of the forms other than the bryozoa, *Lepidocoeleus jamesi* and *Primitia centralis* both occur in the McMicken; *Rafinesquina alternata* and *Byssonychia radiata* range from Southgate to Bellevue, and *Dalmanella emacerata* apparently does not range above the Southgate.

Comparing the Wekwemikongsing fauna with that of the Lorraine of New York, we find that *Modiolopsis modiolare, M. concentrica, Lyrodesma poststriatum, Rafinesquina mucronata, Bythocypris cylindrica,* and *Arthropora shafferi* all occur in the Pulaski or Upper Lorraine; *Ctenodonta filistriata* occurs in the Whetstone Gulf or Lower Lorraine, and *Arthropora cleavelandi* and *Calymene meeki* range from Whetstone Gulf to the Pulaski formation. *Pholadomorpha pholadiformis* has not been observed in the Lorraine of New York.

As stated above, bryozoa are the most prolific forms in the Wekwemikongsing formation, followed by pelecypoda. In the Cincinnatian of Ohio valley, bryozoa are likewise in the majority, whereas in the Lorraine of New York the pelecypoda are most abundant. From this fact, and from the foregoing faunal discussion, the Wekwemikongsing seems to be more closely related to the Maysville of Ohio valley than to the Lorraine of New York.

Fauna of the Wekwemikongsing Formation

Species	Localities			
	Lot 11, con. XII, Howland tp.	Gorrel point	Clay cliff	Kaga-wong falls
GRAPTOLITOIDEA				
Mastigograptus gracillimus (Lesquereux)	x	x	x	
Diplograptus foliaceus vespertinus Ruedemann		x		
Diplograptus sp	x	x	x	
Diplograptus similis sp. nov	x		x	
Diplograptus foliaceus gorrelensis sp. nov		x		
Diplograptus cf. *recurrens* Ruedemann		x		
Climacograptus sp		x		
VERMES				
Cornulites cf. *progressus* Ruedemann	x	x	x	x
Serpulites cf. *lorrainensis* Ruedemann		x		
Serpulites sp		x		
BRYOZOA				
Arthropora shafferi (Meek)	x	x		
Arthropora cincinnatiensis (James)		x		
Arthropora cleavelandi (James)			x	
Bythopora parvula (James)	x	x		
Bythopora arctipora Nicholson	x	x	x	
Bythopora gracilis (Nicholson)			x	x
Bythopora sp. indet			x	
Hallopora onealli creditensis Dyer	x		x	
Hallopora cf. *onealli*			x	
Hallopora cf. *subplana* (Ulrich)			x	
Hallopora encrustans sp. nov			x	
Cf. *Ceramoporella* sp	x			
Cf. *Chiloporella flabellata* (Ulrich)	x			
Constellaria polystomella Nicholson			x	
Dekayella oppressa var. nov			x	
Monotrypella sp. indet			x	
Monotrypella cf. *aequalis* Ulrich			x	
Monotrypella aequalis Ulrich			x	
Atactoporella multigranosa (Ulrich)			x	
Batostoma elongata sp. nov			x	
Dekayia granulosa Fritz			x	
Amplexopora septosa Ulrich			x	
Amplexopora cf. *septosa* Ulrich			x	
Amplexopora septosa maculosa Cumings and Galloway			x	
Amplexopora perversa sp. nov			x	
Stigmatella peculiaris similis var. nov			x	
Stigmatella nana Ulrich and Bassler			x	
Prasopora isolata sp. nov			x	
Peronopora vera Ulrich				x
Homotrypella hospitalis (Nicholson)				x
BRACHIOPODA				
Dalmanella testudinaria (Dalman)	x	x		
Dalmanella fultonensis lorrainensis Ruedemann	x			
Dalmanella emacerata Hall	x	x		
Lingula rectilateralis Emmons		x		
Lingula rotunda gorrelensis var. nov		x		
Lingula cf. *rotunda* Parks		x		
Lingula sp. indet		x	x	
Plectambonites sericeus (Sowerby)			x	
Rafinesquina squamulata (James)			x	
Rafinesquina mucronata Foerste			x	

Fauna of the Wekwemikongsing Formation—Concluded

Species	Localities: Lot 11, con. XII, Howland tp.	Localities: Gorrel point	Localities: Clay cliff	Localities: Kaga-wong falls
BRACHIOPODA—*Concluded*				
Rafinesquina alternata (Emmons)			x	
Schizocrania filosa Hall			x	
Dinorthis sp.				x
PELECYPODA				
Byssonychia radiata Hall	x	x	x	
Ctenodonta sp.	x	x	x	
Ctenodonta madisonensis Ulrich		x	x	
Ctenodonta filistriata Ulrich			x	
Pholadomorpha pholadiphormis Hall	x		x	
Modiolopsis borealis Foerste		x	x	
Modiolopsis concentrica Hall and Whitfield			x	
Modiolopsis postplicata Foerste			x	
Modiodesma modiolare (Conrad)			x	
Clidophorus sp.		x		
Pterinea demissa (Conrad)		x		
Orthodesma postplicatum Foerste		x	x	
Lyrodesma poststriatum Emmons			x	
GASTEROPODA				
Cyrtolites ornatus Conrad		x	x	
Sinuites cancellatus (Hall)		x	x	
Cf. *Cyclora minuta* Hall			x	
Lophospira manitoulinensis Foerste			x	
Lophospira abbreviata Hall			x	
Lophospira sp. indet.			x	
Bellerophon sp. indet.			x	
Holopea sp. indet.			x	
CEPHALOPODA				
Endoceras sp. indet.			x	
CONULARIDA				
Conularia cf. *formosa* Miller and Dyer		x	x	
TRILOBITA				
Cf. *Homotelus stegops* (Green)	x			
Calymene granulosa Foerste	x	x		
Calymene meeki Foerste		x	x	
Odontopleura sp.	x	x	x	
OSTRACODA				
Primitia centralis Ulrich	x	x		
Jonesella crepidiformis Ulrich		x		
Bythocypris cylindrica (Hall)		x		
OTHER CRUSTACEA				
Lepidocoleus jamesi Hall and Whitfield	x		x	
ANNELIDA				
Lumbriconierites wayi sp. nov.				x

MEAFORD FORMATION

The Meaford formation is exposed about 3½ miles northwest of Kagawong near the southeast corner of lot 6, con. XV, Allen tp. Other partial sections may be seen at the following localities: (1) at Kagawong falls; (2) along the east-west road 2 miles south of Little Current (lot 6, con. VII, Howland tp.); (3) about 2½ miles northwest of Kagawong where the Maple Point road ascends the hill from the lake; (4) at Clay cliff; and (5) on the north shore of Barrie island.

The formation consists essentially of an impure, argillaceous or arenaceous limestone, fine grained to crystalline in texture, and grey, green, or even purplish in colour. The beds vary from a few inches to more than 2 feet in thickness. In general, most of the exposures weather grey or even bluish.

THICKNESS AND CONTACTS

The thickness of this formation in the vicinity of Kagawong is about 53 feet.

As stated above *Hebertella insculpta* and *Catazyga headi* have not been observed on Manitoulin island below typical Richmond strata. Therefore, the lower boundary of the Meaford formation is here placed below the first appearance of these species. In accordance with Foerste[1] the upper limit of the formation is placed at the base of the coral biostrome, Gore bay *Columnaria* reef. Above this point the strata are in general more arenaceous and contain many intercalations of shale. Of the species collected from the Meaford formation as here defined, about 53 per cent are confined therein and hence the coral biostrome is considered the beginning of a new faunal development.

An examination of the fauna permits the establishment of the following palæontological zones.

Zone of Hebertella insculpta and Catazyga headi. These two species mark the beginning of the Meaford formation on Manitoulin island and are confined to the lower 10 feet of the formation.

Zone of Platystrophia clarksvillensis, Rhynchotrema perlamellosum, and Hebertella occidentalis. The upper 43 feet of the formation contains a varied fauna, most of the species of which range throughout. However, the above three species are characteristic of this zone. *Platystrophia clarksvillensis* is confined therein; *Rhynchotrema perlamellosum* and *Hebertella occidentalis* although continuing their range into the overlying Kagawong formation occur in much greater abundance throughout this zone and are especially characteristic of the upper 20 feet.

The term Meaford was proposed by Foerste,[2] and defined so as to include all the strata regarded by him as of Waynesville age. The Meaford formation on Manitoulin island is correlated with that of the same name on Workman creek. There are, however, some differences to be noted. First, the Meaford beds on the island are chiefly impure limestones with thin intercalations of shale, whereas those on Workman creek are dominantly shale, becoming calcareous at the top. Secondly, the faunal content of the Manitoulin Meaford shows some variation from that of

[1] Foerste, A. F.: Geol. Surv., Canada, Mem. 138, p. 50, (1924).
[2] Foerste, A. F.: op. cit., 1924, p. 7.

Workman creek. The Manitoulin Meaford has no bryozoa reef comparable with that of the Vincent member on Workman creek; the strophomenoid brachiopods, of which there are at least eight species on the island, are represented on Workman creek by but two forms, only one of which is common to both areas, and *Rynchotrema perlamellosum,* so abundant in the upper part of the Manitoulin Meaford, and *Hebertella insculpta,* which marks the base of the formation there, are both wanting on Workman creek.

A comparison of the Meaford fauna of Manitoulin with that of the Erindale member of the Credit River section shows a marked resemblance. This member, like the Meaford, is divided into two zones, a lower, the *Strophomena varensis* zone, and an upper, the Upper Erindale zone. Although these Erindale zones cannot be detected on the island, it is significant that *Catazyga headi* is found only in the lower zone of both localities, and that over 80 per cent of the Upper Erindale species, exclusive of bryozoa, are found also in the upper zone of the Meaford formation on Manitoulin island.

It is an interesting and significant fact that on Anticosti island, some 900 miles east of Manitoulin, the faunal and lithological aspect of the English Head formation is strikingly similar to that of the Meaford. An examination of the English Head fauna, as determined by Twenhofel,[1] reveals that the lower part of the formation is characterized by the presence of *Catazyga anticostiensis.* This form is closely related to *Catazyga headi,* a species occupying a like stratigraphic position in the Meaford formation. Further, the upper part of the English Head contains an abundance of *Rhynchotrema perlamellosum,* as also does the corresponding horizon of the Meaford.

Fauna of the Meaford Formation

Species	Localities				
	Maple point, lot 6, con. XV, Allen tp.	1·5 miles north-west of Kagawong	Kagawong falls	South of Little Current	Clay cliff
ANTHOZOA					
Streptelasma rusticum (Billings)	x	x	x	x	...
Protarea richmondensis Foerste	...	...	x	...	...
BRYOZOA					
Rhombotrypa quadrata (Rominger)	x	...	x	...	...
Bythopora meeki (James)	...	...	x	...	...
Homotrypella hospitalis Nicholson	...	...	x	...	...
Homotrypella cf. *hospitalis* Nicholson	...	...	x	...	...
Hallopora subplana (Ulrich)	...	...	x	...	...
Homotrypa sp.	...	...	x	...	...
Hallopora sp.	...	...	x	...	...
Stigmatella personata loukata Dyer	...	...	x	...	...
BRACHIOPODA					
Zygospira modesta kagawongensis var. nov.	...	...	x	...	...
Zygospira modesta Hall	x	x	x	x	...
Zygospira kentuckiensis James	x	x	x	...	...

[1] Twenhofel, W. H.: "Geology of Anticosti Island"; Geol. Surv., Canada, Mem. 154, p. 37 (1928).

Fauna of the Meaford Formation—Concluded

Species	Localities				
	Maple point, lot 6, con. XV, Allen tp.	1·5 miles north-west of Kagawong	Kagawong falls	South of Little Current	Clay cliff
BRACHIOPODA—*Concluded*					
Hebertella occidentalis Hall	x	x	x	x	....
Hebertella insculpta (Hall)	x	....	x	....	....
Platystrophia clarksvillensis Foerste	x	....	x	x	....
Rhynchotrema perlamellosum (Whitfield)	x	x	x	x	....
Strophomena sp. indet	x	....	....	....	....
Strophomena sulcata Verneuil	x	....	x	....	....
Strophomena cf. *sulcata* Verneuil	....	....	x	....	....
Strophomena planumbona (Hall)	....	....	x	....	....
Strophomena vetusta (James)	....	....	x	....	....
Strophomena nutans Meek	....	....	x	....	....
Strophomena cf. *neglecta* James	....	....	x	....	....
Strophomena huronensis Foerste	....	....	x	x	....
Strophomena herontica Foerste	....	....	x	....	....
Rafinesquina alternata (Emmons)	....	....	x	....	....
Crania scabiosa Hall	....	....	x	....	....
Plectambonites rugosus manitoulinensis Foerste	....	....	x	....	....
Catazyga headi (Billings)	....	....	x	....	....
Catazyga headi borealis (Billings)	....	....	x	....	....
PELECYPODA					
Pterinea sp. indet	x	....	....	....	....
Pterinea demissa (Conrad)	....	....	x	....	....
Byssonychia radiata (Hall)	....	....	x	x	....
Byssonychia sp	....	....	x	....	....
Modiolopsis manitoulinensis Foerste	....	....	x	....	....
Modiolodon sp	....	....	x	....	....
Ortonella gorensis Foerste	....	....	x	....	....
Cyrtodonta ovalis Foerste	....	....	x	....	....
Cyrtodonta ponderosa Billings	....	....	x	....	....
Vanuxemia kagawongensis Foerste	....	....	x	....	....
Modiolopsis concentrica Hall and Whitfield	....	....	x	....	....
Ischyrodonta sp	....	....	x	....	....
GASTEROPODA					
Cyrtolites ornatus Conrad	x	....	x	....	....
Liospira helena (Billings)	....	....	x	x	....
Bellerophon parksi Foerste	....	....	x	....	....
Helicotoma brocki Foerste	....	....	x	....	....
Archinacella kagawongensis Foerste	....	....	x	....	....
Lophospira manitoulinensis Foerste	....	....	x	....	....
Salpingostoma sp. indet	....	....	x	....	....
Salpingostoma lata Foerste	....	....	x	....	....
CEPHALOPODA					
Orthoceras cf. *duceri* Hall and Whitfield	....	....	x	....	....
Orthoceras lamellosum Hall	....	....	x	....	....
Sactoceras sp. indet	....	....	....	x	....
Spyroceras hammelli (Foerste)	....	....	....	x	....
Cf. *Kindleoceras triangularis* Foerste	....	....	....	x	....
TRILOBITA					
Trilobite indet	x	....	....	....	....
Isotelus maximus Locke	....	....	x	....	....

KAGAWONG FORMATION

The Kagawong formation is widely distributed on Manitoulin island. It forms all the higher Ordovician elevations in the region, and covers most of the extensive, flat areas seen at various places. The best sections may be seen at the following localities: (1) High falls, on lot 52, con. I, Assiginack tp.; (2) near Maple point, on lot 6, con. XV, Allen tp.; (3) above the cliff at Kagawong falls; (4) at the lower West Bay cliff on lot 5, con. IX, Billings tp.; (5) at Clay cliff; and (6) at Gore bay.

The rocks consist essentially of arenaceous or dolomitic limestones varying from grey to dark brown in colour. They are interbedded with numerous, thin bands of grey, arenaceous shales which toward the top become dark and somewhat carbonaceous. The bedding is fairly even, the layers varying from a few inches to upwards of 2 feet in thickness. As a whole the formation weathers buff to dark grey.

As measured near Maple point, on lot 6, con. XV, Allen tp., the thickness of the Kagawong formation is approximately 85 feet.

On Manitoulin island the contact of the Kagawong formation with the overlying Manitoulin dolomite (Silurian) is quite sharp. It is well exposed on lot 11, con. IV, Howland tp., and about 2 miles west of Kagawong on the road to Gore bay. At the latter place the Manitoulin dolomite, containing *Atrypa parksi,* rests upon about 6 inches of thinly bedded, green, argillaceous limestone. This in turn overlies a 6-foot interval of evenly bedded, crystalline, bluish grey limestone. On lot 11, con. IV, Howland tp., the green, argillaceous limestone appears to be absent, the Manitoulin dolomite resting directly upon a dark grey, crystalline limestone essentially similar to that west of Kagawong and containing ostracods and some indeterminable bryozoa.

As a whole the Kagawong formation is not as fossiliferous as the underlying Meaford. Unfortunately the great majority of the bryozoa are so poorly preserved as to render their specific identification impossible.

Columnaria Biostrome. The lower 3 to 5 feet of the formation consists of a coral biostrome, designated by Foerste as the Gore Bay Columnaria reef. This is a definite horizon and is characterized by *Columnaria alveolata* and *Calapoecia huronensis.* Associated with these are *Tetradium huronense, Zygospira modesta,* and some indeterminate ramose bryozoa.

Zone of Beatricea undulata. There are about 30 feet of strata overlying the Gore Bay reef which contain no diagnostic fossils. The fauna here, although fairly abundant in numbers, shows a paucity of species. At the top of this interval, and confined to it, is *Beatricea undulata.* Associated with this form are chiefly *Zygospira kentuckiensis, Streptelasma rusticum, Lophospira* sp., and some poorly preserved nautiloids.

Stromatocerium Biostrome. About 40 feet above the base of the formation is a zone from 3 to 5 feet thick characterized by *Stromatocerium huronense* and *Tetradium huronense.* Associated with these forms are chiefly *Zygospira modesta, Lophospira latacarinata, Ostracod* sp., and ramose bryozoa. This is the Mudge Bay "reef" of Foerste.

Overlying the *Stromatocerium* biostrome is about 31 feet of ill-exposed strata which have yielded very few fossil remains.

The Maple Point Stromatocerium Biostrome. About 30 feet above the Mudge Bay "reef" is a conspicuous zone about 2 feet thick characterized by *Stromatocerium* sp. and *Tetradium huronense.* This "reef" is well seen west of Kagawong on the Maple Point road. It is herein designated as the Maple Point *Stromatocerium* biostrome.

Zone of Cyrtodonta ponderosa. The upper 12 feet of the Kagawong formation is characterized by the presence of a number of pelecypods. It is here designated the *Cyrtodonta ponderosa* zone. The following are other common forms at this horizon: *Cyrtodonta ponderosa perobliqua; C. ovalis, Lophospira* sp., *Rhytimya kagawongensis, Primitia lativia,* and *Leperditia caecigena.*

CORRELATION

The correlation of the Kagawong formation is a matter of some difficulty. Foerste[1] regards these strata as the equivalent of the Queenston shales as exposed on Georgian bay. The results of the present investigation support such a correlation, and the two formations are here considered as equivalent.

The only fossiliferous strata found in the Queenston on Georgian bay are apparently of the same age as those that overlie the Mudge bay *Stromatocerium* biostrome on Manitoulin island. No red shales have been observed on the island, but *Primitia lativia* and *Leperditia caecigena* occur both in the upper part of the Kagawong and in the Queenston shales. Both these forms are known also from the Saluda of Indiana, this being the type locality for the latter species. Further, on Georgian bay, they are associated with such forms as *Byssonychia radiata, Pterinea demissa,* and *Zygospira kentuckiensis,* all of which, though fairly long range species, occur also in the Kagawong beds.

The faunal aspect of the Kagawong formation is distinctly Whitewater and Saluda. The presence of *Beatricea* alone, indicates post-Waynesville time.

Comparing the Kagawong formation with the Credit River section, it is seen that the Meadowvale member resembles that part of the Kagawong between its base and the Mudge Bay biostrome. Both the Meadowvale member and the Kagawong formation begin with a *Columnaria* biostrome, and *Rhombotrypa quadrata, Columnaria alveolata, Stromatocerium huronense, Zygospira modesta, Hebertella occidentalis,* and others, are common to both areas. The beds containing ostracods which overlie the Mudge Bay biostrome on Manitoulin are apparently wanting on Credit river; nor has *Beatricea undulata* been reported from that section.

There is a general resemblance between the Kagawong beds, and the Vaureal formation of Anticosti island. On Anticosti and on Manitoulin islands, the Vaureal and Kagawong formations, respectively, differ from the underlying formations largely in their possession of a greater abundance of corals. In both formations *Rhynchotrema perlamellosum* disappears shortly above the base, and in both, *Beatricea undulata* makes its first appearance. In the Kagawong formation, this latter species is associated with *Calapoecia huronensis;* in the Vaureal formation, with *C. anticostiensis,* a closely related form.

[1] Foerste, A. F.: Geol. Surv., Canada, Mem. 83, p. 168 (1916).

Fauna of the Kagawong Formation

Species	Localities					
	High falls, lot 52, con. 1, Assiginack tp.	Maple point, lot 6, con. xv, Allen tp.	1·5 miles north-west of Kagawong	Top of bluff, Kagawong falls	East-west road 3 miles south of Little Current	Lower West Bay cliff, lot 5, con. IX, Billings tp.
ANTHOZOA						
Streptelasma dispandum Foerste	x	...	...	...	...	...
Streptelasma rusticum (Billings)	x	x	x	x	...	...
Calapoecia huronensis Billings	x	x	x	...	...	...
Columnaria alveolata Goldfuss	x	x	...	...	...	...
HYDROZOA						
Stromatocerium huronense Billings	x	x	x	...	x	...
Tetradium huronense Billings	x	...	...	...	x	...
Tetradium sp.	...	x	x	...	...	...
Beatricea undulata Billings	x	...	...	...	...	...
GRAPTOLITOIDEA						
Graptolite sp.	...	...	...	...	...	x
VERMES						
Annelid teeth	...	...	...	...	...	x
BRYOZOA						
Bythopora meeki (James)	x	x	...	...	...	...
Hallopora sp. indet.	x	...	...	...	...	...
Bryozoans indet.	...	x	x	...	x	...
Rhombotrypa quadrata (Rominger)	...	x	...	...	...	...
BRACHIOPODA						
Hebertella occidentalis Hall	x	x	...	...	...	...
Zygospira kentuckiensis James	x	...	...	...	...	...
Zygospira modesta Hall	x	x	x	x	x	...
Zygospira richmondensis sp. nov.	x	...	...	...	...	...
Rhynchotrema perlamellosum H. and W.	...	x	...	...	...	...
PELECYPODA						
Byssonychia radiata Hall	x	...	...	...	x	...
? *Byssonychia praecursa* Ulrich	x	...	...	...	...	...
Byssonychia sp.	...	x	...	...	...	...
Cyrtodonta cf. *exigua* Foerste	x	...	...	...	...	...
Cyrtodonta ponderosa Billings	x	...	...	...	...	...
Cyrtodonta sp.	...	x	x	x	...	x
Pterinea demissa Conrad	x	...	...	...	...	...
Rhytimya kagawongensis Foerste	...	...	...	x	x	...
Lyrodesma sp.	...	...	...	x	x	...
Ctenodonta sp.	...	...	...	...	x	x
GASTEROPODA						
Lophospira sp. indet.	x	...	x	x	...	x
Lophospira manitoulinensis Foerste	x	...	...	...	...	...

Fauna of the Kagawong Formation—Concluded

Species	Localities					
	High falls, lot 52, con. 1, Assiginack tp.	Maple point, lot 6, con. xv, Allen tp.	1·5 miles north-west of Kagawong	Top of bluff, Kagawong falls	East-west road 3 miles south of Little Current	Lower West Bay cliff, lot 5, con. IX. Billings tp.
GASTEROPODA—*Concluded*						
Lophospira tropidophora (Meek)	x				x	
Lophospira cf. *pulchella* Scofield and Ulrich	x					
Lophospira latacarinata Foerste			x			
Lophospira sp. indet	x					
Liospira helena (Billings)	x					
Helicotoma brocki Foerste	x					
Bucania sp. indet	x					
Eotomaria sp. indet	x					
Hormotoma sp. indet	x					
Bellerophon parksi Foerste	x					
Cyrtolites sp. indet	x					
Cyrtolites ornatus Conrad		x				
Salpingostoma lata Foerste	x					
Gasteropod indet		x	x			
Archinacella kagawongensis Foerste			x			x
CEPHALOPODA						
Maelonoceras (*Beloitoceras*) *ligarius* (Billings)	x					
Orthoceras sp	x				x	x
TRILOBITA						
Cf. *Chasmops breviceps* (Hall)	x					
OSTRACODA						
Primitia lativia Ulrich					x	
Leperditia caecigena Miller					x	x

DETAILED DESCRIPTIONS OF SECTIONS

TRENTON

Section No. 1. South end of bridge, in railway cut at Little Current. This is all stratigraphically above Section No. 2. Total thickness 35 feet, 6 inches.

(6) *Limestone,* dark grey to purplish, weathers buff, hard, fine grained, unevenly bedded up to about 7 inches in thickness, thin ribbons of dark grey shale in the lower part. Thickness, 5 feet, 6 inches. Fossils rare, poorly preserved, including:

Leperditia canadensis loukiana Jones
Leperditia sp. indet.
Tetradium fibratum Safford
Hemiphragma ottawensis Foord
Hormotoma gracilis Hall

(5) *Limestone,* dark grey, weathers blue-green, impure, arenaceous, unevenly bedded in layers from 2 to 8 inches in thickness, the whole interstratified with thin, irregular bands of dark grey and greenish, sandy shale. Thickness, 4 feet, 4 inches. Fossils relatively abundant, including the following:

Tetradium fibratum Safford
Streptelasma corniculum Hall
Eurydictya multipora Hall
Dekayella trentonensis Ulrich
Rhinidictya neglecta Ulrich
Rhinidictya neglecta canadensis Ulrich
Homotrypa subramosa Ulrich
Homotrypa cf. *similis* Foord
Homotrypa callosa Ulrich
Monticulipora arborea Ulrich
Batostoma sp. cf. sp. nov.
Hallopora multitabulata (Ulrich)
Monotrypella? dubia sp. nov.
Mesotrypa maculosa sp. nov.
Mesotrypa infida Ulrich
Homotrypa crenulata sp. nov.
Rhynchotrema inaequialve Castelnau
Dalmanella testudinaria (Dalman)
? *Ctenodonta nasuta* Hall
Cyrtodonta sp. nov.
Vanuxemia inconstans Billings
Vanuxemia cf. *inconstans* Billings
Hormotoma gracilis Hall
Bellerophon sp.
Orthoceras sp. indet.
Spyroceras sp.
? *Ormoceras* sp. indet.
Leperditia canadensis loukiana Jones
Leperditia sp. indet.
Isotelus maximus Locke
Bumastus sp.
Eunicites trentonensis sp. nov.

(4) *Limestone,* dark grey, weathers buff, massive, finely crystalline, small solution cavities occur throughout. Fossils are present, but their structure is obscured by replacement of calcite. Thickness, 10 inches.

(3) *Limestone,* dark grey, weathers light buff, finely crystalline, thin, and unevenly bedded. Thickness, 1 foot, 6 inches.

The following fossils occur:

Rhynchotrema increbescens Hall
Homotrypella minnesotensis Ulrich
Atactoporella sp.
Homotrypa sp.

(2) *Covered interval*—14 feet, 0 inches.

(1) *Limestone,* medium to dark grey, weathers light buff or cream, coarsely crystalline, evenly bedded in layers about 2½ inches thick, thin ribbons of dark grey shale occur at several horizons. Thickness, 9 feet, 4 inches.

A profusion of crinoid columns and bryozoans occur throughout this interval. The following fossils have been identified:

Streptelasma corniculum Hall
Prasopora simulatrix orientalis Ulrich
Mesotrypa maculosa sp. nov.
Calloporina crenulata Ulrich
Monticulipora arborea Ulrich
Rhinidictya sp. indet.
Strophomena sp. indet.
Rhynchotrema increbescens Hall
Ctenodonta sp. indet.
Hormotoma gracilis Hall
Fusispira sp. indet.

Section No. 2. At the lighthouse in Little Current, the lowest Trenton on the island. Total thickness, 4 feet, 5 inches.

(2) *Limestone*, dark blue, weathered dark grey, hard, semi-crystalline, bedding regular, varying in thickness from 5 to 9½ inches. Thickness, 1 foot, 11 inches.

No specifically determinable fossils were obtained, but the following genera were observed:

Stromatocerium sp.
Orthoceras sp.
Leperditia sp.

(1) *Limestone*, grey, mottled with green, weathers light grey, coarsely crystalline, bedding quite regular, about 5 inches thick and presenting rubbly surfaces. Thickness, 2 feet, 6 inches.

The fauna is prolific and has yielded the following forms:

Streptelasma corniculum Hall
Homotrypa subramosa Ulrich
Homotrypa crenulata sp. nov.
Homotrypa cf. *subramosa* Ulrich
Monticulipora arborea Ulrich
Monticulipora manitoulinensis sp. nov.
Monticulipora sp.
Rhinidictya sp. indet.
Euridictya multipora Hall
Dekayella praenuntia echinata Ulrich
Eridotrypa mutabilis minor Ulrich
Camarella panderi Billings
Rhynchotrema increbescens Hall
Strophomena incurvata (Shepard)
Ctenodonta sp. indet.
Helicotoma planulata Salter
Liospira vitruvia Billings
Hormotoma gracilis Hall
Maclurea nitida (Ulrich and Scofield)
Carinaropsis sp. indet.
Actinoceras bigsbyi Bronn
Endoceras sp. indet.
Orthoceras sp. indet.
Bumastus sp. indet.

Section No. 3. Behind Trotter's dock in Little Current. Total thickness, 14 feet, 6 inches.

(3) *Limestone*, greenish, arenaceous, medium-grained in beds about 3 inches thick. Thickness, 2 feet.

(2) *Covered interval*—5 feet, 6 inches.

(1) *Limestone*, grey to bluish, weathers blue-green, hard, coarsely crystalline. Thickness, 7 feet.

The lower 2 feet of the interval appears to be unfossiliferous, but, from the upper part, the following forms were obtained:

Streptelasma corniculum Hall
Mesotrypa angularis Ulrich
Mesotrypa maculosa sp. nov.
Monticulipora arborea Ulrich
Callopora multitabulata Ulrich
Callopora crenulata Ulrich
Prasopora simulatrix orientalis Ulrich
Anaphragma sp.
Batostoma sp.
Rhynchotrema increbescens Hall
Dalmanella testudinaria (Dalman)
Hormotoma gracilis Hall
Liospira vitruvia Billings

The exact horizon represented by this section is somewhat difficult to determine. The fauna is non-committal, but taking into consideration the attitude of the strata it probably represents the 14-foot covered interval observed in Section No. 1.

Section No. 4. In the western part of Little Current beside the main street. Total thickness, 55 feet, 10 inches.

(15) *Limestone*, yellow, impure, arenaceous, the upper few inches consisting of loose, rotten, limy, and sandy material of a residual character. This is here interpreted as representing a weathered surface showing a break between the Trenton and the overlying Collingwood formation. Thickness, 7 inches.

(14) Covered interval—3 feet, 6 inches.

(13) *Limestone,* medium to light grey, weathers buff, crystalline, regularly bedded, in layers varying from 3 to 12 inches in thickness. Thickness, 1 foot, 10 inches.

(12) *Shale,* varies from dark grey to black, carbonaceous, residual, soily in character. Irregular in thickness, varying from about 1 to 3 inches.

(11) *Limestone,* medium grey, weathers buff, massive, coarsely crystalline, shows many small solution cavities, some of which are lined with small crystals of calcite. Fossils absent except for a structure resembling *Tetradium.* Thickness, 1 foot, 2 inches.

(10) *Limestone,* weathers light buff, arenaceous, regularly bedded, interstratified with greenish grey, sandy shale. Thickness, 2 feet, 6 inches.

Fossils are fairly numerous but poorly preserved. The following have been identified:

Streptelasma corniculum Hall
Euridictya multipora Hall
Rhynchotrema increbescens Hall
Hormotoma sp. indet.
Orthoceras sp. indet.

(9) *Limestone,* light grey, weathers buff, somewhat arenaceous, coarsely crystalline, bedding quite even, varying from about 3 to 6 inches in thickness, thin partings of greenish shale occur throughout. Thickness, 5 feet, 4 inches.

Fossils are few and very poorly preserved. The following have been identified:

Euridictya sp. indet.
? *Mesotrypa* sp.
Rhynchotrema increbescens Hall

(8) Covered interval—9 feet.

(7) *Limestone,* medium grey to brown, weathers buff, hard, crystalline, regularly bedded, in layers about 6 inches thick. Thickness, 2 feet.

(6) *Limestone,* mottled, blue-green, arenaceous, in thin, irregular beds. Thickness, 5 feet, 4 inches.

Rhynchotrema increbescens is very prolific, little else occurs except *Euridictya* sp.

(5) *Limestone,* essentially like that above but less arenaceous and with more massive bedding. Fossils extremely rare. Thickness, 3 feet, 1 inch.

(4) *Limestone,* dark grey, weathers dark buff, hard, crystalline, regularly bedded in layers about 8 inches thick.

Fossils are more plentiful than in the immediately overlying interval, and include the following:

Rhynchotrema increbescens (Hall)
Prasopora simulatrix orientalis Ulrich
Euridictya multipora Hall
Mesotrypa angularis Ulrich
Ctenodonta sp. indet.
Cyrtodonta sp. nov.
Hormotoma gracilis Hall
Helicotoma planulata Salter
Lophospira sp.
Spyroceras bilineatum (Hall)
Spyroceras sp.
Cycloceras undulostriatum (Hall)
Bumastus sp.

(3) *Limestone,* essentially like that above with some interbedded, thin, sandy shale layers. Thickness, 5 feet, 4 inches.

The following fossils were obtained here:

Cf. Batostoma winchelli Ulrich
Mesotrypa maculosa sp. nov.
Monticulipora arborea Ulrich
Prasopora simulatrix orientalis Ulrich
Euridictya multipora Hall
Rhynchotrema increbescens (Hall)
Lingula sp. indet.
Helicotoma planulata Salter
Hormotoma trentonensis Ulrich and Scofield
Fusispira subfusiformis Hall

(2) *Limestone,* dark grey to bluish, weathers buff, crystalline, irregularly bedded in layers from 2 to 7 inches thick, the whole interbedded with greenish, arenaceous shale. Thickness, 5 feet, 4 inches.

The following fossils occur here:

Prasopora simulatrix orientalis Ulrich
Monticulipora arborea Ulrich
Mesotrypa maculosa sp. nov.
Dekayella trentonensis (Ulrich)
Rhynchotrema increbescens (Hall)
Bellerophon sp.

(1) *Limestone,* dark grey, weathers greenish buff, crystalline, irregularly bedded, with rough surfaces; the whole is interbedded with green, arenaceous shale. Thickness, 5 feet, 4 inches.

Fossils are fairly abundant; the following forms have been identified:

Streptelasma corniculum Hall
Prasopora simulatrix orientalis Ulrich
Dekayella trentonensis (Ulrich)
Monticulipora arborea Ulrich
Mesotrypa angularis Ulrich and Bassler
Mesotrypa maculosa sp. nov.
Rhinidictya neglecta Hall
Rhynchotrema increbescens (Hall)
Fusispira subfusiformis Hall
Bumastus sp.

The interval between the top of the exposure in the railway cut (Section No. 1) and the Collingwood shale is supplied by the upper part of this section.

Section No. 5. In the quarry on the lake shore east of Sheguiandah. Total thickness, 6 feet, 10 inches.

(4) *Shale, brown to black, carbonaceous,* evenly bedded. *Collingwood formation*—4 feet, 11 inches.

(3) *Limestone* (Trenton), medium grey, weathers greenish, hard, argillaceous. This bed forms the erosional contact between the Trenton and Collingwood formations. It shows distinct truncation, being reduced in thickness from 27 inches to 2 inches in a lateral extent of about 70 feet; many of the irregularities of the surface contain quartzite pebbles, indicating an erosional period; mineralization, in the form of marcasite and pyrite, is more or less common.

(2) *Limestone,* grey to greenish, weathers green, hard, crystalline, presents a massive appearance but is evenly bedded with more or less of calcite crystals formed along the bedding planes. Thickness, 2 feet, 4 inches.

Fossils are rare and difficult to obtain, although crinoid columns and *Zygospira recurvirostris* were observed.

(1) *Limestone*, grey to dark green, weathers dark green, hard, crystalline, evenly bedded, from 1 to 3 inches thick, the whole interstratified with thin ribbons of green, arenaceous shale. Thickness, 4 feet, 6 inches.

Fossils are more common here than in the above interval; the following have been identified:

Euridictya multipora Hall
Rhinidictya sp. indet.
Escharopora subrecta Ulrich
? *Prasopora* sp. indet.
Rhynchotrema increbescens (Hall)
Zygospira recurvirostris Hall
Hebertella borealis (Billings)
Hormotoma cf. *salteri* Ulrich
Fusispira sp.
Lophospira sp. indet.
Orthoceras sp. indet.
Conularia sp. indet.

This section, although occupying the same stratigraphic position as the upper part of that seen at Little Current (Section No. 4) seems to differ from it both faunally and lithologically. There are at least four species that do not occur at the latter locality. When it is considered that these two localities are some 8 miles apart, and that the Trenton exhibits an erosional surface, the above-mentioned lithological difference may not be unexpected.

COLLINGWOOD FORMATION

The Collingwod formation of Manitoulin island is a lithological unit. At no single locality is the entire formation exposed, and all exposures except those occurring at Sheguiandah consist of flat areas exhibiting at the most but a few feet of strata.

Along the small stream connecting Bass lake with Sheguiandah bay, 16 feet of the black shale was measured. A greater thickness doubtless exists, but exact measurement is rendered almost impossible by proximity to the quartzite ridge which has affected the attitude of the strata. The only variation observed in the lithology is that at some horizons the shale breaks with a conchoidal fracture, whereas at others it exhibits paper-thin lamination, probably due chiefly to weathering.

Ogygites canadensis, the index fossil of the Collingwood formation, appears to be absent in the exposures at Sheguiandah, and although occurring at Little Current it appears to be confined to the lower 1 foot or 18 inches of the formation. Elsewhere, as for instance in the Georgian Bay region, this fossil occurs in numbers throughout the formation, and is even more prolific at the top than at the bottom.

Its absence from the Sheguiandah locality might be accounted for by assuming some local variation in, say, the salinity of the water in which the Collingwood formation on Manitoulin island was deposited. But since the two localities are only 6 miles apart this does not seem probable. It is more reasonable to consider that the lower 18 inches of the formation containing *Ogygites canadensis* was deposited before the invading sea reached the higher elevation at Sheguiandah.

SHEGUIANDAH FORMATION

The following sections occur at intervals from a point about 2½ miles south of Little Current to the east-west road 3 miles south of that village.

Section No. 6. On lot 16, con. XII, Howland tp.

Shale, greenish brown, weathers light blue, soft, thinly bedded. In places there are thin bands in which the shale is dark grey and much harder, and about 20 feet from the base of the exposure is a band of coarsely crystalline, ferruginous limestone about one inch thick. Thickness, 48 feet.

Fossils are rare; the following have been identified:

Bythopora parvula (James)
Bythopora arctipora (Nicholson)
Aspidopora areolata Ulrich
Cornulites cf. *progressus* Ruedemann
Orbiculoidea lamellosa Hall
Zygospira cincinnatiensis Meek
Dalmanella fultonensis lorrainensis Ruedemann
Dalmanella emacerata (Hall)
Cf. *Dalmanella rugostriata* Parks and Dyer
Leptobolus insignis Hall
Calymene meeki Foerste

Section No. 7. On lot 13, con. XII, Howland tp.

Shale, brown to green, weathering blue, soft, thinly bedded. Thickness, 1 foot.

Fossils occurring here include:

Glossograptus quadrimucronatus Hall
Leptobolus insignis Hall
Geisonoceras tenuistriatum (Hall)

Section No. 8. On lot 12, con. XII, Howland tp.

Shale, brown to green, weathering blue, thinly bedded to fissile. Thickness, 9 feet.

The following fossils are present:

Climacograptus manitoulinensis sp. nov.
Lingula sp. indet.
Dalmanella fultonensis lorrainensis Ruedemann
Dalmanella emacerata Hall
Zygospira cincinnatiensis Meek
Leptobolus insignis Hall
Ctenodonta filistriata Ulrich
Lophospira cf. *abbreviata* (Hall)
Geisonoceras tenuistriatum (Hall)
Aparchites minutissimus Ruedemann
? *Triarthrus* sp. indet.

Section No. 9. On lot 11, con. XII, Howland tp.

Shale, dark grey, weathering blue, thinly bedded, the upper 6 or 8 feet is distinctly green and much softer. Thickness, 32 feet, 6 inches.

The following fossils were obtained from this exposure:

Mastigograptus gracillimus (Lesquereux)
Cornulites cf. *progressus* Ruedemann
Serpulites cf. *lorrainensis* Ruedemann
Cf. *Bythopora parvula* (James)
Aspidopora areolata Ulrich
Lingula sp. indet.
Archinacella sp. indet.
Cuneamya scapha brevoir Foerste
Orthoceras sp. indet.
Calymene meeki Foerste
Odontopleura sp.
Cf. *Homotelus stegops* (Green)
Triarthrus canadensis Smith
Aparchites minutissimus (Hall)

WEKWEMIKONGSING FORMATION

Section No. 10. Southwest corner of lot 11, con. XI, Howland tp. Total thickness, 32 feet, 8 inches.

(5) *Shale*, dark grey, fissile, hard, with hard, crystalline, limy bands about one inch in thickness. Thickness, 5 feet, 4 inches.

(4) *Shale*, olive green, mottled blue, soft, thinly bedded. Thickness, 5 feet, 4 inches.

(3) *Shale*, dark grey, fissile. Thickness, 1 foot.

This interval contains a profusion of graptolites identified as *Diplograptus similis* sp. nov.

(2) *Shale*, dark grey to distinctly brown, evenly bedded, interstratified with thin, coarsely crystalline limestone layers. Thickness, 7 feet.

Fossils fairly abundant, especially on the limestone surfaces; the following have been identified:

Mastigograptus gracillimus (Lesquereux)
Arthropora shafferi (Meek)
Bythopora parvula (James)
Bythopora arctipora Nicholson
? *Dalmanella fultonensis lorrainensis* Ruedemann
Dalmanella testudinaria (Dalman)
Byssonychia sp. indet.
Ctenodonta sp. indet.
Pholadomorpha pholadiformis Hall
Cornulites progressus Ruedemann
Cf. *Homotelus stegops* (Green)
Calymene granulosa Foerste
Odontopleura sp.
Primitia centralis Ulrich
Lepidocoeleus jamesi Hall

(1) *Shale*, olive green, soft, arenaceous, evenly bedded, becoming indistinguishable toward the top. A 2-inch bed of hard, coarsely crystalline limestone occurs at the base. Thickness, 14 feet.

Fossils are rare in the shale, but some occur on the surface of the limestone band. The following have been identified:

Arthropora shafferi (Meek)
Hallopora onealli creditensis Dyer
Cf. *Chiloporella flabellata* (Ulrich)
Cf. *Ceramoporella* sp.
Cornulites cf. *progressus* Ruedemann
Odontopleura sp.
Lepidocoeleus jamesi Hall

Section No. 11. At Clay cliff, about 3 miles north of Wekwemikongsing. Total thickness, 26 feet, 5 inches.

(3) *Shale*, bluish grey, soft, clayey, and evenly bedded. This shale is interbedded with numerous layers of hard, crystalline, dark grey lime-

stone, some of which become quite siliceous in character, beds varying from about 4 to 9 inches in thickness. Thickness, 21 feet, 5 inches.

Fossils are prolific, especially on the surfaces of the hard layers. The following have been identified:

Mastigograptus gracillimus (Lesquereux)
Diplograptus similis sp. nov.
Cornulites cf. *progressus* Ruedemann
Arthropora cleavelandi (James)
Bythopora arctipora Nicholson
Bythopora gracilis (Nicholson)
Bythopora sp. indet.
Hallopora onealli creditensis Dyer
Hallopora cf. *onealli* (James)
Hallopora cf. *subplana* (Ulrich)
Hallopora encrustans sp. nov.
Constellaria polystomella Nicholson
Monotrypella sp. indet.
Monotrypella cf. *aequalis* Ulrich
Monotrypella aequalis Ulrich
Atactoporella multigranulosa (Ulrich)
Amplexopora septosa Ulrich
Amplexopora septosa maculosa Cumings and Galloway
Amplexopora perversa sp. nov.
Stigmatella peculiaris similis var. nov.
Stigmatella nana Ulrich and Bassler
Prasopora isolata sp. nov.
Lingula sp. indet.
Plectambonites sericeus (Sowerby)
Rafinesquina squamula (James)
Rafinesquina mucronata Foerste
Rafinesquina alternata (Emmons)
Schizocrania filosa Hall
Byssonychia radiata Hall
Ctenodonta madisonensis Ulrich
Ctenodonta filistriata Ulrich
Pholadomorpha pholadiformis Hall
Modiolopsis borealis Foerste
Modiolopsis concentrica Hall and Whitfield
Modiolopsis postplicata Foerste
Orthodesma postplicata Foerste
Modiodesma modiolare (Conrad)
Lyrodesma poststriatum Foerste
Cyrtolites ornatus Conrad
Sinuites cancellatus (Hall)
Cf. *Cyclora minuta* Hall
Lophospira manitoulinensis Foerste
Lophospira abbreviata Hall
Bellerophon sp. indet.
Endoceras sp. indet.
Conularia cf. *formosa* Miller and Dyer
Calymene meeki Foerste
Odontopleura sp.
Lepidocoelus jamesi Hall and Whitfield

(2) *Covered interval*—3 feet.

(1) *Limestone,* crystalline, dark grey, mottled with bluish argillaceous material and disposed in beds about 3 inches in thickness. Thickness, 2 feet.

The fossils obtained here are:

Modiolopsis concentrica Hall and Whitfield
Byssonychia radiata (Hall)
Ctenodonta madisonensis Ulrich
Ctenodonta filistriata Ulrich
Calymeme meeki Foerste

Section No. 12. At Gorrel point, near the village of Gore Bay. Total thickness, 88 feet, 4 inches.

At Gorrel point, about 2½ miles northeast of the village of Gore Bay is a long stretch of high, shale banks which expose the following strata:

(17) *Shale,* bluish grey, soft, clayey, breaks easily into thin bands. Unfossiliferous. Thickness, 7 feet.

(16) *Shale,* dark brown, soft, thinly bedded. Thickness, 3 feet.

The only fossils observed were some fragments of *Lingula* sp. and some poorly preserved, small pelecypods of the *Ctenodonta* type.

(15) *Limestone,* light grey, siliceous, finely crystalline. Thickness, 6 inches.

(14) *Shale,* brown, soft, and clayey. Fragments of *Ctenodonta* only were observed. Thickness, 5 feet, 6 inches.

(13) *Covered interval*—18 feet, 6 inches.

(12) *Shale,* green, soft, evenly bedded. Thickness, 5 feet, 9 inches.
The following fossils were obtained here:

Mastigograptus gracillimus (Lesquereux)
Climacograptus sp.
Lingula rectilateralis (Emmons)
Sinuites cancellatus (Hall)
Cyrtolites ornatus Conrad

(11) *Clay shale,* dark grey to bluish, soft, thinly bedded. Thickness, 2 feet.

Dalmanella emacerata and crinoid columns were the only fossils observed.

(10) *Limestone,* grey, weathers buff, hard, crystalline. Thickness, 9 inches.
Fossils occurring here are:

Arthropora shafferi (Meek)
Bythopora parvula (James)
Serpulites cf. *lorrainensis* Ruedemann
Primitia centralis Ulrich
Bythocypris cylindrica (Hall)

(9) *Shale,* essentially similar to that above the hard layer. Thickness, 3 feet, 4 inches.
Fossils are rare, but the following occur:

Diplograptus sp.
Mastigograptus gracillimus (Lesquereux)
Bythopora arctipora Nicholson
Bythopora parvula James
Arthropora shafferi (Meek)
Lingula rotunda gorrelensis var. nov.
Clidophorus sp. indet.
Pterinea sp. indet.
Sinuites cancellatus (Hall)
Calymene meeki Foerste
Byssonychia radiata Hall

(8) *Shale,* soft, dark grey, breaks with conchoidal fracture. Thickness, 4 feet.
Only *Dalmanella emacerata* was observed.

(7) *Limestone,* hard, crystalline, blue-grey in colour. Thickness, 5 inches.
No fossils were observed.

(6) *Shale,* dark grey, arenaceous, thinly bedded. Thickness, 2 feet.
No specifically identifiable fossils were seen although the following genera are represented here:

Byssonychia sp.
Modiolopsis sp.
Sinuites sp.

(5) *Limestone,* blue-grey, hard, crystalline. Unfossiliferous. Thickness, 3 inches.

(4) *Shale,* dark grey to almost black, thinly bedded. Thickness, 2 feet, 2 inches.

Byssonychia radiata and crinoid columns were the only fossils observed.

(3) *Limestone,* dark grey, weathers buff, crystalline, containing solution cavities. Thickness, 10 inches.

Fossils are prolific on the surfaces of this layer. The following have been identified:

Arthropora cincinnatiensis (James)
Arthropora shafferi (Meek)
Bythopora parvula (James)
Bythopora arctipora Nicholson
Calymene meeki Foerste
Primitia centralis Ulrich
Jonesella crepidiformis Ulrich
Odontopleura sp.
Cornulities cf. *progressus* Ruedemann

(2) *Shale,* dark grey, and thinly bedded. Thickness, 6 inches.

This interval yielded a number of specimens, but only a few species. The following were identified:

Mastigograptus gracillimus (Lesquereux)
Diplograptus foliaceus vespertinus Ruedemann
Diplograptus cf. *recurrens* Ruedemann
Arthropora shafferi (Meek)
Bythopora parvula (James)
Lingula rotunda gorrelensis var. nov.

(1) *Shale,* dark green mottled with blue, weathers grey, evenly bedded, but in places breaks with a conchoidal fracture. Thickness, 31 feet, 9 inches.

The following fossils occur:

Mastigograptus gracillimus (Lesquereux)
Diplograptus foliaceus vespertinus Ruedemann
Diplograptus foliaceus gorrelensis var. nov.
Serpulites cf. *lorrainensis* Ruedemann
Lingula cf. *rotunda* Parks
Lingula rotunda gorrelensis var. nov.
Byssonychia radiata Hall
Orthodesma postplicatum (Foerste)
Modiolopsis borealis Foerste
Ctenodonta madisonensis Ulrich
Clidophorus sp. indet.
Cyrtolites ornatus Conrad
Conularia cf. *formosa* Miller and Dyer

Some doubt exists as to whether all the strata of the above section are referable to the Wekwemikongsing. Interval No. 1 lies immediately below an horizon containing numerous layers of hard, crystalline limestone. This latter horizon is lithologically and faunally similar to the lower 20 feet of the Wekwemikongsing formation as exposed at Section No. 9 (lot 11, con. XII, Howland tp.). If these two represent corresponding horizons the base of the Wekwemikongsing formation here must be drawn at the top of Interval No. 1 of this section. On the other hand, in this interval, no trace of the genus *Triarthrus* could be found, and since its absence elsewhere marks the lower limit of the Wekwemikongsing Interval No. 1 would fall within this formation.

Section No. 13. At Kagawong falls, about 300 feet below base of falls.

Shale, blue, weathers practically same colour, interbedded with layers of hard, crystalline, purplish limestone varying from 1 to 5 inches in thickness. Thickness, 13 feet.

The shale yielded no fossils, but from the surfaces of the limestone layers the following species were obtained:

Perenopora vera Ulrich
Bythopora gracilis (Nicholson)
Homotrypella hospitalis (Nicholson)
Helopora sp. indet.
Cornulites cf. *progressus* Ruedemann
Dinorthis sp.
Lumbriconereites wayi sp. nov.

This exposure lies immediately below the lowest horizon of *Hebertella insculpta* and *Catazyga headi,* and is, therefore, referred to the top of the Wekwemikongsing formation.

MEAFORD FORMATION

Section No. 14. About 3½ miles northwest of Kagawong, near southeast corner of lot 6, con. XV, Allen tp. Total thickness, 53 feet, 1 inch.

(7) *Limestone,* light grey to purplish, weathering buff, argillaceous, irregularly bedded, varying from 4 inches to 1½ feet in thickness. Thickness, 19 feet.

This division is quite prolific in fossils although the preservation is very poor. The best specimens occur weathered out, and include the following forms:

Rhombotrypa quadrata (Rominger)
Streptelasma rusticum (Billings)
Zygospira modesta Hall
Hebertella occidentalis Hall
Platystrophia clarksvillensis Foerste
Rhynchotrema perlamellosum (Whitfield)
Trilobite indet.

(6) *Limestone,* dark blue, argillaceous, finely crystalline, evenly bedded. Thickness, 8 feet, 6 inches.

This division has yielded only the following two forms:

Hebertella occidentalis Hall
Strophomena sp. indet.

(5) *Limestone,* grey, weathering light grey or buff, arenaceous, regularly bedded in layers from a few inches to 2 feet in thickness. Some hard, crystalline bands occur at several horizons. The upper 4 feet of the interval is inaccessible. Thickness, 11 feet, 7 inches.

The only fossil observed was *Streptelasma rusticum* (Billings).

(4) *Limestone,* essentially similar to that described above. The rock is not very fossiliferous and no specimens were obtained, although in the lower 4 feet poorly preserved remains of *Streptelasma,* strophomenoids, and ramose bryozoans were noticed. Thickness, 6 feet, 6 inches.

(3) *Limestone,* hard, concretionary, showing cavities filled with calcite. In several places objects were noticed that suggested the cross-sections of *Beatricea,* all extremely calcified and unidentifiable. Thickness, 1 foot.

(2) *Limestone,* impure, arenaceous, weathers bluish and quite soft on the surface. Thickness, 4 feet, 6 inches.

The fauna yielded the following forms:

Zygospira kentuckiensis James
Zygospira modesta (Hall)
Strophomena sulcata Verneuil
Pterinea sp. indet.

(1) *Limestone,* essentially like that above, but with interbedded, soft, blue shale. Thickness, 2 feet.

The fossils obtained are:

Streptelasma rusticum (Billings)
Zygospira kentuckiensis James
Platystrophia clarksvillensis Foerste
Rhynchotrema perlamellosum Whitfield
Cyrtolites ornatus Conrad
Hebertella insculpta (Hall)

This section represents the total thickness of the Meaford formation on this part of Manitoulin island. The base is characterized by the presence of *Hebertella insculpta,* a typical Richmond species, and the upper limit is marked by a coral biostrome, designated by Foerste as the Gore Bay *Columnaria* reef.

Catazyga headi, a form usually associated with *Hebertella insculpta* at other localities, is not present here. At Kagawong falls, some 3½ miles distant, this species occurs in abundance forming a zone near the base of the Meaford member. Its absence may be due to the very limited lateral extent of the horizon at this locality.

Section No. 15. About 1½ miles northwest of Kagawong on the Maple Point road. Total thickness, 74 feet, 11 inches.

(3) *Limestone,* grey, weathers bluish, impure, coarsely crystalline, evenly bedded in layers from 3 inches to 18 inches in thickness. Thickness, 32 feet, 8 inches.

Fossils are not plentiful, but the following have been obtained:

Rhynchotrema perlamellosum Whitfield
Hebertella occidentalis Hall
Zygospira kentuckiensis James
Ramose bryozoa

(2) *Covered interval*—37 feet, 8 inches.

(1) *Clay,* soft, blue-green, with interbedded layers of hard limestone from 1 to 4 inches thick. These layers represent an upper horizon of the Wekwemikongsing formation. Thickness, 5 feet.

This section represents the upper 32 feet of the Meaford formation. But for local differences in colour, probably due to weathering, the general appearance of this section is similar to the upper part of Section No. 14, and represents the *Rhynchotrema perlamellosum* zone.

Section No. 16. At Kagawong falls. Total thickness, 41 feet, 4 inches.

(10) *Limestone,* bluish, weathering light grey, hard, evenly bedded, in layers about 5 inches thick. Thickness, 4 feet, 6 inches.

The following fossils were obtained here:

Streptelasma rusticum (Billings)
Strophomena cf. *sulcata* (James)
Strophomena planumbona (Hall)
Rhynchotrema perlamellosum var. nov.
Liospira helena (Billings)
Bellerophon parksi Foerste
Isotelus maximus Locke

(9) *Limestone,* essentially the same lithologically as that above, but distinctly argillaceous and shows a reddish stain in some places. Thickness, 5 feet, 2 inches.

The interval is very prolific in fossil remains, many are weathered out and exhibit excellent preservation. The following forms were obtained here:

Protarea richmondensis papillata Foerste
Streptelasma rusticum Billings
Rhombotrypa quadrata **(Rominger)**
Bythopora meeki (James)
Homotrypella hospitalis Nicholson
Homotrypella cf. *hospitalis* Nicholson
Hallopora subplana (Ulrich)
Homotrypa sp.
Rhynchotrema perlamellosum (Whitfield)
Hallopora sp.
Hebertella occidentalis Hall
Platystrophia clarksvillensis Foerste
Zygospira modesta (Hall)
Strophomena planumbona (Hall)
Strophomena vetusta (James)
Strophomena nutans Meek
Strophomena cf. *neglecta* James
Rafinesquina alternata (Emmons)
Crania scabiosa Hall
Byssonychia cf. *radiata* (Hall)
Byssonychia sp.
Pterinea demissa (Conrad)
Modiolodon sp.
Modiolopsis manitoulinensis Foerste
Ortonella garensis Foerste
Helicotoma brocki Foerste
Bellerophon parski Foerste
Archinacella kagawongensis Foerste
Cyrtolites ornatus Conrad
Liospira helena (Billings)
Lophospira manitoulinensis Foerste
Orthoceras cf. *duceri* Hall and Whitfield
Orthoceras lamellosum Hall
Isotelus sp.

(8) *Limestone,* grey, weathering light grey, argillaceous, unevenly bedded. Some irregular beds of hard, crystalline, purplish limestone occur at several horizons. Thickness, 7 feet, 5 inches.

This interval does not appear to be very fossiliferous, but the following forms were collected:

Streptelasma rusticum Billings
Homotrypa streetsvillensis similis var. nov.
Hallopora sp.
Zygospira kentuckiensis James
Zygospira modesta kagawongensis var. nov.
Rafinesquina alternata (Emmons)
Strophomena gerontica Foerste
Strophomena huronensis Foerste
Hebertella occidentalis Hall
Platystrophia clarksvillensis Foerste
Pterinea demissa Conrad
Cyrtodonta ovalis Foerste
Lophospira manitoulinensis Foerste
Bellerophon parski Foerste
Salpingostoma sp. indet.

(7) *Limestone,* mottled, weathering light grey to white, arenaceous, regularly bedded. Thickness, 3 feet, 8 inches.

The fauna collected here is as follows:

Streptelasma rusticum Billings
Pterinea demissa Conrad
Vanuxemia kagawongensis Foerste
Cyrtodonta ponderosa Billings
Lophospira manitoulinensis Foerste
Bellerophon parski Foerste

(6) *Shale,* grey, weathers bluish, crumbly, arenaceous. This division is comparatively unfossiliferous and has yielded no specifically identifiable material. Thickness, 1 foot, 6 inches.

(5) *Limestone,* dark grey, mottled green, bedding indistinguishable. Thickness, 1 foot, 9 inches.

The fauna collected includes:

Streptelasma rusticum Billings
Rafinesquina alternata (Emmons)
Plectambonites rugosus manitoulinensis Foerste

(4) *Limestone,* dark grey to green, arenaceous, unevenly bedded, containing harder layers that are coarsely crystalline and dark grey to purplish in colour. Thickness, 8 feet.

This division is fairly fossiliferous, yielding the following forms:

Catazyga headi (Billings)
Catazyga headi borealis (Billings)
Zygospira kentuckiensis James
Zygospira modesta Hall
Platystrophia clarksvillensis Foerste
Hebertella insculpta (Hall)
Strophomena sulcata Foerste
Streptelasma rusticum Billings
Stigmatella personata lukata Dyer
Homotrypella hospitalis (Nicholson)
Modiolopsis concentrica Hall and Whitfield
Pterinea demissa Conrad
Bellerophon parski Foerste
Liospira helena (Billings)

(3) *Limestone,* essentially similar to that of the above division but more argillaceous and containing hard bands that are lenticular and concretionary in character. Thickness, 6 feet, 4 inches.

Fossils from this division include:

Catazyga headi (Billings)
Hebertella insculpta (Hall)
Columnaria alveolata Goldfuss
Vanuxemia kagawongensis Foerste
Salpingostroma lata Foerste
Ischyrodonta sp. indet.

(2) *Covered interval*—2 feet, 4 inches.

(1) *Limestone,* bluish, weathering dark grey, hard, coarsely crystalline. Fossils are rare, but *Hebertella insculpta* (Hall) was noted. Thickness, 8 inches.

This section shows about 41 feet 4 inches of the Meaford formation. The base of the Richmond formation, at this locality, is marked by an 8-inch bed of hard, crystalline limestone containing *Hebertella insculpta* (Hall) and resting upon soft, blue clay-shale. The latter is here regarded as belonging to the Wekwemikongsing formation. The top of the Meaford formation is not actually exposed here, there being a covered interval between the base of the coral biostrome, which forms the base of the Kagawong formation, and division 10 of this section.

Section No. 17. Along the east-west road 2 miles south of Little Current (lot 6, con. VIII, Howland tp.).

Limestone, medium grey, weathering buff, crystalline, evenly bedded, in layers about 5 inches thick and presenting rough surfaces. Certain of the beds are purplish on fresh fracture, others are mottled green to yellow as a result of their arenaceous content. Thickness, 21 feet.

Fossils are fairly abundant, but extremely difficult to obtain except where loosened by weathering. The following forms were collected from this horizon.

Streptelasma rusticum (Billings)
Rhynchotrema perlamellosum Whitfield
Zygospira modesta Hall
Platystrophia clarksvillensis Foerste
Strophomena huronensis Foerste
Byssonychia radiata Hall
Liospira helena Billings
Sactoceras sp. indet.
Spyroceras hammelli (Foerste)
Cf. *Kindeloceras triangularis* Foerste
Hebertella occidentalis Hall

Most of the fossils listed above are known to range practically throughout the Meaford formation, but the presence of *Rhynchotrema perlamellosum* and *Hebertella occidentalis* would indicate the zone characterized by these species.

KAGAWONG FORMATION

Section No. 18. On the Sheguiandah road about 2 miles northwest of Manitowaning (lot 52, con. I, Assiginack tp.). Total thickness, 29 feet, 1 inch.

(4) *Limestone,* bluish grey, weathering dark grey to brownish, hard, finely crystalline, evenly bedded. Thickness, 6 feet, 3 inches.

Fossils are not prolific and are difficult to obtain, but the following have been identified:

Beatricea undulata Billings
Calapoecia huronensis Billings
Streptelasma rusticum (Billings)
Hebertella occidentalis Hall
Zygospira kentuckiensis James
Lophospira sp. indet.
Liospira sp. indet.

(3) *Limestone,* dark grey, fine grained, thinly bedded with ribbons of grey shale intercalated throughout. Thickness, 6 feet, 8 inches.

Fossils are prolific; the following have been obtained:

Streptelasma rusticum (Billings)
Streptelasma dispandum Foerste
Bythopora meeki (James)
Hallopora sp. indet.
Zygospira kentuckiensis James
Zygospira modesta (Hall)
Zygospira richmondensis sp. nov.
? *Catazyga erratica* (Hall)
Byssonychia radiata Hall
Cyrtodonta cf. *exigua* Foerste
Pterinea demissa Conrad
Helicotoma brocki Foerste
Bucania sp. indet.
Liospira sp. indet.
Hormotoma sp. indet.
Lophospira manitoulinensis Foerste
Lophospira tropidophora (Meek)
Maelonoceras (Beloitoceras) ligarius (Billings)
Cf. *Chasmops breviceps* (Hall)

(2) *Limestone,* dark grey, semi-crystalline, unevenly bedded in layers up to 8 inches thick, and interbedded with thin ribbons of grey shale. Thickness, 10 feet, 4 inches.

Fossils are fairly abundant and the following have been collected:

Calapoecia huronensis Billings
Streptelasma rusticum (Billings)
Zygospira modesta (Hall)
Zygospira kentuckiensis James
Hebertella occidentalis Hall
Byssonychia radiata (Hall)
?*Byssonychia praecursa* Ulrich
Cyrtodonta ponderosa Billings
Bellerophon parksi Foerste
Liospira helena (Billings)
Lophospira cf. *pulchella* Ulrich and Scofield
Cyrtolites sp. indet.
Salpingostoma lata Foerste

(1) *Limestone,* dark grey, semi-crystalline, evenly bedded, from 3 inches to 1 foot in thickness and interbedded with layers of soft, blue, arenaceous shale up to 4 inches thick. Thickness, 5 feet, 10 inches.

The lower 3 feet of this interval forms the coral biostrome designated by Foerste as the "Gore Bay *Columnaria* reef." The following fossils were obtained here:

Calapoecia huronensis Billings
Stromatocerium huronense Billings
Tetradium huronense Foord
Columnaria alveolata Goldfuss
Zygospira modesta (Hall)
Zygospira kentuckiensis James
Lophospira sp. indet.
Liospira helena (Billings)
Orthoceras sp.
Ostracods indet.

The above section represents the lower part of the Kagawong formation as exposed on this part of Manitoulin island. The writer agrees with Dr. Foerste in placing the base of this formation at the base of the coral biostrome forming the lower 3 feet of Interval 1.

Section No. 19. Continuing upward from the top of Section No. 14. Total thickness, 85 feet, 5 inches.

Silurian, Manitoulin member—Cataract formation with *Orthis flabellites, Coelospira planoconvexa,* etc.

(7) *Covered interval*—3 feet.

(6) *Limestone,* brown, mottled with green, weathering dark grey, impure, argillaceous, finely crystalline, regularly bedded in layers from 8 to 16 inches in thickness. Thin, carbonaceous, shaly partings occur throughout. Thickness, 15 feet, 9 inches.

Fossils are extremely rare and badly preserved; the following were noted:

Stromatocerium sp.
Tetradium sp.
Byssonychia sp.
Cyrtodonta sp.
Gasteropod indet.

(5) *Covered interval*—21 feet, 8 inches.

(4) *Limestone,* blue-grey to brown, weathers dark grey, argillaceous, crystalline, showing solution cavities. Fossils are very rare, consisting chiefly of indeterminate bryozoans. Thickness, 1 foot, 5 inches.

(3) *Covered interval*—37 feet, 7 inches.

(2) *Limestone,* blue to purplish, often brownish, weathers grey, impure, crystalline, irregularly bedded. Thickness, 3 feet.

Fossils are not prolific, but the following have been identified:

Streptelasma rusticum (Billings)
Rhynchotrema perlamellosum Hall and Whitfield
Zygospira modesta Hall
Hebertella occidentalis Hall
Cyrtolites ornatus Conrad
Bryozoans indet.

(1) *Limestone,* similar to that above. This interval forms the coral biostrome (Gore Bay *Columnaria* reef of Foerste) and marks the base of the Kagawong formation. Thickness, 3 feet.

The following fossils were obtained:

Streptelasma rusticum (Billings)
Columnaria alveolata Goldfuss
Calapoecia huronensis Billings
Rhombotrypa quadrata (Rominger)
Zygospira modesta Hall

The above section represents the total thickness of Kagawong strata on this part of the island. It is not well exposed, and practically no specifically identifiable fossils were obtained with the exception of those forming, and associated with, the coral biostrome which marks the base of the formation. About 8 feet from the top of the section, that is, in the upper portion of Interval 6, a number of very poorly preserved specimens of *Tetradium* and *Stromatocerium* were observed. These form the Maple Point *Stromatocerium* biostrome, the third and highest biostrome in the Kagawong formation.

Section No 20. About 1½ miles northwest of Kagawong along road to Maple point. Total thickness, 85 feet, 8 inches.

(6) *Manitoulin dolomite* (Silurian).

(5) *Limestone,* grey, weathering dark, crystalline, unevenly bedded. Thickness, 16 feet.

Fossils are rare and practically unidentifiable, but the following were noted:

Lophospira sp.
Cyrtodonta sp.
Stromatocerium sp.
Tetradium sp.

(4) *Covered interval*—32 feet, 3 inches.

(3) *Limestone,* essentially similar to that above. The lower 4 feet of the interval forms the Mudge Bay reef of Foerste. Thickness, 5 feet, 4 inches.

The following fossils were obtained:

Tetradium sp.
Stromatocerium huronensis Billings
Cyrtodonta sp.
Lophospira latacarinata Foerste
Archinacella kagawongensis Foerste
Bryozoa sp. indet.

(2) *Covered interval*—26 feet, 9 inches.

(1) *Limestone,* impure, light grey, weathering grey, crystalline, thinly bedded, and with rough surfaces. Thickness, 5 feet, 4 inches.

Fossils are rare, but the following have been identified:

Streptelasma rusticum (Billings)
Calapoecia huronensis Billings
Zygospira modesta Hall

The lower 2 or 3 feet of Interval 5, which contains specimens of *Tetradium* and *Stromatocerium,* represents the Maple Point *Stromatocerium* biostrome horizon.

Section No. 21. Along road to West bay from top of bluff at Kagawong falls. Total thickness, 50 feet, 3 inches.

(9) *Limestone,* dark grey, weathering buff, finely crystalline, regularly bedded in layers from 2 to 12 inches in thickness, interstratified with thin ribbons of dark shale, some of which are quite carbonaceous. Thickness, 10 feet.

Fossils are comparatively rare, poorly preserved, and consist chiefly of indeterminate bryozoans and brachiopods. At the top of the interval a few pelecypods and loose specimens of *Tetradium* were observed, suggesting the horizon of the Maple Point *Stromatocerium* biostrome.

(8) *Limestone,* grey, weathering greenish buff, finely crystalline, bedding shows rough, rubbly surfaces. This interval was measured along a low gradient. Thickness, 10 feet.

(7) *Covered interval*—10 feet.

(6) *Limestone,* grey, weathering light grey, crystalline, thin, regular bedding with rough surfaces. Some thin layers of brown to purplish dolomite. Thickness, 10 feet, 9 inches.

Fossils are fairly numerous but difficult to obtain; the following have been identified:

Rhytimya kagawongensis Foerste
Lyrodesma sp.
Lophospira sp.
Primitia lativia Ulrich

(5) *Dolomite,* dark grey to purplish, weathering almost white, hard, finely crystalline, thin, regular bedding. Thickness, 1 foot, 6 inches.

The only fossils noted were *Streptelasma* sp. and numerous indeterminate bryozoans.

(4) *Limestone,* grey, weathering dark, thinly bedded. Thickness, 1 foot.

(3) *Covered interval*—2 feet.

(2) *Limestone,* purplish, weathering dark brown, coarsely crystalline, irregularly bedded with many solution cavities. Thickness, 5 feet.

Fossils are rare. Poorly preserved specimens of *Tetradium* and *Stromatocerium* indicate the Mudge Bay biostrome horizon.

(1) *Covered interval*—37 feet, 8 inches.

(Top of falls at Kagawong)

The occurrence of *Tetradium* and *Cyrtodonta* sp. at the top of Interval 9 is taken as indicating the Maple Point *Stromatocerium* biostrome horizon. If this be correct the upper limit of the Kagawong formation at this locality should be about 10 feet above the top of this interval. On this basis the above section would indicate some 97 feet as the thickness of the Kagawong formation. This is somewhat thicker than at other localities studied. It may be due to slight inaccuracies in measuring the long, low gradients, Intervals 1 and 8, by hand level.

Section No. 22. On the east-west road between concessions IV and V, Howland township. Total thickness, 65 feet, 6 inches.

Manitoulin dolomite (Silurian).

(3) *Limestone,* dark grey, weathering dark, semi-crystalline, regularly bedded up to 10 inches in thickness. Thin layers of grey, sandy shale occur interbedded with the limestone. Thickness, 16 feet.

Fossils are rare. Near the top ostracods occur, and in the lower part some bryozoa, with pelecypods and gasteropods scattered throughout. The following have been identified:

Tetradium huronense Foord
Rhytimya kagawongensis Foerste
Lyrodesma sp.
Byssonychia radiata (Hall)
Ctenodonta sp.
Lophospira cf. *tropidophora* (Meek)
Orthoceras sp.
Leperditia caecigena Miller

(2) *Covered interval*—33 feet.

(1) *Limestone,* grey to bluish, weathering dark buff, impure, semi-crystalline, bedding varies from thin to almost massive. Thickness, 16 feet, 6 inches.

Fossils are rare, the chief of these occurring in the Mudge Bay biostrome which constitutes the upper 3 or 4 feet of this interval. The following forms were recognized:

Stromatocerium huronense Billings
Tetradium huronense Foord
Bryozoa sp.
Zygospira modesta Hall
Ostracod sp.

Section No. 23. In the lower West Bay cliff, centre of lot 5, con. IX, Billings tp. Total thickness, 19 feet, 7 inches.

Manitoulin dolomite (Silurian) with *Coelospira planoconvexa, Atrypa parksi, Dalmanella eugeniensis,* and *Brockocystis tecumseth.* Forms the top of the cliff.

(3) *Limestone,* grey-brown, weathering blue-grey, finely crystalline, evenly bedded in layers from 2 to 6 inches thick which are separated by sandy partings. Thickness, 13 feet, 3 inches.

On the weathered surfaces the lime has been leached from the rock and the fossils stand out in relief. The fauna includes:

Hebertella occidentalis Hall
Ctenodonta sp.
Cyrtodonta sp.
Archinacella kagawongensis Foerste
Lophospira sp.
Orthoceras sp.
Leperditia sp.

(2) *Limestone,* dark brown, weathering buff, semi-crystalline, massive, thick-bedded. Thickness, 2 feet.

Contains abundant remains of *Stromatocerium* sp. and probably represents the biostrome here designated as the Maple Point *Stromatocerium* biostrome.

(1) *Limestone,* dark grey to brown, finely crystalline, quite massive, interbedded with dark brown to black, carbonaceous shale. Thickness, 4 feet, 4 inches.

The rock yielded the following fossil forms:

Fucoid marking indet.
Annelid teeth
Graptolites sp.

Covered from lake level—115 feet.

The Maple Point *Stromatocerium* biostrome is beautifully displayed and shows that its distance from the Silurian contact remains quite consistent in relation to other localities where it has been observed.

DESCRIPTIONS OF NEW SPECIES

Class, *GRAPTOLITOIDEA* Lapworth

Order, GRAPTOLOIDEA Lapworth

Suborder, **Axonophora** Frech

Family, DIPLOGRAPTIDAE Lapworth

Climacograptus manitoulinensis sp. nov.

Figure 1

This species varies considerably in size. An average specimen measures 3 mm. in length and 1·2 mm. in width, but specimens 6 mm. in length and 1·4 mm. in width are known to occur. The thecæ number fourteen or fifteen in a space of 10 mm. They show distinct, transverse striations which in places cross the entire frond. The frond tapers gradually to a width of about 1 mm. at the sicular end. The sicula shows a short, median spine with an apertural spine on one side. The nemacaulis is not always preserved. In some species, however, it is quite distinct and may project beyond the end of the frond.

This form resembles *Climacograptus putillus* (Hall), but differs chiefly in having the thecæ sub-parallel to the axis of the rhabdosome throughout

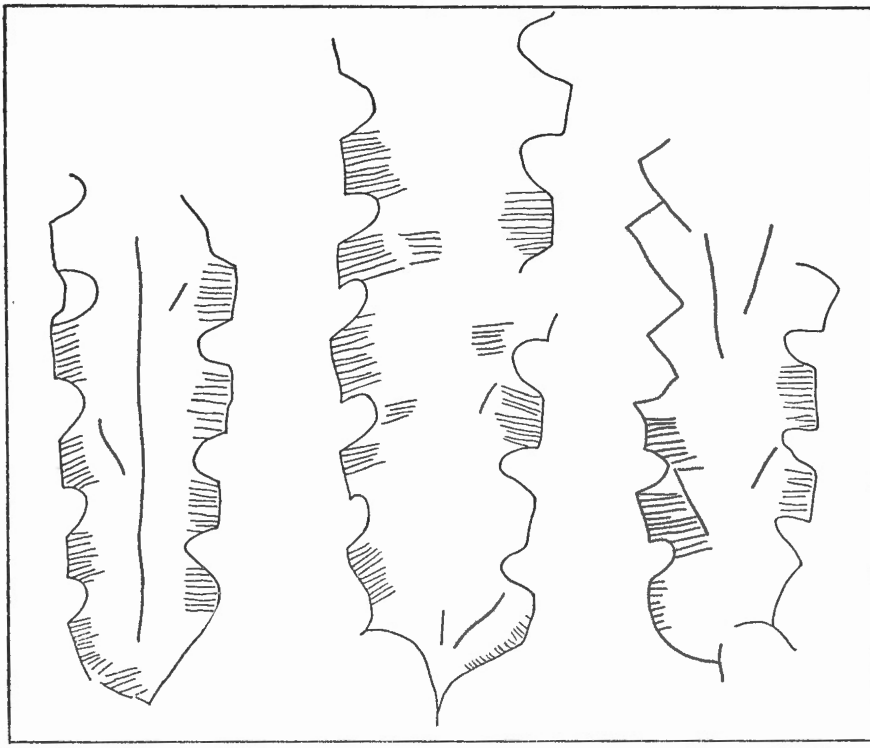


Figure 1. ***Climacograptus manitoulinensis*** **sp. nov., Sheguiandah formation, Manitoulin island.**

the entire length, in the smaller width at the sicular end, and in having transverse striations crossing the thecæ.

Horizon. Sheguiandah formation.
Locality. Lot 12, con. XII, Howland tp.
Types. Royal Ontario Museum, Toronto.

Diplograptus foliaceus gorrelensis var. nov.

Figure 2

The rhabdosome varies from 15 mm. to 35 mm. in length with a maximum width of 3 mm. which is attained at about one-quarter of the length from the proximal end. The thecæ, which number eleven or twelve in a distance of 10 mm., are inclined at an angle of from 30 to 40 degrees to the axis of the stipe and overlap about one-third of their length. The apertural margins are approximately horizontal and slightly concave with the lip produced into a short, more or less horizontal spine. This feature gives rise to a mucronate appearance in certain flattened specimens. The sicula is small, about 1·2 mm. in width, with a median spine and two lateral spines.

This variety is intermediate between *D. foliaceus acutus* Lapworth and *D. foliaceus vespertinus* Ruedemann. It differs from the former in

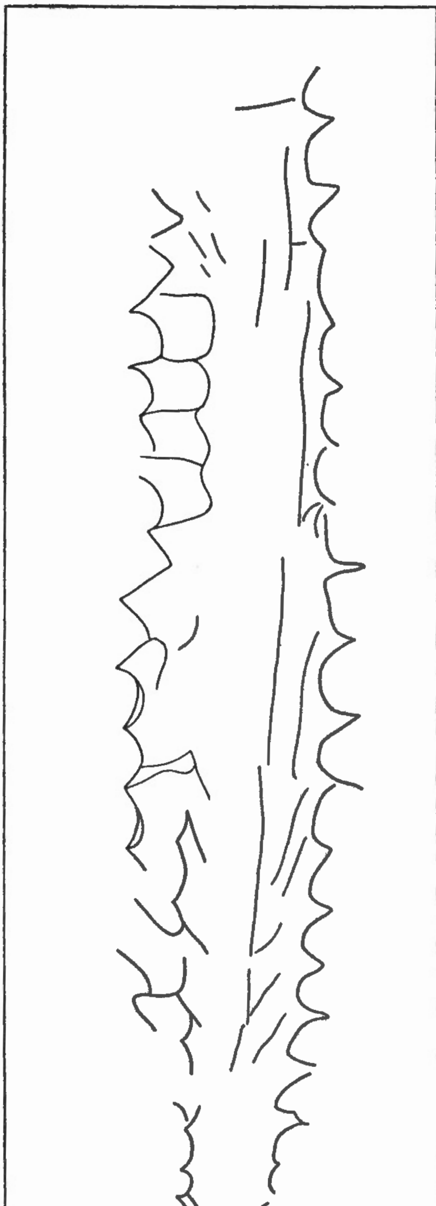


Figure 2. ***Diplograptus foliaceus gorrelensis*** var. nov., Wekwemikongsing formation, Manitoulin island.

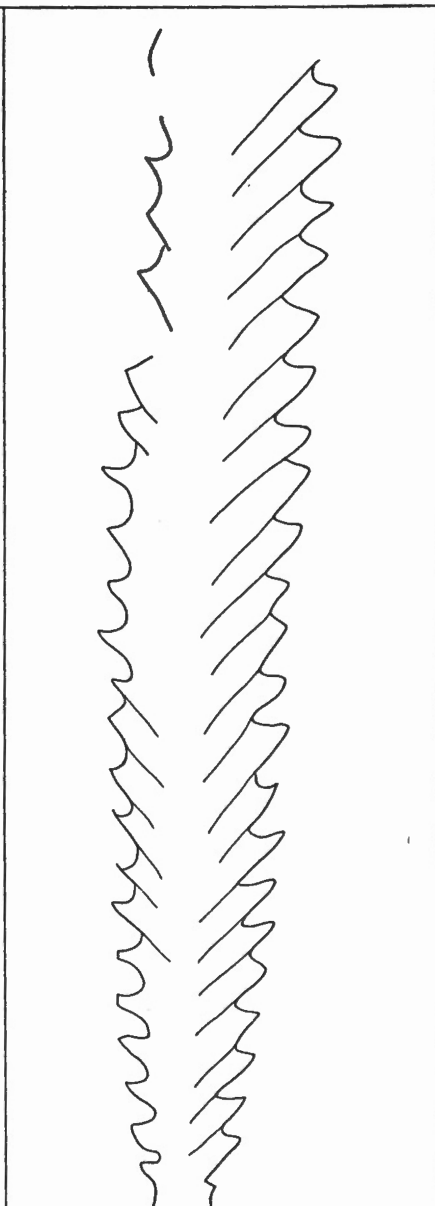


Figure 3. ***Diplograptus similis*** sp. nov., Wekwemikongsing formation, Manitoulin island.

being shorter and in having the thecæ less highly inclined. From the latter it differs in being narrower, in having the thecæ more closely set, and in possessing short, apertural spines on the thecæ.

Horizon. Wekwemikongsing formation.
Locality. Gorrel point, Manitoulin island.
Type. Royal Ontario Museum, Toronto.

Diplograptus similis sp. nov.

Figure 3

The frond is approximately 23 mm. long and 3 mm. wide at its maximum, tapering gradually to about 1 mm. at the sicular end. The thecæ, which are parallel and elongate, overlap more than half their length and number about fifteen in a space of 10 mm. near the proximal end. In the more mature portion of the frond, about thirteen occur in the same distance. The apertural lip is approximately transverse to the axis of the thecæ. The sicular end has a median spine and a short lateral spine on each side. The nemacaulis is not preserved.

This species resembles *D. montis* Parks, but the spines are not so well developed; it attains a greater width, and the thecæ are not as closely set.

From *D. recurrens* Ruedemann, it differs in having the thecæ inclined at a greater angle to the axis of the stipe, in the frond attaining a greater width, and in having the thecæ overlap to a greater degree.

Horizon. Wekwemikongsing formation.
Locality. Clay cliff, and on lot 11, con. XI, Howland tp.
Type. Royal Ontario Museum, Toronto.

Phylum, **VERMES**

Class, *CHAETOPODA*

Order, TUBICOLA

Serpulities cf. *lorrainensis* Ruedemann

Several fragments referable to the above species have been obtained from the strata at Gorrel point. Typical fragments measure 22 mm. in length with an average width of about 0·5 mm. The proximal end has not been observed. The welts are thin and inconspicuous, but the connecting test appears to be relatively strong. The surface is granular.

This form closely resembles *S. lorrainensis* Ruedemann, but differs chiefly in its extreme slenderness, being only about one-quarter the width of that species.

Horizon. Wekwemikongsing formation.
Locality. Gorrel point, Manitoulin island.

Order, ERRANTIA

Eunicites trentonensis sp. nov.

Plate I, figure 1

The jaw is elongate, relatively narrow, widest midway in its length, curved upward anteriorly, and tapering rapidly to form a bluntly rounded posterior extremity. The first tooth is large and hook-like. This is followed by a series of about seventeen backwardly directed, more or less pointed teeth which gradually decrease in size toward the posterior end of the jaw. The length of the jaw is 4 mm., the greatest width 1 mm.

This form resembles *E. varians* Grinnell, described from the Cincinnation rocks at Toronto. It differs chiefly in that the first tooth is larger and more hook-like, and in that the jaw is narrower and more elongate.

Horizon. Trenton formation.
Locality. Railway cut, Little Current.
Type. Royal Ontario Museum, Toronto.

Lumbriconereites wayi sp. nov.

Plate I, figure 3

The jaw is oblong, straight, of nearly uniform width, truncated posteriorly, and with a well-marked protuberance in the central portion. The first tooth is large, rounded, and forwardly projecting. This is followed by about seventeen, low, rounded teeth, the first eight or nine of which are erect or nearly so, the remainder directed slightly backwards and gradually diminishing in size. The approximate length and width of the jaw are 6·5 mm. and 1·75 mm., respectively.

In general shape this form resembles *L. dactylodus* Hinde, but differs in lacking the four curved anterior teeth of that species.

Horizon. Wekwemikongsing formation.
Locality. Kagawong falls, Manitoulin island.
Type. Royal Ontario Museum, Toronto.

Phylum, **MOLLUSCOIDEA**

Class, *BRYOZOA* Ehrenberg

Order, TREPOSTOMATA Ulrich

Family, MONTICULIPORIDAE *Nicholson*

Prasopora isolata sp. nov.

Plate II, figures 5 and 6; Plate III, figure 3

The zoarium consists of an irregular, circular expansion with a basal epitheca, diameter about 20 mm. and the thickness approximately 1 mm., upper surface gently convex and the under surface correspondingly concave. The zoœcia are hexagonal in outline and number about eight in the space of 2 mm., except that at intervals of from 3 to 4 mm. maculæ occur composed of clusters of cells distinctly larger than the average. These clusters, in many instances, appear to be slightly depressed below the general surface of the zoarium.

Tangential sections show that the zoœcia have comparatively thick walls, also, that mesopores are few among the ordinary tubes, though relatively numerous, and large and angular in the maculæ. Acanthopores are indistinct, occurring at the angles of the zoœcia.

Vertical sections show that the zoœcia contain four or five cystiphragms with as many straight or slightly curved diaphragms, and that the mesopores are crowded with straight diaphragms.

This species closely resembles *P. donensis* Parks and Dyer, but differs in lacking any evidence of monticules, in having hexagonal rather than circular zoœcia, and in having diaphragms confined to the lower part of the zoœcial tubes, and in the quincuncial arrangement of the apertures.

There is a certain resemblance, also, to *P. lenticularis* Ulrich. *P. isolata* differs, however, in the presence of acanthopores, in showing fewer mesopores among the ordinary tubes, and in having polygonal zoœcia.

Horizon. Wekwemikongsing formation.
Locality. Clay cliff, Manitoulin island.
Types. Royal Ontario Museum, Toronto.

Homotrypa crenulata sp. nov.

Plate II, figures 1 and 2; Plate III, figure 6

The zoarium is ramose, consisting of cylindrical to somewhat flattened branches from 5 to 8 mm. in diameter; surface covered with low, rounded monticules, more or less irregularly disposed and consisting of zoœcia larger than the average.

Tangential sections show that the zoœcial apertures are polygonal to sub-polygonal in outline, that the zoœcial walls are thick and in many cases granular, and that the tubes average about twelve in a space of 3 mm. in the intermonticular areas. Mesopores are extremely few or absent among the ordinary tubes and are rare in the monticules; when present, the mesopores are small and rounded. Acanthopores are large, many inflecting the walls of the zoœcia, and averaging about four to each tube.

Vertical sections show that the mature region is relatively short and the axial region correspondingly long. In the latter, the walls are thin and crenulated and the tubes crossed by remote diaphragms. The zoœcia curve gently towards the mature region and approach the surface directly. Here, the walls are much thickened and the tubes are lined, chiefly on one side, but in some cases on both, by a series of closely set cystiphragms. A few straight diaphragms also occur in the mature region.

This species shows a general resemblance to *H. minnesotensis* Ulrich, but differs in having more direct apertures, thicker walls in the mature region, a more closely set series of cystiphragms, and large acanthopores.

From *H. subramosa* Ulrich, it differs in possessing monticules, in having thicker walls, larger zoœcia, and fewer diaphragms in the axial region.

Horizon. Trenton formation.
Locality. Railway cut, Little Current.
Types. Royal Ontario Museum, Toronto.

Homotrypa streetsvillensis similis var. nov.

Plate V, figures 1, 2, and 3

The zoarium is ramose consisting of cylindrical branches measuring from 4 mm. to 6 mm. in diameter, the surface exhibiting maculæ composed of cells slightly larger than the average.

Tangential sections show that the zoœcia are thick walled, about eight or nine occur in a space of 2 mm., and the apertures are irregularly polygonal in outline. Mesopores are extremely rare, although an occasional one may be seen in the maculæ and elsewhere. Acanthopores are small and indistinct.

In vertical sections the walls are thin and crenulated in the axial region, thickening appreciably with the approach to the mature region. Diaphragms are few and only present in the sub-mature region where a few, incomplete, hook-like cystiphragms also occur.

Horizon. Meaford formation.
Locality. Kagawong falls.
Types. Royal Ontario Museum, Toronto.

Homotrypa cf. *subramosa* Ulrich

Plate VI, figures 4, 5, and 6; Plate III, figure 12

The Trenton rocks at Little Current have yielded a form closely related to *H. subramosa* Ulrich in its internal structure, but the zoarium shows the presence of low, rounded monticules, a feature not possessed by *H. subramosa.*

Lacking sufficient material for a comprehensive study of this form, it has been tentatively referred to *H. subramosa.*

Horizon. Trenton formation.
Locality. Lighthouse, Little Current.
Types. Royal Ontario Museum, Toronto.

Mesotrypa maculosa sp. nov.

Plate IV, figures 3 and 4; Plate III, figure 1

The zoarium of this species varies from discoidal expansions with a diameter of from 10 mm. to 50 mm. and a thickness of from 3 mm. to 7 mm., to hat-shaped forms approximately 20 mm. in diameter with a height of from 10 mm. to 20 mm. Certain of the latter types give off small branches. The surface is smooth with conspicuous maculæ occasionally rising into low monticules and composed of zoœcia larger than the average.

Tangential sections show the zoœcial apertures polygonal to subcircular in outline, walls moderately thick, and about eight of the ordinary tubes occur in a space of 2 mm. The zoœcia forming the maculæ are conspicuously larger and more angular in outline, averaging about 6 in 2 mm. Mesopores are few or absent at the surface; when present they are usually restricted to the maculæ. Acanthopores are prominent and large, from three to five situated around each zoœcium.

Vertical sections show that the zoœcial walls are of uniform thickness throughout their length. The tubes are crossed by diaphragms which present some variation in arrangement. In certain sections they appear to be confined to the outer region, are straight, and number about two in the space of a tube diameter; in others, they are distributed more regularly with an average distance apart of from one to two tube diameters. In addition, most of the sections examined show a few diaphragms that are curved and more or less infundibuliform. The mesopores, relatively abundant, show a pinching out toward the surface; they are crossed by closely set, straight diaphragms giving a somewhat chain-like appearance to these tubes.

This species closely resembles *M. angularis* Ulrich, both in the manner of growth and the general internal characteristics. Certain sections agree very closely except for the smaller size of the zoœcia; others, however, show further specific differentiation in the thicker walls, in zoœcia with more rounded apertures, and, in some instances, having maculæ rise into low monticules.

Horizon. Trenton formation.
Locality. Little Current, Manitoulin island.
Types. Royal Ontario Museum, Toronto.

Monticulipora manitoulinensis sp. nov.

Plate V, figures 7, 8, and 9

The zoarium is ramose, consisting of sub-cylindrical to compressed branches varying from 8 mm. to 18 mm. in width and from 6 mm. to 10 mm. in thickness, surface showing either low, rounded monticules or maculæ consisting of zoœcia somewhat larger than the average, zoœcial apertures small, sub-polygonal in outline, and numbering about seventeen in a space of 3 mm.

Tangential sections show that the zoœcia are variable in size with moderately thick, granular walls. Acanthopores are distinct, of medium size, numbering about two or three to each zoœcium. In many instances the acanthopores slightly inflect the zoœcia. Mesopores are rare, a few of small size occurring chiefly in the monticules or clusters of larger zoœcia forming the maculæ.

Vertical sections show that the zoœcial tubes curve gradually from the axial zone, approaching the surface directly. In the immature region the walls are thin and somewhat crenulated, becoming appreciably thickened in the mature region. Diaphragms are numerous throughout the entire length of the tubes. In the axial region, both straight and curved diaphragms occur, the latter probably representing modified cystiphragms. Towards the mature region true cystiphragms make their appearance and occur either in a closely set series or somewhat isolated, and diaphragms are more numerous, averaging about three in the space of one tube diameter.

This species is closely related to *M. arborea* Ulrich, but differs in having zoœcia smaller, about seventeen as compared with fourteen in a space of 3 mm., acanthopores more densely tabulated with fewer true cystiphragms in the axial region, and in the presence of mesopores.

Horizon. Trenton formation.
Locality. Lighthouse, Little Current.
Types. Royal Ontario Museum, Toronto.

Family, HETEROTRYPIDAE Ulrich

Dekayella praenuntia echinata Ulrich

Plate V, figures 4, 5, and 6; Plate III, figure 9

Specimens referable to this variety occur at Little Current and agree very closely in internal structure. The form of the zoarium, however, is somewhat different. Typical zoaria of *D. praenuntia echinata* consist of large, compressed branches, whereas the present form is composed of sub-globose masses which give off flattened branches.

Sufficient material upon which to base the constancy of this form is not available. The interpretation offered here is that the zoaria from Little Current represent the basal portions of forms that grew ultimately into compressed branches, in view of which the present forms are referred to *D. praenuntia echinata*.

Horizon. Trenton formation.
Locality. Lighthouse, Little Current.
Types. Royal Ontario Museum, Toronto.

Stigmatella peculiaris similis var. nov.

Plate IV, figures 1 and 2; Plate III, figure 7

The zoarium is ramose, consisting of cylindrical branches about 5 mm. in diameter, surface smooth.

Tangential sections show that the zoœcia have moderately thick walls, that they are polygonal in outline, and that they vary in size, nine to twelve appearing in the space of 2 mm. Mesopores are practically absent. Acanthopores are distinct, occurring chiefly at the angles of the tubes with as many as five surrounding each zoœcium.

Vertical sections show that the walls in the axial region are thin and crenulated and that the tubes are devoid of diaphragms. The zoœcia curve outward to the periphery rather abruptly, presenting a shallow, mature region where the walls are slightly thickened and one or two straight diaphragms are developed.

This species closely resembles *S. peculiaris* Fritz, in both external and internal characters, but differs in having the zoœcia more irregular in size, in having no diaphragms in the mature region, and in the more abrupt outward curve of the tubes at the periphery.

Horizon. Wekwemikongsing formation.
Locality. Clay cliff, Manitoulin island.
Types. Royal Ontario Museum, Toronto.

Family, TREMATOPORIDAE Ulrich

Batostoma elongata sp. nov.

Plate II, figures 3 and 4; Plate III, figure 2

The zoarium is large, ramose consisting of cylindrical branches from 10 mm. to 18 mm. in diameter and at least 50 mm. in length. The surface is covered with conspicuous, rounded monticules disposed regularly at intervals of about 3·5 mm. measuring from centre to centre, and composed of zoœcia somewhat larger than the average. A few mesopores occur at the centre of many of the monticules.

Tangential sections show that the zoœcia are thick walled, and sub-polygonal to rounded in outline; about eight zoœcia occur in the space of 2 mm. except in the monticules where they are conspicuously larger and more irregular in outline. The integrate character is distinct, a thin, dark line separating each zoœcium. Acanthopores are small but numerous, about six situated around each zoœcium.

Vertical sections show that the tubes in the axial region are thin walled, slightly crenulated, and crossed by remote diaphragms varying from about two to four tube diameters apart. As the tubes approach the mature region, which is exceptionally long, they curve abruptly outward, have much thickened walls, and are crossed by more closely spaced diaphragms averaging about three to a tube diameter. A few of these diaphragms are incomplete and more or less infundibuliform.

The species is characterized chiefly by its large size, the conspicuous monticules, and the long, mature region.

Horizon. Wekwemikongsing formation.
Locality. Clay cliff, Manitoulin island.
Types. Royal Ontario Museum, Toronto.

Batostoma sp.

Plate IV, figures 5 and 6; Plate VI, figures 1, 2, and 3; Plate III, figures 10 and 11

The zoarium is ramose, somewhat robust in its growth, consisting of cylindrical to slightly flattened branches which vary from 10 mm. to 18 mm. in diameter. The longest one measured is about 35 mm. in length. The surface is studded with numerous, slightly raised, rounded monticules composed of cells somewhat larger than the average. The zoœcial apertures are sub-polygonal to rounded in outline and number from three to four in the space of 1 mm. in the intermonticular areas.

Tangential sections show zoœcial apertures sub-polygonal or rounded in outline, and zoœcia variable in size, from eleven to thirteen occurring in the space of 3 mm. in the intermonticular areas, whereas about nine occupy the same space in the monticules. Mesopores are rare, only an occasional, small, rounded tube occurring among the large zoœcia of the monticules. Acanthopores are extremely difficult to detect owing to the poor state of preservation of the zoœcial walls, but they probably occur at the angles of the zoœcia.

Vertical sections show that the walls in the axial region are thin and crenulated, and that they are devoid of diaphragms. The zoœcia approach the surface more or less abruptly; here the walls become much thickened and the tubes are crossed by straight or slightly curved diaphragms which number about two in the space of a tube diameter in the early part of the region. Toward the periphery the diaphragms are more sparsely developed, being about one tube diameter apart.

In the manner of growth and general internal characters, this form closely resembles *B. superba* (Foord). It differs, however, in its smaller zoœcia, in the thinner and more crenulated walls in the axial region, and also in that the tubes bend abruptly outwards as they approach the surface. If acanthopores are absent another difference must be recognized as they are very distinct in *B. superba.*

A large number of microscopic sections have been prepared from the material at hand: none of these sections, however, shows the structure sufficiently well preserved to warrant positive specific identification.

Horizon. Trenton formation.
Locality. Railway cut, Little Current.
Types. Royal Ontario Museum, Toronto.

Family, HALLOPORIDAE Bassler

Hallopora encrustans sp. nov.

Plate IV, figures 7 and 8; Plate III, figure 8

The zoarium forms an incrustation over a crinoid stem eventually giving off branches from 4 mm. to 5 mm. in diameter. The surface is smooth or slightly monticulose, the low monticules consisting of zoœcia somewhat larger than the average.

Tangential sections show that the zoœcial walls are moderately thick, the zoœcia are sub-polygonal to rounded in outline, and about seven occur in the space of 2 mm. Mesopores are numerous, small, and rounded, practically isolating each zoœcium.

Vertical sections show that the zoœcial walls are thin, slightly crenulated, and practically devoid of diaphragms in the axial region. Towards the periphery the tubes bend gradually outwards, opening directly to the surface and presenting a relatively deep, mature region with somewhat thickened walls. The tubes are crossed by straight or slightly curved diaphragms, numbering from one to two in the space of one tube diameter. Mesopores, crossed by a closely set series of diaphragms, are developed in the mature region. In certain places these mesopores appear to be bunched, two occurring side by side and separating the zoœcia.

This species is distinguished chiefly by its incrustating habit and by the bunching of the mesopores as seen in vertical sections.

Horizon. Wekwemikongsing formation.
Locality. Clay cliff, Manitoulin island.
Types. Royal Ontario Museum, Toronto.

Family, AMPLEXOPORIDAE Ulrich

Amplexopora perversa sp. nov.

Plate II, figures 7 and 8; Plate III, figure 5

The zoarium is ramose, consisting of cylindrical to flattened branches from 5 mm. to 12 mm. in diameter, surface covered with low, rounded, subsolid monticules composed of a few, very small mesopores and surrounded by zoœcia conspicuously larger than the average. These monticules are diposed at intervals of from 3 mm. to 4 mm., measuring from centre to centre. Well-preserved specimens show acanthopores situated chiefly at the angles of the zoœcial apertures.

Tangential sections show that the zoœcia have relatively thick walls, are sub-polygonal to rounded in outline, and approximately eight occur in the space of 2 mm. Mesopores are absent among the ordinary tubes, but form the centre of the monticules where they are small and angular. About five or six acanthopores are present around each zoœcium.

Vertical sections show that diaphragms are remote in the axial region where the walls of the tubes are thin and somewhat crenulated. Towards the mature region the tubes curve gradually outwards, have much thickened walls, and are crossed by diaphragms averaging from two to three in the space of a tube diameter. A few irregular diaphragms are also present in the mature region.

In its manner of growth and general external features the present species resembles *A. persimilis* Nickles, but differs in having more closely set diaphragms, thicker walls in the mature region, and fewer acanthopores of larger size which do not inflect the zoœcial walls.

Horizon. Wekwemikongsing formation.
Locality. Clay cliff, Manitoulin island.
Types. Royal Ontario Museum, Toronto.

Monotrypella cf. *M. aequalis* Ulrich

Plate VI, figures 7, 8, and 9; Plate III, figure 4

The zoarium is ramose, consisting of cylindrical or somewhat flattened branches measuring from 5 mm. to 10 mm. in diameter, surface exhibiting low, rounded monticules consisting of zoœcia usually conspicuously larger than the average, although, in certain instances, noticeably smaller. The monticules are disposed at intervals of about 3 mm., measuring from centre to centre.

Tangential sections show the zoœcia polygonal in outline, thin walled, numbering from seven to eight in the space of 2 mm., those in the monticules larger, as few as five occupying the same space, mesopores extremely rare, but a few do occur among the large cells forming the monticules, acanthopores absent.

Vertical sections show that the tubes, in the axial region, have thin, slightly crenulated walls and are crossed by straight diaphragms averaging about one and a half tube diameters apart. Towards the periphery the tubes bend gradually outwards and the walls become very slightly thickened. In this region diaphragms become more numerous, averaging about three in the space of one tube diameter. In one section the mature region shows two mesopores crossed by a closely set series of straight diaphragms.

The present form resembles *M. aequalis* Ulrich in its general external and internal structure, but differs in having a much shorter mature region where the diaphragms are straight not curved and in the presence of interstitial tubes. Owing to the lack of well-preserved material it has been tentatively referred to this species.

Horizon. Wekwemikongsing formation.
Locality. Clay cliff, Manitoulin island.
Types. Royal Ontario Museum, Toronto.

Monotrypella ? dubia sp. nov.

Plate VI, figures 10, 11, and 12; Plate III, figure 13

The zoarium is irregularly globose, measuring about 30 mm. in diameter and from 10 mm. to 12 mm. in thickness, surface somewhat irregular with maculæ of zoœcia larger than the average, zoœcial apertures polygonal in outline, averaging about ten in the space of 2 mm. except in the maculæ where seven or eight occupy the same space.

Tangential sections show that the zoœcia, though polygonal, exhibit some irregularity in outline, that the walls are moderately thin, and that the integrate character as shown by the thin, dark line of demarcation between the tubes is fairly distinct. Mesopores are practically absent, but an occasional, small, angular, mesopore-like structure may be seen at the zoœcial angles. Acanthopores are wanting.

Vertical sections show that the mature and immature regions are practically indistinguishable, that the walls are of uniform thickness except near the periphery where they become slightly thickened, and that the tubes show closely set diaphragms throughout their length disposed at intervals of about one tube diameter. In the peripheral region a number of the diaphragms are irregular, curving obliquely across the tubes.

This species is referred to the genus *Monotrypella* with some hesitation. It agrees closely with *Monotrypella* in tangential and vertical sections, in possessing relatively thin walls in the axial region, in the general character of the diaphragms, and in the absence of acanthopores. It differs, however, in the manner of growth, in the possession of mesopore-like structures, and in having a number of irregular diaphragms which, in some instances, become infundibuliform, thus simulating the genus *Mesotrypa.*

The specimens from Little Current differ from typical *M. aequalis* Ulrich, the genotype, in the possession of more closely set diaphragms.

Owing to lack of comparative material, it is thought advisable to refer the present form to the genus *Monotrypella.*

Horizon. Trenton formation.
Locality. Railway cut, Little Current.
Types. Royal Ontario Museum, Toronto.

Class, *BRACHIOPODA* Dumeril
Order, ATREMATA Beecher
Superfamily, Lingulacea Waagen
Family, lingulidae Gray

Lingula rotunda gorrelensis var. nov.

Plate I, figure 5

Only two poorly preserved and somewhat crushed examples of this variety have been obtained. The shell, which is moderately convex, measures 10 mm. in length and 8 mm. in width. The beak is covered with fine, concentric growth lines; in places where the shell is exfoliated, fine radiating lines also appear.

This variety resembles *L. rotunda* Parks, differing from it, however, in its smaller size and less rotund shape.

Horizon. Wekwemikongsing formation.
Locality. Gorrel point, Manitoulin island.
Type. Royal Ontario Museum, Toronto.

Order, TELOTREMATA Beecher

Superfamily, SPIRIFERACEA Waagen

Family, ATRYPIDAE Gill

Zygospira richmondensis sp. nov.

Plate I, figures 4 and 6

The shell is broad and sub-triangular in shape, and variable in size, the largest having a length of 10 mm. and a width of 11 mm. The greatest width of the shell is from one-half to two-thirds the distance between the beak and the anterior margin.

The pedicle valve is moderately convex with beak small, distant, and incurved over the brachial valve, although not touching it. Six plications, moderately elevated above the general convexity of the shell, form a low fold. A groove along the median line of this fold is slightly wider than those adjacent to it; this groove, together with one plication on either side of it, forms a shallow but distinct median sinus on the fold. From four to five lateral plications occur on either side of the fold.

The brachial valve is somewhat less convex than the pedicle; a broad, shallow sinus extends from the beak to the anterior margin and is defined by the third plication on each side of a median one. About five plications occur on either side of the sinus.

In some of the younger specimens it is difficult to detect the shallow sinus on the fold of the pedicle valve, but this fold is always occupied by six plications with a distinctly wider median groove.

This species closely resembles *Z. kentuckiensis* James, in size and general outline. It differs from that species in having six median plications on the pedicle fold instead of four, in having fewer lateral plications, and in having a shallow, median depression in the fold of the pedicle valve.

Horizon. Kagawong formation.
Locality. High falls, Manitoulin island.
Types. Royal Ontario Museum, Toronto.

Phylum, **MOLLUSCA**

Class, *PELECYPODA* Goldfuss

Order, PRIONODESMACEA Hall

Family, CRYTODONTIDAE Ulrich

Vanuxemia sp.

Plate I, figures 7 and 8

The Trenton rocks in the railway cut at Little Current have yielded a number of pelecypods referable to the genus *Vanuxemia,* but, unfortunately, many of these specimens are so imperfectly preserved that they do not admit of specific determination. They are of moderate size, averaging about 35 mm. in height and 28 mm. in length, ovate, moderately convex with terminal beaks, the latter closely incurved and situated almost at the anterior extremity of the ligamental area. The ventral margin is broadly rounded, the anterior margin forms nearly a right angle with the cardinal axis. The ligamental area is straight and relatively high, the cardinal teeth strong, slightly curved, about six in number and situated directly beneath the beaks, the lateral teeth are long, straight, and at least two in number. The anterior muscle scar is very deeply impressed and situated near the margin of the shell.

In size and shape these specimens closely resemble *V. inconstans* Billings, but differ in the dentition, Billings' species having but three cardinals and two laterals, whereas the present form shows at least six of the former.

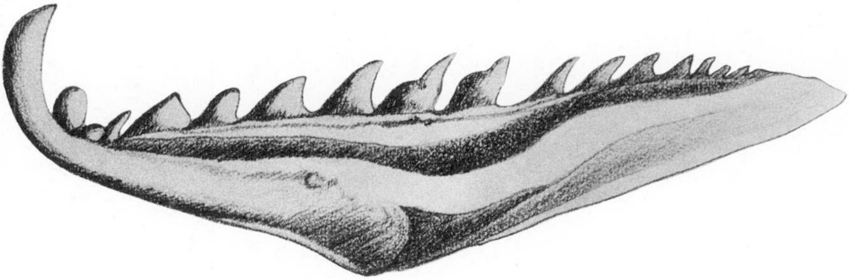
In the multiplicity of the cardinal teeth this form resembles *V. dixonensis* Meek and Worthen, but the general outline is somewhat different and the ligamental area is much higher and heavier.

Horizon. Trenton formation.
Locality. Railway cut, Little Current.
Type. Royal Ontario Museum, Toronto.

Plate I

All figures natural size unless otherwise stated

Figure 1. *Eunicites trentonensis* sp. nov. X 25. (Page 68.)
Figure 2. *Vanuxemia* sp. Interior of left valve.
Figure 3. *Lumbriconereites wayi* sp. nov. X 4. (Page 69.)
Figure 4. *Zygospira richmondensis* sp. nov. Pedicle valve. (Page 78.)
Figure 5. *Lingula rotunda gorrelensis* var. nov. (Page 77.)
Figure 6. *Zygospira richmondensis* sp. nov. Brachial valve. (Page 78.)
Figure 7. *Vanuxemia* sp. Interior of right valve. (Page 79.)
Figure 8. *Vanuxemia* sp. Exterior of left valve. (Page 79.)



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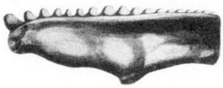

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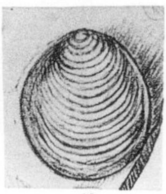

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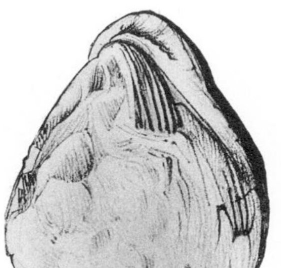

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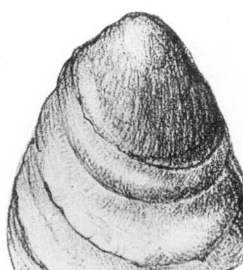

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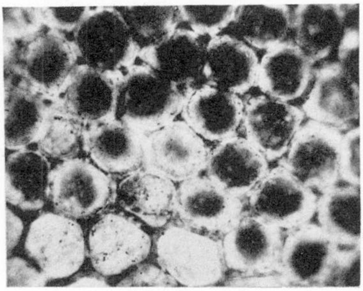
Plate II

All figures magnified thirty-five diameters

Figure 1. *Homotrypa crenulata* sp. nov. Tangential section. (Page 70.)
Figure 2. *Homotrypa crenulata* sp. nov. Vertical section. (Page 70.)
Figure 3. *Batostoma elongata* sp. nov. Tangential section. (Page 73.)
Figure 4. *Batostoma elongata* sp. nov. Vertical section. (Page 73.)
Figure 5. *Prasopora isolata* sp. nov. Tangential section. (Page 69.)
Figure 6. *Prasopora isolata* sp. nov. Vertical section. (Page 69.)
Figure 7. *Amplexopora perversa* sp. nov. Tangential section. (Page 75.)
Figure 8. *Amplexopora perversa* sp. nov. Vertical section. (Page 75.)



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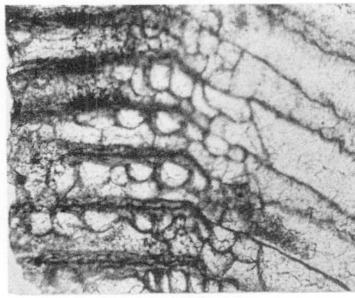

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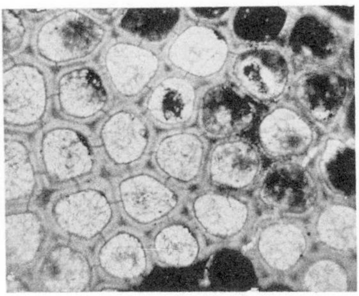

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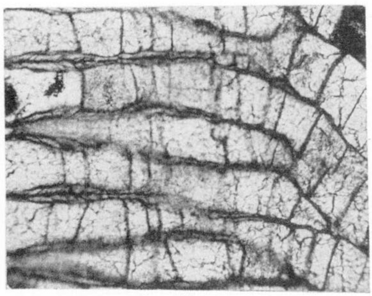

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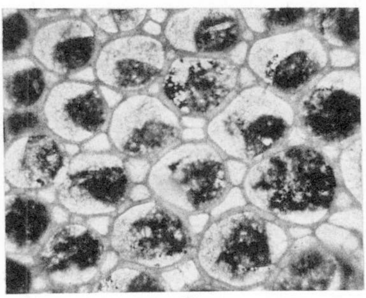

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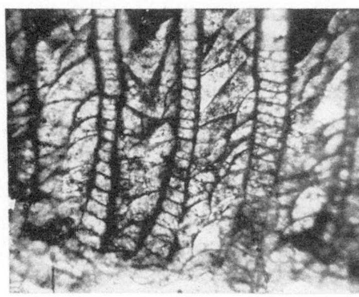

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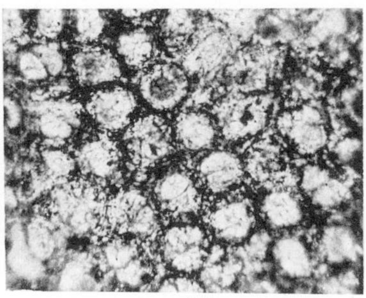

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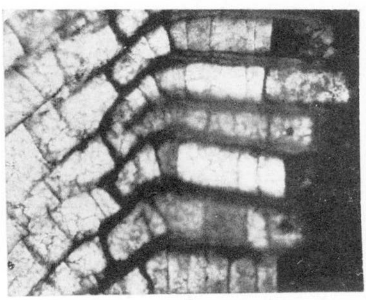

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Plate III

All figures natural size

Figure 1. *Mesotrypa maculosa* sp. nov. (Page 71.)
Figure 2. *Batostoma elongata* sp. nov. (Page 73.)
Figure 3. *Praspora isolata* sp. nov. (Page 69.)
Figure 4. *Monotrypella* cf. *M. aequalis* Ulrich. (Page 76.)
Figure 5. *Amplexopora perversa* sp. nov. (Page 75.)
Figure 6. *Homotrypa crenulata* sp. nov. (Page 70.)
Figure 7. *Stigmatella peculiaris similis* var. nov. (Page 73.)
Figure 8. *Hallopora encrustans* sp. nov. (Page 75.)
Figure 9. *Dekayella praenuntia echinata* Ulrich. (Page 73.)
Figure 10. *Batostoma* sp. (Page 74.)
Figure 11. *Batostoma* sp. (Page 74.)
Figure 12. *Homotrypa* cf. *H. subramosa* Ulrich. (Page 71.)
Figure 13. *Monotrypella ? dubia* sp. nov. (Page 77.)

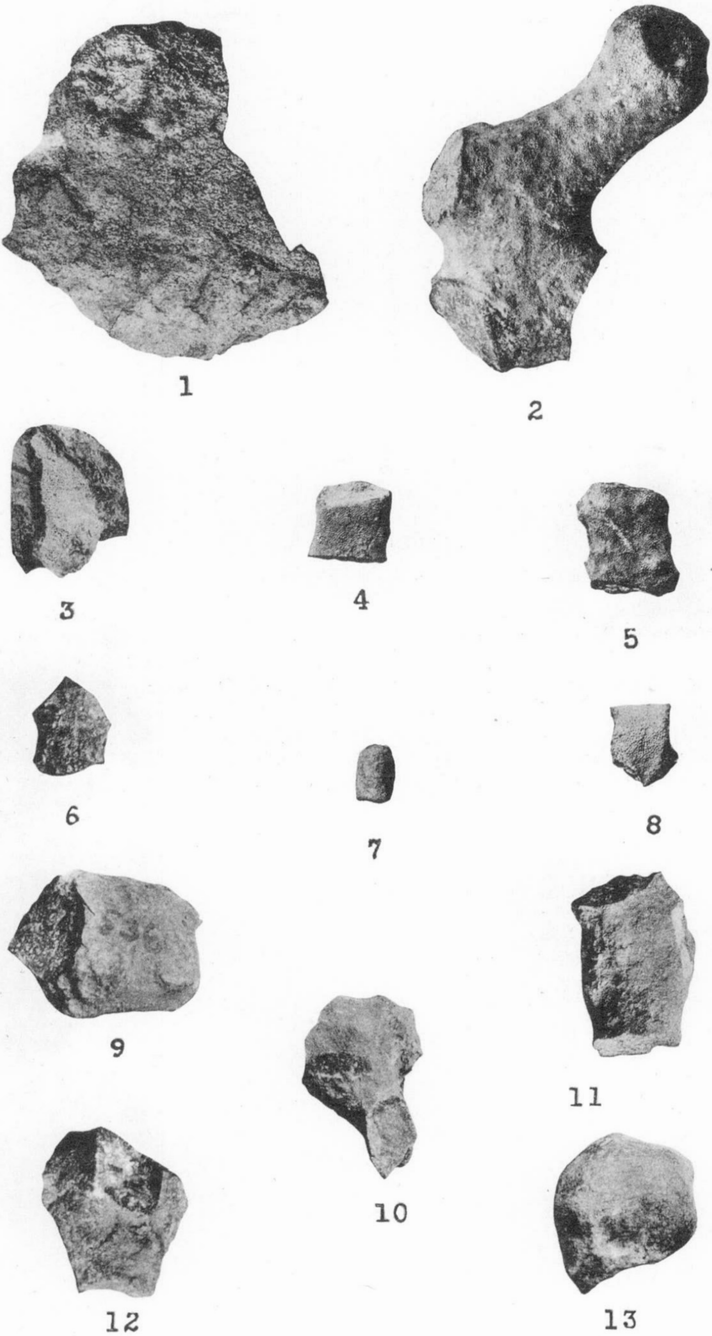
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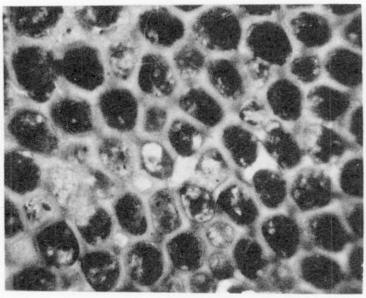
PLATE IV

All figures magnified thirty-five diameters unless otherwise stated

Figure 1. ***Stigmatella peculiaris similis*** var. nov. Tangential section. (Page 73.)
Figure 2. ***Stigmatella peculiaris similis*** var. nov. Vertical section. (Page 73.)
Figure 3. ***Mesotrypa maculosa*** sp. nov. Tangential section. (Page 71.)
Figure 4. ***Mesotrypa maculosa*** sp. nov. Vertical section. (Page 71.)
Figure 5. ***Batostoma*** sp. Tangential section. X 10. (Page 74.)
Figure 6. ***Batostoma*** sp. Vertical section. X 10. (Page 74.)
Figure 7. ***Hallopora encrustans*** sp. nov. Tangential section. (Page 75.)
Figure 8. ***Hallopora encrustans*** sp. nov. Vertical section. (Page 75.)



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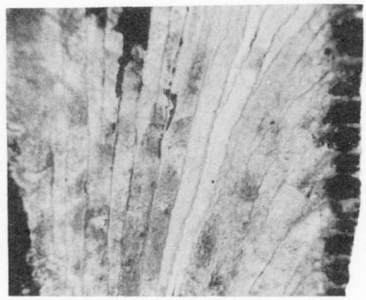

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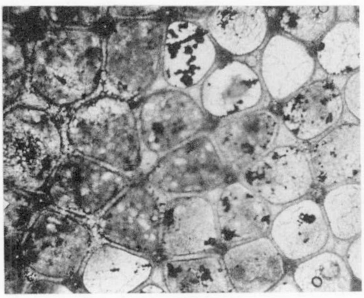

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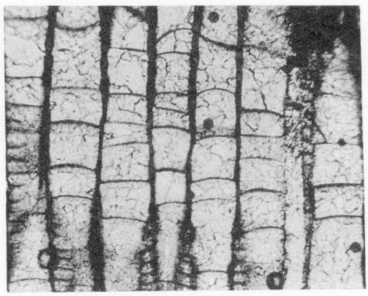

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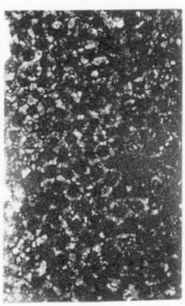

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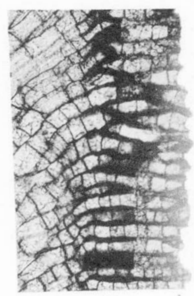

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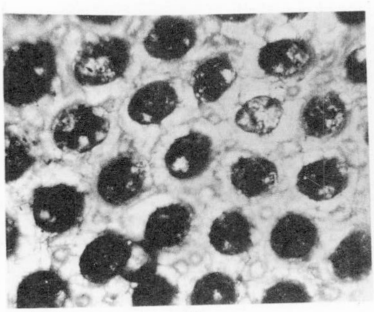

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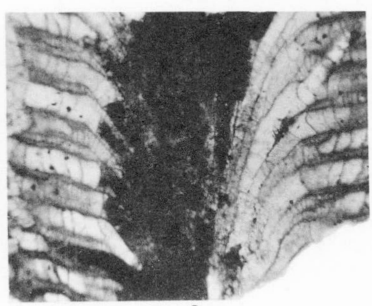

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Plate V

All figures magnified ten diameters

Figure 1. *Homotrypa streetsvillensis similis* var. nov. Tangential section. (Page 70.)
Figure 2. *Homotrypa streetsvillensis similis* var. nov. Vertical section. (Page 70.)
Figure 3. *Homotrypa streetsvillensis similis* var. nov. Tangential section. (Page 70.)
Figure 4. *Dekayella praenuntia echinata* Ulrich. Tangential section. (Page 73.)
Figure 5. *Dekayella praenuntia echinata* Ulrich. Vertical section. (Page 73.)
Figure 6. *Dekayella praenuntia echinata* Ulrich. Tangential section. (Page 73.)
Figure 7. *Monticulipora manitoulinensis* sp. nov. Tangential section. (Page 72.)
Figure 8. *Monticulipora manitoulinensis* sp. nov. Vertical section. (Page 72.)
Figure 9. *Monticulipora manitoulinensis* sp. nov. Tangential section. (Page 72.)

PLATE V

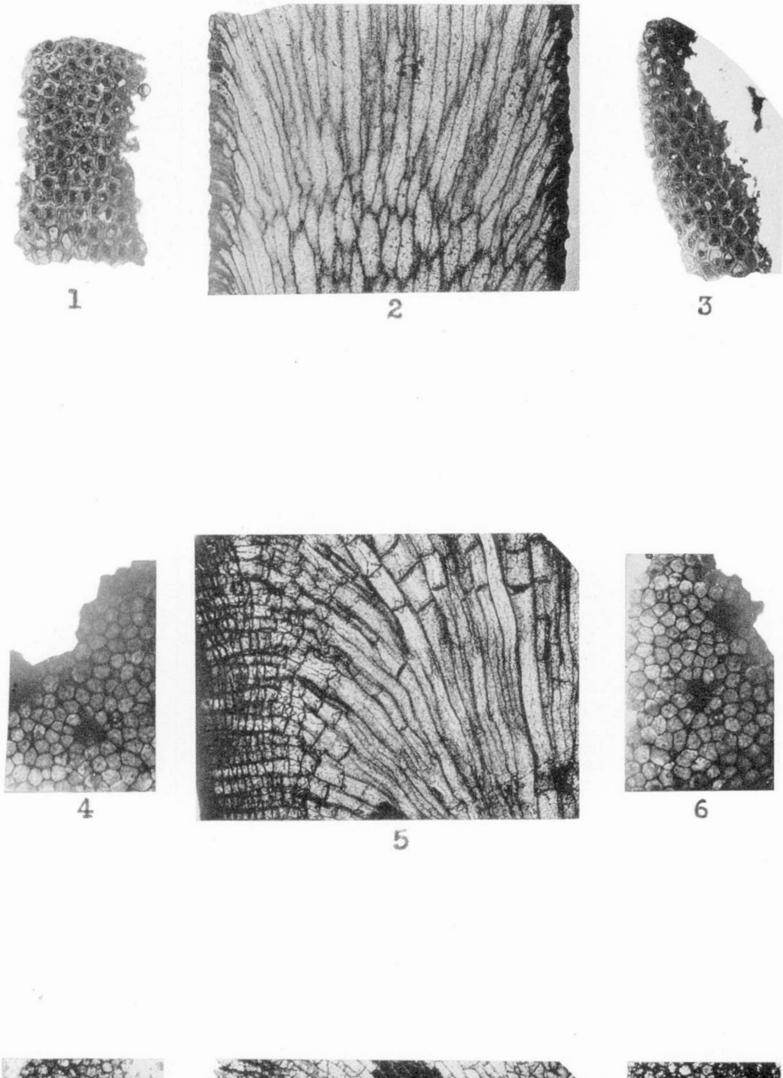
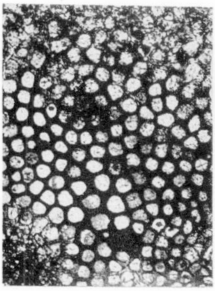


Plate VI

All figures magnified ten diameters

Figure 1. *Batostoma* sp. Tangential section. (Page 74.)
Figure 2. *Batostoma* sp. Vertical section. (Page 74.)
Figure 3. *Batostoma* sp. Tangential section. (Page 74.)
Figure 4. *Homotrypa* cf. *H. subramosa* Ulrich. Tangential section. (Page 71.)
Figure 5. *Homotrypa* cf. *H. subramosa* Ulrich. Vertical section. (Page 71.)
Figure 6. *Homotrypa* cf. *H. subramosa* Ulrich. Tangential section. (Page 71.)
Figure 7. *Monotrypella* cf. *M. aequalis* Ulrich. Tangential section. (Page 76.)
Figure 8. *Monotrypella* cf. *M. aequalis* Ulrich. Vertical section. (Page 76.)
Figure 9. *Monotrypella* cf. *M. aequalis* Ulrich. Tangential section. (Page 76.)
Figure 10. *Monotrypella ? dubia* sp. nov. Tangential section. (Page 77.)
Figure 11. *Monotrypella ? dubia* sp. nov. Vertical section. (Page 77.)
Figure 12. *Monotrypella ? dubia* sp. nov. Tangential section. (Page 77.)



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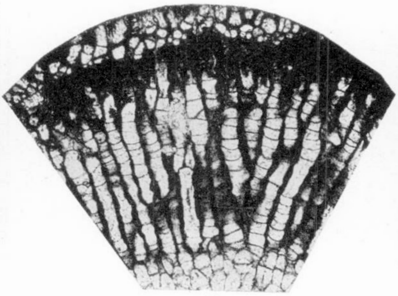

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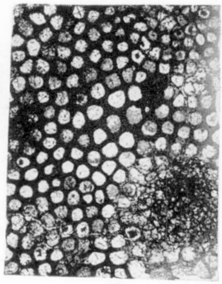

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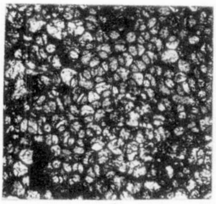

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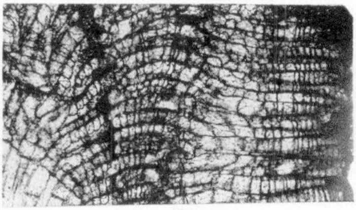

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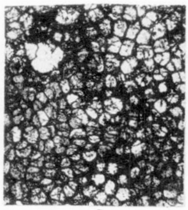

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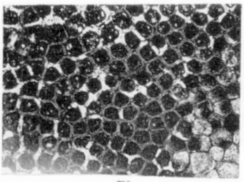

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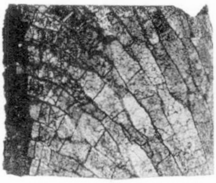

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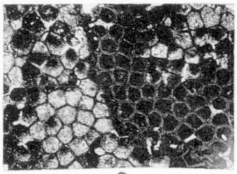

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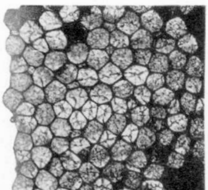

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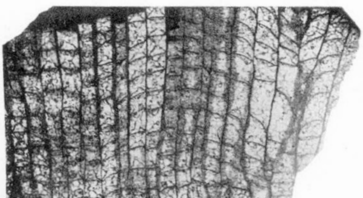

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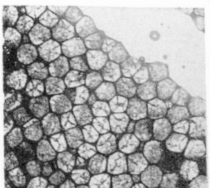

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PART III

A STUDY OF THE COBOURG FORMATION

By J. C. Sproule

INTRODUCTION

This study of the Cobourg formation of the Trenton group was undertaken in 1932. The problem was to investigate the physical and faunal characteristics of the Cobourg formation in the province of Ontario and to define its lower and upper boundaries and consequent relationship to the Sherman Fall or "*Prasopora* beds" below and the Collingwood above. The greater part of the field work has been done in the province of Ontario, but correlation and formational contact problems made it necessary to study equivalent rocks in the state of New York as well.

The writer acknowledges indebtedness to Professor W. A. Parks of the University of Toronto for suggestions and criticism, to Mr. C. S. Evans under whose guidance the field work was carried on, and to Mr. J. F. Caley and Mr. John Monteith who kindly co-operated in the field in 1933; and also to Miss A. E. Wilson of the Geological Survey, Canada, Dr. G. M. Kay of Columbia University, Professor Charles Schuchert, Curator Emeritus of the Peabody Museum of Natural History, Dr. Rudolf Ruedemann, State Palæontologist of New York, Dr. A. F. Foerste, Dr. R. S. Bassler, and Dr. E. O. Ulrich of the Smithsonian Institution, all of whom have assisted very materially by their helpful criticisms and suggestions.

The Upper Trenton rocks at Picton, Prince Edward county, Ontario, were described[1] by Raymond (10) in 1912 as the type of the "Picton" formation. He changed the name, however, to "Cobourg" in 1921 (11) when it was discovered that the term "Picton" had been preoccupied by Cushing in 1910, who had applied it as a formational term to a granite. "Cobourg" was chosen in its place because the rocks of that age are so well exposed in the vicinity of Cobourg on lake Ontario. Dr. G. M. Kay of Columbia University, and the writer, working independently, during the summer of 1933, found that only the lower part of the Cobourg (Picton) formation is exposed in the neighbourhood of Picton, and that the lower 43 feet of the former "Picton" formation in reality belongs to the *Prasopora* beds. Recent quarrying operations have made possible a more exact determination of the contact than was possible when Raymond described the section.

The original "Trenton" formation, described first at Trenton Falls, New York, by Timothy Conrad (4) in 1837 and Lardner Vanuxem (14) in 1842, at the top included the lower 120 feet of what is now recognized as Cobourg. Vanuxem selected *Rafinesquina alternata deltoidea* (Conrad) as the most characteristic fossil of his "Trenton" formation, and *R. alternata deltoidea* is

[1] Numbers refer to "References Cited", p. 111.

now recognized as being confined to the above-mentioned upper 120 feet in this region, i.e. to the Cobourg formation.

The Trenton of these early workers comprised all beds between the Leray-Watertown formations of the Black River group and the Utica shale. More recently several members have been recognized within these limits, called collectively the "Trenton group." Foerste's (5) subdivisions of the Trenton group are presented in the following chart:

Ordovician Correlation Table, According to Foerste

		North-central New York	Central Ontario
Middle and Upper Ordovician	Cincinnatian	Absent	Richmond
		Lorraine Utica	Humber River Don River Gloucester Collingwood
	Mohawkian	Upper Trenton Middle Trenton Lower Trenton	Cobourg Middle Trenton (Prasopora beds) Hull Rockland
			Glens Falls
		Watertown limestone	
		Leray Lowville	Leray Lowville

Rudolf Ruedemann (20) summed up in final form the idea expressed in earlier literature that the upper member of the Trenton, the Cobourg, is merely a contemporaneously deposited limy phase of the Lower and Middle Utica. Ruedemann's "Utica" includes all dark shale beds between the Canajoharie shale ("*Prasopora* beds") and the base of the Frankfort.

Professor Parks (9) took the next logical step by proving the inseparability of the Collingwood and Upper Cobourg on evidence provided by *Ogygites latimarginatus* (Hall), earlier considered by Raymond as the index fossil of the Collingwood formation. Parks collected *O. latimarginatus* from the upper beds of the Cobourg at Collingwood, and consequently he called them "Lower Collingwood." Later work in other areas, however, has revealed that this form occurs sporadically at lower horizons than at the type locality. Furthermore, the Collingwood black shale itself does not everywhere contain its "index fossil." Caley (3) has found that at Little Current on Manitoulin island, *O. latimarginatus* occurs only in the lower 2 feet of the 13 feet of Collingwood black shale exposed there, and does not occur at all in the 20 feet of similar strata exposed in the vicinity of Sheguiandah, though in other respects the fauna of this black shale is overwhelmingly "Collingwood." *O. latimarginatus* then should no longer be regarded as the index fossil of the Collingwood formation.

The genus *Triarthrus* is a more satisfactory marker of the base of the Collingwood than is *Ogygites*. According to Parks *Triarthrus* may also be used, in Canada at least, to define the top of the Utica shale series.

Kay has in recent years done considerable work on the Ordovician rocks of Iowa, Missouri, New York, and central Ontario. Kay (6, 7, 8) proposed to include the Gloucester of Ontario, as well as the Collingwood formation, in the "Trenton group." Kay's chart is reproduced below to express his idea of the continuity of the Cobourg and Utica.

Columnar Section of the Trenton Group, after G.M. Kay

Mohawkian series	Trenton group	Gloucester	75	feet
		Collingwood	50	"
		Upper Cobourg	75 +	"
		Lower Cobourg	175 −	"
		Sherman Fall	125 +	"
		Hull	100	"
		Rockland	60 +	"
	Black River Watertown limestone			

"The thicknesses of the limestone formations are the maxima in New York; the shales are represented as at their type localities in Ontario."

If the Cobourg formation is Lower and Middle Utica in age, it seems natural that the Collingwood and Gloucester, of Upper Utica age, should be included in the same rock group as the lower and middle members. We shall see, however, in succeeding pages, that such is not a logical arrangement. In the first instance the "Utica," if it includes the Cobourg, is not an unbroken succession, and in the second, the Gloucester grades imperceptibly up into the Lorraine wherever the contact is exposed.

The present investigation has revealed that the Cobourg formation is in reality a separate and fairly well-defined unit. The upper boundary is generally quite sharp; the lower, although not so distinct, may be determined within a few inches. Lithologically the formation is unique only in the upper portion in restricted localities, but it is definable throughout by the faunal association. The general faunal features and a number of the peculiarities already discussed permit the identification of almost any outcrop of these rocks. Criteria useful in determining the lower and upper limits are discussed below.

DISTRIBUTION, STRUCTURE, AND THICKNESS

The Cobourg formation in Ontario extends as a band across the central part of the province from Manitoulin island to Picton, trending in a general northwest-southeast direction parallel to the border of the Canadian Shield. The surface width of this band varies from a few yards, on Manitoulin island, to a maximum of nearly 20 miles, in the vicinity of lake Simcoe.

The constituent strata of the Cobourg are conformable with the underlying Trenton and Black River formations. Consequently they dip away

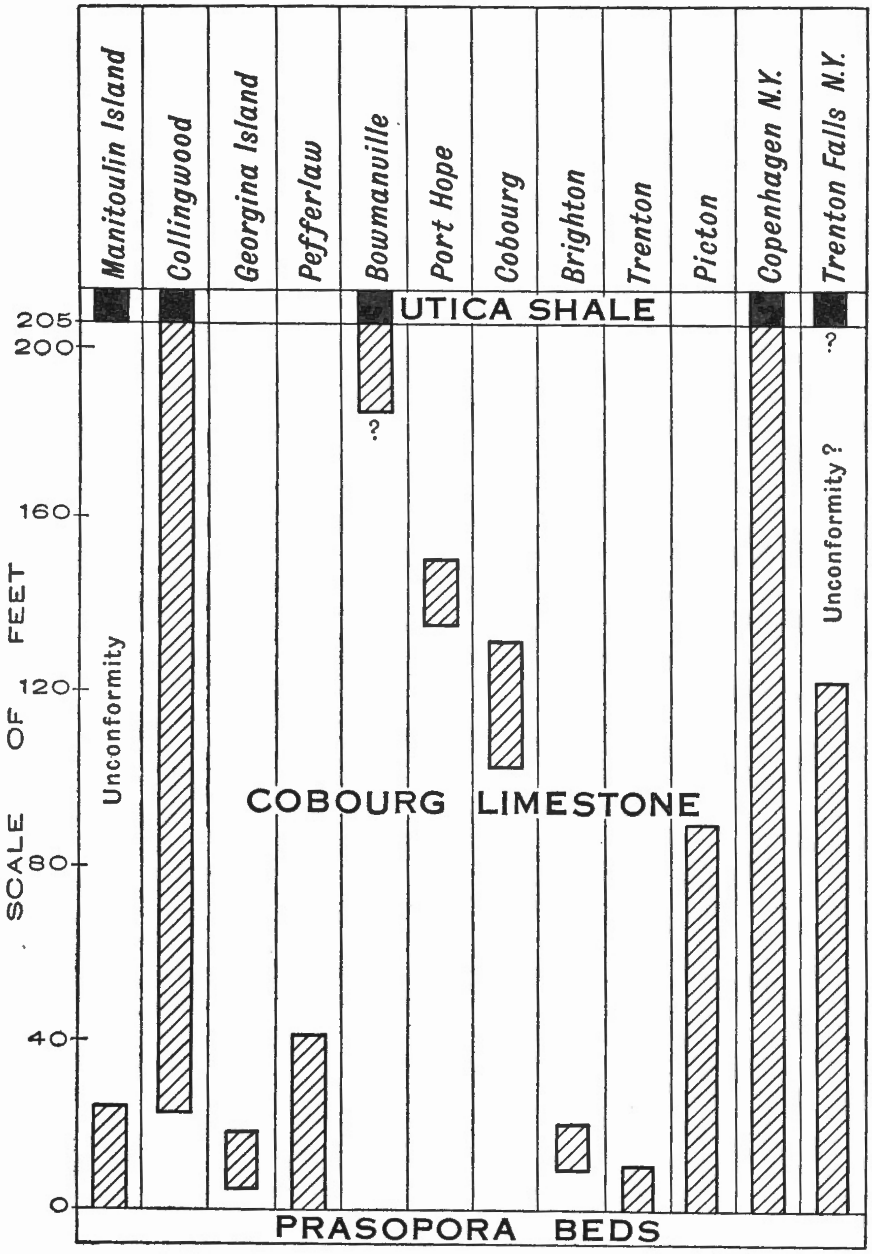

Figure 4. Comparative thicknesses, and horizons of the Cobourg limestone in Ontario and New York state.

from the shield at low angles, rarely exceeding 30 feet a mile. The most accurate structural determination was made at Collingwood by plane-table surveys; here the beds were estimated to dip south 61 degrees west at a rate of 30 feet a mile.

Major irregularities in structure have not been observed. There is a small dome in the Lower Cobourg rocks on the shore of Georgian bay 2 miles southwest of Collingwood, but it is too small to be of much economic importance. Robert Cherry of Collingwood has, up to the present time, drilled three gas wells on this dome, the first of which he began in August 1928. The wells have yielded small quantities of gas and a considerable quantity of salt water. Mr. Cherry bottles the water and sells it as a general health restorer.

The Cobourg underlies a fairly large area in south-central Ontario, but is exposed only in a few places where the drift mantle has been removed. Accurate determinations of the thickness are, as a result, difficult to make. Raymond gives an estimate of 200 feet for the thickness of the Cobourg in "central Ontario." Plane-table measurements give a thickness of 185 feet for the section exposed at Collingwood. The base of this section at Collingwood is probably within 20 feet of the *Prasopora* beds (well-log determinations). The only complete section known to the writer is exposed on Deer river at Copenhagen, New York, where the measured thickness is 205 feet. In other localities its thickness depends upon the amount of erosion during the Cobourg-Collingwood interval. In one locality on Manitoulin island, for example, only 30 feet of the Cobourg is left. In another, near by, the Collingwood black shale rests directly on Precambrian quartzite.

The following chart shows the principal outcrop occurrences, the thicknesses of exposed strata, and their approximate or exact position in the formation.

LITHOLOGY

The Cobourg rocks are practically all light to dark grey, argillaceous limestones and limy clays that weather to a loose, irregular, grey, or buff-coloured clay-lime rubble. There are occasional interbedded bands of crystalline and crinoidal limestones, from a fraction of an inch to 2 feet or more thick. An exception to this manner of occurrence is seen in the upper part of the formation in parts of northern New York where the beds are in many cases recrystallized for 30 feet or more below the unconformable contact with the Utica. The depth of crystallization appears to be at a maximum where the unconformity is greatest.

A more detailed description of the lithology may be obtained by reference to almost any one of the reports given in the bibliography.

THE LOWER BOUNDARY

In establishing the stratigraphic boundaries of the Cobourg formation the greatest difficulty is encountered at the base; that is, at the contact with the Sherman Fall (*Prasopora* beds of Raymond). There are useful lithologic features that may be used locally, but they are not widely applicable. Faunal criteria only, have proved useful in making the division. More than one hundred and twenty species have been identified from the Cobourg formation. Comparatively few of these are confined to the member, but of the restricted forms several have turned out to be of real value. The outstanding examples are: *Rafinesquina alternata deltoidea* (Conrad), *Cyclospira bisulcata* Emmons, *Hormotoma trentonensis* Ulrich and Scofield, *Trochonema umbilicatum* (Hall) (recurrent from the basal Trenton). They all begin at, or within a very few feet above, the top of the *Prasopora* zone, and continue to the top of the formation. Kay defines the base of the Cobourg by the occurrence of *Ischadites* sp. The finding, however, of *Ischadites* sp. below the black shale, in the Cobourg contact zone, on Big brook near Frenchville, New York, throws some doubt on the value of this as an index form.

The difficulty of drawing an exact lower boundary is increased by the paucity of the fauna in the lower 15 feet or so. The *Prasopora* fauna from below gradually fades into this indeterminate zone, and new Cobourg forms appear at first as scattered individuals, becoming more dominant higher in the sequence.

THE UPPER BOUNDARY

The upper limit is definite, the break being abrupt both lithologically and faunally as indicated by the contact conditions at several localities.

Northern Michigan. Professor R. C. Hussey states (personal communication) that near Newberry in northern Michigan, the Bills Creek beds, of Lower Richmond age, rest directly upon the Upper Trenton. The Upper Trenton of Michigan is closely related to the Prosser of Wisconsin, the upper part of which is Cobourg in age.

Manitoulin Island. In the town of Little Current on Manitoulin island the Collingwood black shale rests directly on basal Cobourg limestones. According to Caley (3) all but the lower 30 feet of the Cobourg formation had been eroded prior to the deposition of the Collingwood shale. The contact is well exposed in a road cut on the west side of the town. The black shale is there underlain by 34 inches of strata weathered to an irregularly rotted limestone with a marly residue. This bed is in turn underlain by a dense, hard, limestone bed, 8 to 10 inches thick, beneath which lie typical Cobourg limestone bands separated by shaly partings.

Beside the main road at the south end of the town another exposure reveals the black shale in direct contact with a limestone band closely similar to the uppermost hard limestone band described above. At this place only a fraction of an inch of marl-like "soil" covers the weathered surface of the limestone.

On both sides of the Little Current road a third of a mile north of Sheguiandah settlement the Collingwood shale is seen in direct superposition on a long hogback of Precambrian quartzite.

On the east side of the same road, just outside Sheguiandah, the lower contact of the Collingwood shale is again exposed. It rests here upon conglomeratic limestones apparently of the Black River formation.

In an abandoned limestone quarry on the shore of Sheguiandah bay one-third of a mile northeast of Sheguiandah, the Collingwood shale overlies basal Cobourg limestones with an angular unconformity. The strata in the quarry all dip gently eastward away from a Precambrian quartzite ridge. There are several of these quartzite ridges in the neighbourhood of Sheguiandah. They are evidently the source of the many quartzite pebbles and boulders present in the contact zone immediately beneath the black shale. The contact of the Collingwood with the underlying Cobourg is visible over a horizontal extent of 70 feet. Within this distance the lime band below the contact is truncated from a thickness of 27 inches at one edge of the outcrop to 2 inches at the other edge. The conglomerate at the contact is composed of angular to well-rounded pebbles in a sandy, lime matrix.

Wherever the contact has been seen on Manitoulin island the uppermost limestone beds contain appreciable quantities of iron and zinc sulphides, deposited in vugs and cracks in the old erosion surface. Similar metallic sulphides are a prominent feature at the same horizon in parts of northern New York.

Western Peninsula of Ontario. On the south shore of Georgian bay the hiatus is at a minimum. It was here, nevertheless, that the presence of an unconformity was first suspected. An investigation of the contact phenomena in other areas followed.

On the beach at Craigleith interbanded, dense grey limestones and black, petroliferous shales of the Collingwood formation rest with a slight unconformity on the rubbly weathering, argillaceous limestones of the Cobourg. The contact is marked by ½ to 2 inches of a soft grey to buff-coloured marl with thin, undulating layers of rotten brown shale, containing many broken fragments of *Dalmanella* and *Diplotrypa* "pebbles" up to 1 inch in diameter. The marly material of the contact zone is similar to that occurring in the same zone at Little Current on Manitoulin island. This bed is overlain by 9 inches of dark, nodular, limestone bands with undulating layers of rotted, brown and black, bituminous shale. The dense grey limestones above the contact are much harder and purer in composition than are the more argillaceous and rubbly weathering limestones of the upper part of the Cobourg formation.

The uppermost Cobourg is not now exposed on the north shore of lake Ontario, but the debris from an old quarry at Bowmanville, excavated in the contact zone, indicates that conditions there are similar to those existing at Craigleith. In the waste dump beside the quarry are the same black limestone nodules and the same rotten brown shale of the basal Collingwood present at Craigleith. Many specimens of *Catazyga headi filistriata* var. nov. and *Diplotrypa neglecta* Ulrich were found here, both of which are abundant in zones within 20 feet below the contact on Georgian bay.

New York. The Cobourg formation was studied at various localities in the upper Black River and Mohawk valleys of New York state.

On Deer river at Copenhagen there is a continuous section from the *Prasopora* beds at the base to the overlying Deer River bituminous black shale. The uppermost beds are exposed in the stream bed only at periods of low water. Although an exact determination of the contact could not be made, it is placed tentatively at or near the base of a series of dense, nodular, dark limestones and undulating, grey-brown to black shale in the upper part of which were collected pygidia of *Ogygites latimarginatus* (Hall). Ruedemann (13) lists the following species from the black shales of the Deer River formation immediately above the transition beds: *Climacograptus typicalis posterus* Ruedemann, *Glossograptus quadrimucronatus timidus* Ruedemann, *Leptobolus insignis* Hall, *Geisonoceras tenuistriatum* (Hall), *Camarotoechia humilis* Ruedemann (identified as *Zygospira modesta* (Say) from the Collingwood of Ontario). To those we can add *Schizocrania filosa* Hall, *Triarthrus eatoni* (Hall), and *Ogygites latimarginatus* Hall, forms collected by the writer. Those species are all listed from the Collingwood black shales of Ontario by Parks (9). The two shales compare closely in lithological characters also. The writer, then, is strongly of the opinion that the Collingwood should be correlated with the Deer River shales.

Regardless, however, of the relative ages of the Collingwood of Canada and the Utica shales of the Black River and upper Mohawk valleys, the similarity in the contact features beneath the Utica shale in Canada and in northern New York is remarkable. Kay states that at Rodman the Utica black shale lies disconformably on a 5-foot series of nodular limestones and that he collected *Ogygites latimarginatus* in the nodular series. Kay's description indicates that the nodular limestone is similar to that at Copenhagen and at Collingwood. The writer has not seen the Rodman section, but at the other two localities mentioned the nodular limestone contains undulating beds of petroliferous brown and black shale not unlike the pure black shales of the overlying Utica.

It is not unreasonable to suppose that the first appearance of black shale is an indication of a fundamental change. The break on Georgian bay is undoubtedly below the nodular limestone, consequently the break is here also placed in or below it.

Farther south in the Upper Mohawk valley, at Big brook near Frenchville, and near Holland Patent (13), the Utica-Cobourg contact is well exposed. At both these localities the dark shales of the Utica are sharply disconformable on the rough, cavernous, and sun-cracked limestone of the Cobourg formation. Near Frenchville some of the basal Utica shales are finely ripple-marked. Within the limits of the outcrops the unconformity is not angular, but the upper 6 inches of the limestone is partly brecciated and has many irregular cracks and cavities filled with cupriferous iron, lead, and zinc sulphides.

It is highly probable that the break is of a like nature in the upper Black River valley. Lardner Vanuxem (14) is referring to the eroded surface of the Cobourg near Martinsburg when he says: "The Trenton limestone is the most metalliferous rock in the district as regards lead and zinc ores, but neither are found as yet in profitable quantity. The most favourable locality is near Martinsburg in Lewis county, about one-half mile northwest of the village. . . . ." The minerals referred to are all sulphides (mostly ferruginous) deposited in vugs and cracks probably from sulphate waters percolating along the porous zone immediately below the black, organic shales of the Utica.

In the region north and west of Utica city, Ruedemann finds no trace of the middle zone of the Utica. Lower and upper zones only are present 7½ miles west of Holland Patent. The Utica shale at Utica city is 800 feet thick, but only about 350 feet thick (Upper Utica only) at Holland Patent, 10 miles north, where incidentally the unconformity between the limestone and shale is very pronounced. In the upper Mohawk and Black River valleys there is absolutely no sign of a lateral transition as evidence of synchronous deposition of the Utica shale and the upper Trenton formations as suggested by Ruedemann. The conclusion is that the thickening of the Upper Cobourg northward and westward may be due in part to a lateral change in conditions of sedimentation, but differential erosion is also a prominent factor.

Farther south and east, in the Schenectady basin, Ruedemann (12) records an hiatus between the Schenectady beds, which he correlates with the upper part of the Trenton group, and the Indian Ladder shale, of Eden age.

It is not the purpose of this paper to go farther afield than the Ontario-New York side of the Great Lakes region, but it may be relevant to note in passing that conditions at the top of the Galena, in the Wisconsin-Illinois area, are surprisingly similar to conditions at the top of the Cobourg. H. F. Bain (1) in discussing the base of the Maquoketa, a Richmond shale formation, at its contact with the Galena, writes:

"With these fossils are a number of small pebbles or pellets of calcareous material. These are the best evidence of unconformity. They indicate in conjunction with the lithologic change from dolomite to shale and the introduction of a new fauna, a certain readjustment of land and sea.

"It is believed that they do not necessarily indicate such a period of elevation, erosion, or depression as is ordinarily connoted by the term unconformity, but rather a change in shoreline in some adjacent area, by which sediment previously excluded from this particular basin was introduced. That this change was gradual rather than sudden is apparently shown by the increasingly thicker clay partings between the layers of dolomite near the top of the Galena."

SUMMARY

The upper boundary of the Trenton group has been followed in a direction parallel to the present margin of the Canadian Shield and its southward extension, the Adirondack mountains; from northern Michigan, through Georgian Bay district, and across the Ontario peninsula; south into New York, up Black River and upper Mohawk valleys, hence eastward into the Schenectady basin. The result of our observations made throughout this distance unquestionably justifies the belief that in the Great Lakes region a widespread regression of the sea took place late in Trenton time. The hiatus was not everywhere of the same duration, but varied from an unknown minimum in the Ontario peninsula, to a maximum, equal possibly to Utica-Eden time, in northern Michigan. The resultant unconformity brings the Collingwood black shale or younger rocks into contact with Cobourg or older rocks.

PALÆONTOLOGY

GENERAL FAUNAL CHARACTERISTICS

An attempt was made to follow previous workers in erecting faunal zones, but it was found that all " zones " break down in the light of a thorough investigation. The formation may not even be divided into lower and upper members, except in restricted localities. A division into two may be practicable in New York, but the same does not hold in Quebec, Ontario, or Michigan.

The fluctuating conditions of Middle Ordovician time were such that many of the forms of life were migratory; sometimes, but not always, recurring in the same region. In different localities they occur at different horizons, depending, of course, on how far laterally uniform conditions persisted. Hence the zones erected may often be shown to be non-existent over any great distance. *Hormotoma trentonensis* Ulrich and Scofield, *Rafinesquina alternata deltoidea* (Conrad), *Cyclospira bisulcata* Emmons, and *Diplotrypa petropolitana prolifica* (Fritz) are among the best known of Cobourg forms that have been used as zonal indices. Most of them, however, range from the bottom to the top of the Cobourg formation and one or more are common in almost any outcrop. An analysis of the fauna in the lower 20 feet of the section exposed at Collingwood was compared with that of the upper 20 feet near Craigleith. The resemblance in the two faunas is very strikingly shown in the following composite list of fossils from these two horizons. Those species common to both horizons are marked with an asterisk.

Desmograptus cancellatus (Hopkinson). Upper horizon
**Streptelasma corniculum* Hall
**Cheirocrinus logani* (Billings)
**Prasopora patera* Ulrich and Bassler
Hallopora dumalis (Ulrich). Upper horizon
Batostoma evansi sp. nov. Lower horizon
Monotrypa undulata (Nicholson). Lower horizon
**Diplotrypa neglecta* Ulrich
**Diplotrypa petropolitana prolifica* (Fritz)
**Lingula cobourgensis* (Billings)
**Orbiculoidea lamellosa* (Hall)
**Platystrophia amoena* McEwan
**Hebertella bellarugosa* (Conrad)
**Rafinesquina alternata deltoidea* (Conrad)
**R. alternata camerata* (Conrad)
**R. alternata robusta* (Wilson)
**R. alternata nasuta* (Conrad)
**Sowerbyella sericeus* (Sowerby)
**S. minnesotensis* (Sardeson)
S. gibbosus (W. and S.). Lower horizon
**Dinorthis iphigenia* (Billings)
**D. meedsi* W. and S.
**Strophomena billingsi* W. and S.
**Dalmanella rogata* (Sardeson)
Orthis tricenaria Conrad. Lower horizon
**Rhynchotrema increbescens* (Hall)
Catazyga headi filistriata var. nov. Upper horizon
**Cyclospira bisulcata* (Emmons)
**Vanuxemia* cf. *V. suberecta* Ulrich

Ctenodonta alta (Hall). Lower horizon
Whitella ventricosa (Hall). Lower horizon
**Ambonychia* sp.
**Sinuites cancellatus* (Hall)
Salpingostoma expansum. Lower horizon
**Hormotoma* cf. *gracilis* (Hall)
**H. trentonensis* Ulrich and Scofield
**H. bellicincta* (Hall)
**Liospira vitruvia* Billings
**Lophospira elevata* U. and S.
L. bicincta Hall. Upper horizon
Subulites elongatus Conrad. Lower horizon
**Schizolopha textilis* Ulrich
**Trochonema umbilicatum* Hall
**Fusispira subfusiformis* (Hall)
**F. nobilis* Ulrich and Scofield
**Conularia trentonensis* Hall
**Endoceras proteiforme* Hall
**E.* sp. Upper horizon
Cameroceras trentonense Conrad. Upper horizon
**Probillingsites primus* (Fritz)
**Orthoceras* sp.
**O. ? Sactoceras?*
**Sactoceras* sp.
Trocholites ammonius Conrad. Lower horizon
Beloitoceras parksi sp. nov. Lower horizon
**Cyrtoceras* sp.
**Ogygites latimarginatus* (Hall)
**Isotelus maximus* Locke
**Illaenus americanus* Billings
**Calymene senaria meeki* Foerste
Ceraurinus marginatus Barton. Lower horizon
Ceraurus dentatus Raymond and Barton

The imperfection of Middle Ordovician faunal zones may be further illustrated by citing cases of several species occurring in the Cobourg formation far from their typical position in the stratigraphic column. Neither *Prasopora simulatrix* Ulrich nor *Zygospira recurvirostris* (Hall) has been previously recorded over 10 feet above the *Prasopora* zone in Ontario, whereas in New York both occur, generally in association, high in the Cobourg formation; and *Zygospira recurvirostris* has also been collected by the writer from Cobourg strata at Brighton, Cobourg, Port Hope, Collingwood, and Craigleith. On Georgian bay near Collingwood there is a zone replete with *Catazyga headi filistriata* var. nov., a few feet below the Collingwood black shale. *Catazyga headi* is a characteristic Richmond species in Ontario and the United States. It has been recorded by Foerste (5) below the Richmond only from the Lorraine of the St. Lawrence valley, Quebec. The range of *Desmograptus cancellatus* (Hopkinson), collected in the upper limestone strata at Collingwood, is also considerably extended. According to Bassler's "Index of American Ordovician and Silurian Fossils" *D. cancellatus* is confined to the Lower Ordovician. A number of specimens of *Diplograptus*, from Cobourg strata at Collingwood, were identified by Dr. Ruedemann as *D. macer* Ruedemann, previously reported only from the Canajoharie shales (Trenton) of New York. *Orthis tricenaria* Conrad, common to Black River and basal Trenton rocks, has recently been collected by A. E. Wilson (15) from the lower part of the Cobourg in Cornwall area and by the writer from equivalent strata near Brighton and at Collingwood. *Heterocrinus heterodactylus* Hall, occurring near the top of the Cobourg at Collingwood, has hitherto been reported only from the Eden of New York and Ohio. *Ortonella hainesi* (Miller), found on Sunset beach at Collingwood, has heretofore been regarded as a typical Upper Richmond Whitewater species.

Cobourg outcrops yield a considerable fauna from any horizon except the lower 10 to 15 feet, which is notoriously poor in fossils wherever it has been observed. A complete list of the fossils, collected during the course of this study, from the Cobourg formation of Ontario and New York, follows. Those species not now known to range outside the Cobourg are marked with an asterisk.

PLANTAE

Buthotrephis sp.

SPONGIA

Ischadites sp.

ANTHOZOA

Streptelasma corniculum Hall

GRAPTOLITOIDEA

Desmograptus cancellatus (Hopkinson)
Mastigograptus simplex (Walcott)
**Diplograptus macer* Ruedemann
D. sp.
Dendrograptus sp.

VERMES

Cornulites sp.
Worm borings

CYSTIDEA

Cheirocrinus logani (Billings)

CRINOIDEA

Heterocrinus heterodactylus Hall
**Dendrocrinus alternatus* (Hall)
D. gracilis (Hall)
Many unidentifiable stems

BRYOZOA

Protocrisina exiguus (Ulrich)
Corynotrypa inflata (Hall)
Ceramoporella sp.
**Homotrypa similis* Foord
Prasopora patera Ulrich and Bassler
P. simulatrix orientalis Ulrich
P. grandis (Ulrich)
Monotrypa undulata (Nicholson)
Batostomella sp.
Mesotrypa infida Ulrich
M. sp.
Hallopora dumalis (Ulrich)
**Batostoma evansi* sp. nov.
**Diplotrypa neglecta* Ulrich
D. petropolitana prolifica (Fritz)
Pachydictya acuta (Hall)
P. sp.
Rhinidictya paupera Ulrich

BRACHIOPODA

Lingula cobourgensis Billings
L. riciniformis Hall
L. obtusa Hall
L. canadensis Billings
L. sp.
Orbiculoidea lamellosa (Hall)
Schizotreta pelopea (Billings)
Schizocrania filosa Hall
Crania setigera Hall
Crania, 4 undetermined species
Platystrophia amoena McEwan
Hebertella bellarugosa (Conrad)
Rafinesquina alternata (Emmons)
R. alternata deltoidea (Conrad)
R. alternata camerata (Conrad)
R. alternata robusta (Wilson)
R. alternata nasuta (Conrad)
Sowerbyella sericeus (Sowerby)
S. minnesotensis (Sardeson)
S. gibbosus Winchell and Schuchert
**Dinorthis iphigenia* Billings
D. meedsi Winchell and Schuchert
D. subquadrata (Hall)
Orthis tricenaria Conrad
Dalmanella rogata Sardeson
Strophomena billingsi Winchell and Schuchert
**Parastrophia hemiplicata* Hall
Rhynchotrema increbescens (Hall)
Zygospira recurvirostris (Hall)
Catazyga headi filistriata var. nov.
Cyclospira bisulcata Emmons

PELECYPODA

**Matheria elongata* sp. nov.
Vanuxemia terminalis Ulrich
V. cf. *V. suberecta* Ulrich
Ambonychia sp.
A. bellistriata Hall
A. amygdalina Hall
Ortonella hainesi (Miller)
Ctenodonta alta (Hall)
C. sp.
Cyrtodonta sp.
Modiolopsis consimilis Ulrich
Whitella ventricosa (Hall)

GASTEROPODA

Sinuites cancellatus (Hall)
Salpingostoma expansum (Hall)
S. cf. *S. imbricatum* Ulrich and Scofield
Carinaropsis carinata Hall
L. medialis Ulrich and Scofield
L. bicincta Hall
L. medialis Ulrich and Scofield
Hormotoma trentonensis Ulrich and Scofield
H. cf. *gracilis* (Hall)
**H. simplex* Wilson
**H. bellicincta* (Hall)
Liospira vitruvia Billings

GASTEROPODA—*Concluded*

L. obtusa Ulrich
Trochonema umbilicatum (Hall)
Schizolopha textilis Ulrich
Tetranota bidorsata (Hall)
Holopea ventricosa Hall
Subulites elongatus Conrad
Fusispira subfusiformis (Hall)
F. nobilis Hall
Conularia trentonensis Hall

CEPHALOPODA

Endoceras proteiforme Hall
E. n. sp (not named)
**Cameroceras trentonensis* Conrad
Probillingsites welleri Foerste
**P. primus* (Fritz)
P. sp.
Orthoceras amplicameratum Hall
O. several sp.
O. ? *Sactoceras* sp. ?
Sactoceras sp.
Polygrammoceras sp.
Michelinoceras sp.
Kionoceras sp.
Trocholites ammonius Conrad
**Ephippiorthoceras sigmoidale* Fritz
Cyrtoceras sp.
**Beloitoceras parksi* sp. nov.
B. sp.
Scofieldoceras sp.

TRILOBITA

Ogygites latimarginatus (Hall)
Isotelus maximus Locke
I. gigas Dekay
Illaenus americanus Billings
Calymene senaria meeki Foerste
**Ceraurinus marginatus* Barton
Ceraurus pleurexanthemus Green
C. dentatus Raymond and Barton

OSTRACODA

Leperditella sp.
Aparchites sp.

Diplotrypa petropolitana prolifica (Fritz) is one of the most diagnostic of Cobourg fossils. It is found throughout the upper 185 feet of Cobourg strata, but is most abundant in the upper 120 feet on Georgian bay, on lake Ontario, and in northern New York. Within this range its absence was noted only from the *Diplotrypa neglecta* beds between Craigleith and Collingwood, which lie between 10 and 60 feet below the Collingwood contact.

Diplotrypa neglecta Ulrich appears to have the same range in Ontario as has *D. petropolitans prolifica.* In that portion of the section referred to above it is the most abundant fossil. Many of the beds are composed almost entirely of their zoaria. Associated with it are abundant *Hallopora dumalis* (Ulrich).

Batostoma evansi sp. nov. has been found at Cobourg and Port Hope, and throughout the lower two-thirds of the section at Collingwood. At Collingwood, 120 feet below the black shale contact, it forms a practically solid bed 6 inches in thickness. *Mastigograptus simplex* is with it in this strong zone.

All the species of *Rafinesquina* of the Cobourg are herein treated as varieties of *R. alternata* because they all have retained at least some trace of the alternate character of the radiating ribs of the parent species. They all grade into *R. alternata* and any or all of the varieties may be found at any horizon in the Cobourg formation. By far the most abundant and most significant one is the variety *R. alternata deltoidea* (Conrad).

Cephalopods are among the commonest fossils in the Cobourg formation, but generally their poor state of preservation renders them difficult to determine. A large number can be described only as *Orthoceras* sp. or *Sactoceras* sp.

DESCRIPTIONS OF SPECIES

Diplotrypa petropolitana prolifica (Fritz)

Mesotrypa prolifica Fritz

This variety differs from the Baltic provinces species only in the size of the zoœcia which average 5 to 6 in 2 mm. in the Ontario, as compared with 3·5 to 4 in 2 mm. in the Russian, form. In other respects the two appear to be identical. Dr. M. A. Fritz (9) in describing this variety as *Mesotrypa prolifica* suggested a possible relationship with *Diplotrypa petropolitana* (Pander). The name "prolifica" is here retained as a varietal term.

Horizon and Locality. Diplotrypa petropolitana prolifica is very common throughout the upper 185 feet of the Cobourg formation on Georgian bay. It is also found, but less commonly, in equivalent strata on lake Ontario and in New York.

Batostoma evansi sp. nov.

Plate VII, figures 1, 2, and 3

Zoaria small, 3 to 5 mm. in diameter. Zoœcial tubes comparatively large, 5 to 6 in 2 mm. with very thin walls in the axial region, considerably thickened in the mature zone; mature region thin, less than 5 mm. Mesopores few, and rather irregular in shape and size.

The form is referred to the genus *Batostoma* with a query because it seems most closely allied to that genus in most respects, but differs in the absence of acanthopores.

The new form is closest to *Batostoma winchelli* Ulrich, but differs from it in having much larger zoœcia, a thinner mature region, and no acanthopores.

Horizon and Locality. The types were collected from a strong 6-inch zone on the beach and in the quarry at Collingwood. A few specimens were also found at other horizons in the lower 120 feet of the Collingwood section, and at Port Hope, Cobourg, and Brighton.

The form has been named in honour of Mr. C. S. Evans, Geological Survey, Canada.

Types. Royal Ontario Museum, Toronto.

Catazyga headi filistriata var. nov.

Plate VII, figures 4, 5, 6, and 7

The variety *Catazyga headi* here described is, on the whole, slightly smaller in size than the typical Richmond form, averaging 14 mm. in length, 13 mm. in width, and 10 mm. in thickness. This difference in size by itself is not sufficient to justify a new variety. The greatest difference between the two is in the size and number of the radiating ribs, which in the new variety are slightly finer and closer together, having 11 ribs in 2 mm. whereas the upper Ordovician form has 4 to 7 ribs in 2 mm. A close comparison reveals that the general proportions in the two are the same.

The varietal name is suggested by the filiform character of the ribbing. *Catazyga headi* itself is considered to be a typical Richmond species that has hitherto been reported below that formation only from the Lorraine shales of Quebec.

Horizon and Locality. Catazyga headi filistriata was collected only from the upper 30 feet of Cobourg strata on Georgian bay and on lake Ontario.

Types. Royal Ontario Museum, Toronto.

Matheria elongata sp. nov.

Plate VII, figures 8 and 9

Only one specimen of this species has been collected, but the outlines and markings are believed to be sufficiently distinct to warrant describing it as a new species.

Shell very thin, small, and elongate quadrate; very inequilateral, with small beaks placed far forward; surface strongly marked with concentric growth lines; hinge about two-thirds of the length of the shell with long, narrow, ligamental area posterior to the beaks; teeth not visible; one pair of strongly developed muscle scars anterior to the beaks, posterior pair obscure; pallial line not defined. The measurements of the holotype are: length 15 mm.; maximum width behind the umbones 4 mm.; height at the umbones 4·5 mm.; greatest height behind the umbones 5 mm.

This species differs from all of the seven or eight known species by its more elongate outline.

Horizon and Locality. The holotype was collected from Cobourg strata on the beach at Collingwood about 110 feet below the black shale contact.

Type. Royal Ontario Museum, Toronto.

Fusispira subfusiformis (Hall)

Plate VIII, figure 1

This form is figured here to show the very fine interior moulds of the protoconch, a structure that is very rarely preserved.

Horizon and Locality. The specimen was found in Cobourg strata on the beach at Collingwood about 110 feet below the black shale contact.

Plesiotype. Royal Ontario Museum, Toronto.

Fusispira nobilis Ulrich and Scofield

Plate VIII, figure 2

This form, like the above, is figured to show the unusual protoconch.

Horizon and Locality. This specimen also was found in Cobourg strata on the beach at Collingwood.

Plesiotype. Royal Ontario Museum, Toronto.

Beloitoceras parksi sp. nov.

Plate IX, figures 1, 2, and 3

The type consists of a portion of the living chamber with ten well-preserved cameræ. Outlines dorsally slightly gibbous at the top of the phragmacone and the base of the living chamber, ventral gently convex; sutures of the septa rise toward the venter, the amount of this rise increasing on approaching the living chamber, sutures of the septa on the dorsum are more nearly transverse; siphuncle diameter 1 mm., located close to the venter, but not in contact with it (1 mm. away in this specimen). Greatest length of the conch 55 mm., 29 mm. of this taken up by the living chamber; maximum height 27 mm. and maximum width 21 mm., through the base of the living chamber; height and width of the most distal of the ten cameræ, 14 mm. and 7 mm., respectively.

This species differs from all three of those previously described in the more forwardly curved ventral saddles and the presence of a gibbosity on the dorsum at the base of the living chamber and the top of the phragmacone.

Horizon and Locality. Cobourg beach, 5 feet below the top of the exposed section.

This species is named after Dr. W. A. Parks, at whose suggestion this study of the Cobourg formation was initiated.

Type. Royal Ontario Museum, Toronto.

Endoceras sp. nov.

Plate IX, figure 4

This specimen was sent to Dr. Foerste at his request. On commenting on it in his reply he says:

"The lower part of the siphuncle once was filled with a succession of much elongated, funnel-shaped endocones. Only the uppermost endocone is preserved. It is 180 mm. long and its surface is faintly striated in a vertical direction. I have never seen another endocone showing similar vertical striations. The calcitic deposit beneath this well-preserved endocone formerly consisted of a close succession of endocones as in Zittel, *Endoceras proteiforme,* Figure 1105, 1913 edition. This calcareous succession of former endocones has recrystallized and no structure can be recognized within it at present. The much elongated endocone suggests the genus *Endoceras,* but nothing is known of the structure of the siphuncle or of the conch. Hence this specimen cannot be identified with any previously described species. It certainly cannot be identified with *Endoceras proteiforme.*"

This species cannot, therefore, be named until better specimens are collected.

Horizon and Locality. Cobourg limestone, between Sunset point and the harbour at Collingwood, about 110 feet below the black shale.

Ceraurinus marginatus Barton

Plate VIII, figure 3

The specimen figured is more complete than Barton's type which shows neither the posterior of the thorax nor the pygidium. The Collingwood form is complete except for the free checks and the tips of the two pygidial spines.

Horizon and Locality. Basal Cobourg beds, near Collingwood, Ontario.

Plesiotype. Royal Ontario Museum, Toronto.

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PLATE VII

Figure 1. *Batostoma evansi* sp. nov. Two views of the surface of the zoarium. X 2. (Page 107.)

Figure 2. Tangential section of the same. X 5. (Page 107.)

Figure 3. Vertical longitudinal section of the same. X 5. (Page 107.)

Figure 4. *Catazyga headi filistriata* var. nov. Dorsal aspect. X 2·5. (Page 108.)

Figure 5. Lateral view of the same. X 2·5. (Page 108.)

Figure 6. Ventral view of another specimen of *Catazyga headi filistriata*. X 2·5. (Page 108.)

Figure 7. The same view of a broader and slightly larger specimen of *Catazyga headi filistriata*. X 2·5. (Page 108.)

Figure 8. *Matheria elongata* sp. nov. View from the right side, showing strongly marked anterior muscle scar, well-defined growth lines, etc. X 2. (Page 108.)

Figure 9. *Matheria elongata*, dorsal aspect, showing long, narrow escutcheon, and small umbo, etc. X 2. (Page 108.)

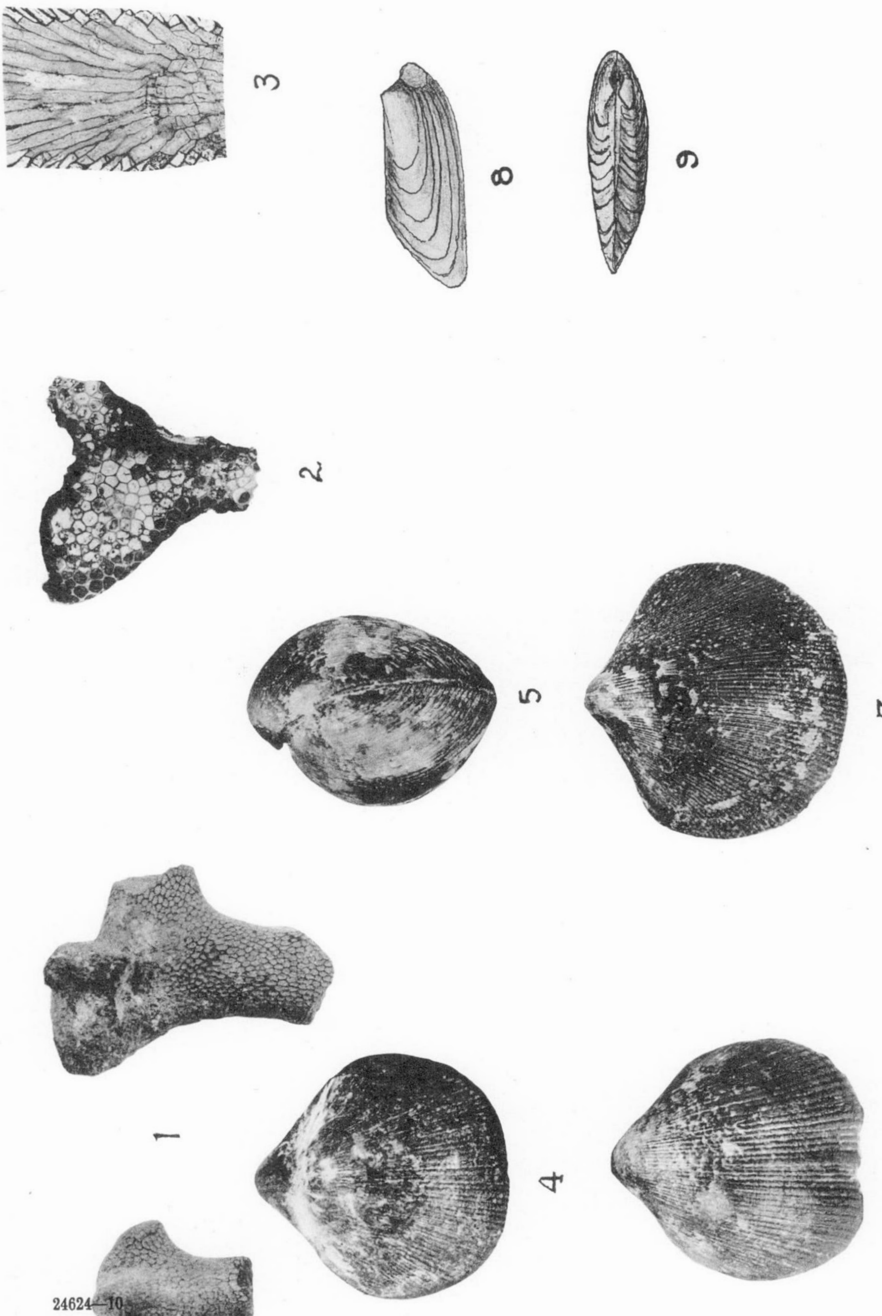

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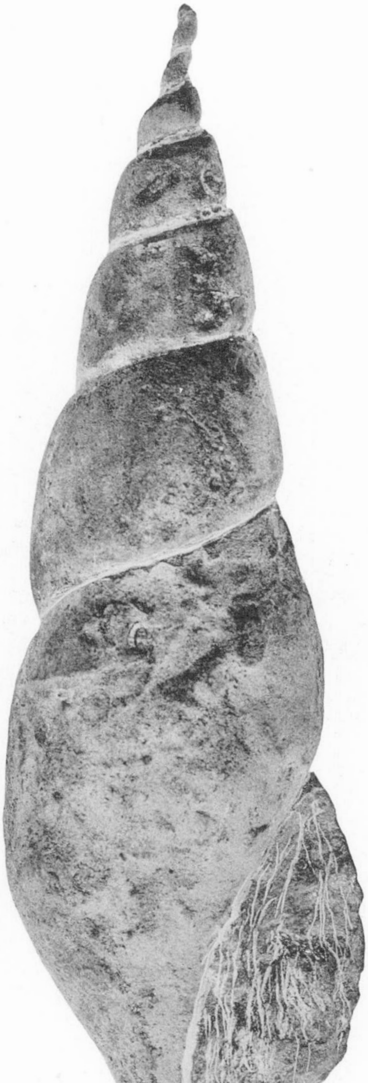
Plate VIII

Figure 1. *Fusispira subfusiformis* (Hall). The protoconch, consisting of three whorls, and the adult spire, with five. Natural size. (Page 109.)

Figure 2. *Fusispira nobilis* Ulrich and Scofield. Two whorls of the protoconch and four of the spire. Natural size. (Page 109.)

Figure 3. *Ceraurinus marginatus* Barton. Drawing. Anterior margin of the free cheek restored. Natural size. (Page 110.)

PLATE VIII.



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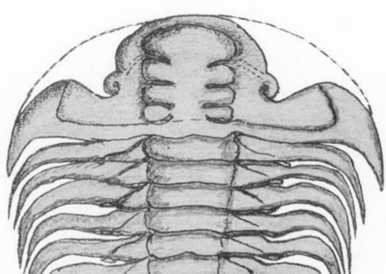

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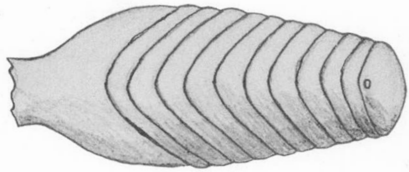
PLATE IX

Figure 1. *Beloitoceras parksi* sp. nov. Drawing. Ventral aspect of the conch, showing position of the siphuncle, saddles on the venter, and general shape of the conch. Natural size. (Page 109.)

Figure 2. *Beloitoceras parksi*. Drawing. Distal view. Natural size. (Page 109.)

Figure 3. The same as figures 1 and 2, from the left side; showing the gibbosity on the dorsum and the strong curve of the ventral saddles. Natural size. (Page 109.)

Figure 4. *Endoceras* sp. nov. Drawing, showing parts of three endocones. Only one is well preserved; the other two are partly filled with coarsely crystalline calcite. Note the peculiar lines along the endocone. Natural size. (Page 109.)



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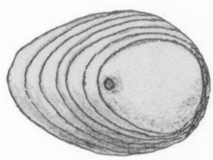

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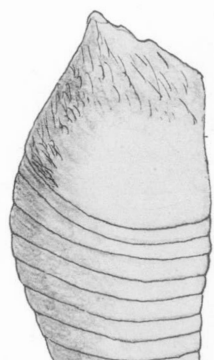

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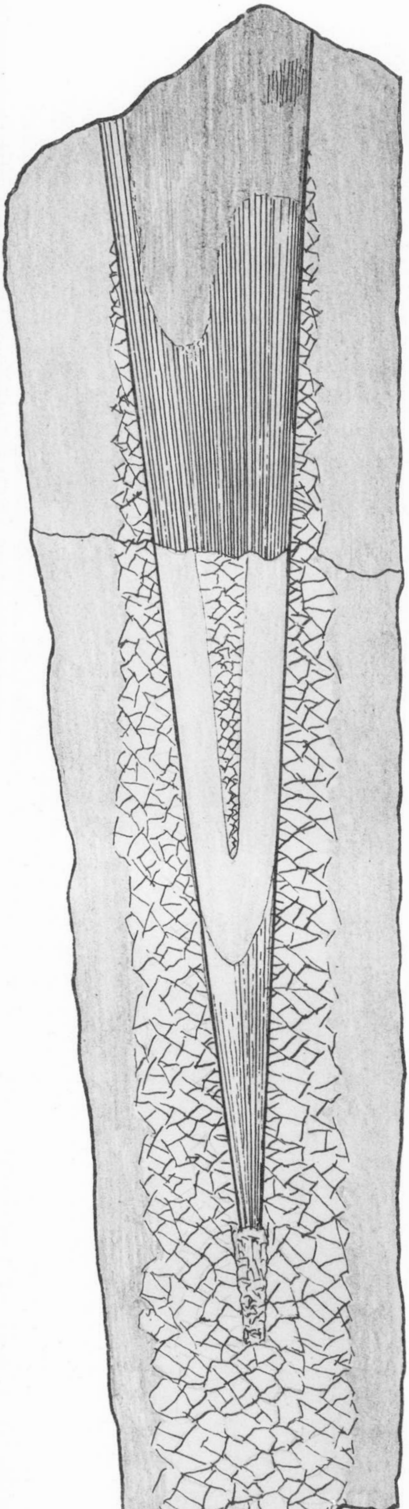

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PART IV

THE BLACK RIVER GROUP IN THE VICINITY OF MONTREAL

By V. J. Okulitch

INTRODUCTION

In the autumn months of 1932 Mr. J. J. Harris made a detailed study of the stratigraphy of the Black River group in Montreal area. Later the author revised Mr. Harris' results, making additions and changes in description and correlation and shifting the boundaries of formations to agree with the palæontological evidence. The results of the combined work are presented in this paper.

Thanks are extended to Dr. T. H. Clark for his direction and advice, both in the field and in the laboratory.

The first description of the Black River in this vicinity was written by Logan. Later Ells, Ami, and Raymond contributed to our knowledge of the group. Logan's work, assembled and summarized in the "Geology of Canada" (1863), formed the foundation for all later work and is, in many respects, still authoritative. Ells, in the years 1889 and 1890, re-examined the vicinity of the lower Ottawa and, more particularly, the island of Montreal, but added little to the information given us by Logan. H. M. Ami in 1900 issued a paper relating to the geology of the principal cities in eastern Canada. The work contains synoptical tables of the succession of the geological formations occurring in these cities and their immediate vicinities. During 1911 and 1912 Raymond studied the stratigraphy of Ontario and Quebec and briefly described the Black River occurrences on the island of Montreal and at St. Vincent de Paul. Correlations of Quebec and Ontario beds are given in his papers and the Pamelia formation was traced as far east as L'Orignal. A detailed study of the fauna of the region was published in 1935.

The present work is confined to a systematic and detailed study of a few typical exposures in the local quarries.

POINTE CLAIRE, GOLF COURSE QUARRY

Twelve miles west of Montreal and about half a mile due north of Pointe Claire, situated about 250 yards to the west of Cartier street, is a disused quarry. The maximum height of the vertical wall is 38 feet. The upper 21 feet is definitely a part of the Leray formation; the lower 17 feet belongs to the Lowville. The description of the beds, in natural order, with respective thicknesses and fossils, is here given.

Description

Bed Nos.	Top of Section	Thickness Individual Ft.	In.	Cumulative Ft.	In.
	Top of Section				
20	Dark grey, nearly black, light-weathering limestone. Stratification obscure; contains plates and nodules of chert......... *Hesperorthis* cf. *tricenaria*, *Rhynchotrema increbescens*, *Streptelasma profundum*.	3	2	38	4
19	Dark grey, weathering light buff, well-stratified limestone...... *Columnaria halli*.	......	8	35	2
18	Dark grey, light-weathering limestone showing obscure stratification and brown bands. Chert nodules................. *Columnaria halli*, *Streptelasma profundum*.	3	6	34	6
17	Fine-grained, dark grey, light-weathering, well-stratified, crystalline limestone.. *Columnaria halli*.	1	6	31	0
16	Dark grey, light-weathering, dense, unbedded limestone........ *Actinoceras* cf. *A. billingsi*.	1	6	29	6
15	Fine-grained, well-stratified limestone containing irregularly horizontal light-brown streaks............................	1	0	28	0
14	Dark, blocky limestone which weathers dark brown. Irregularly horizontal, light brown, sandy layers are common throughout. The rock is partly crystalline. Crossbedding is apparent in a few places.................................... *Rafinesquina alternata*, *R. clara*, *R. minnesotensis*, *R. transitionalis*, *Strophomena emaciata*, *S. incurvata*, *Zygospira recurvirostris*, *Hormotoma gracilis*, *Gonioceras*, *Bumastus bellevillensis*, *Isotelus gigas*.	10	0	27	0
	Base of Leray				
	Top of Lowville				
13	Dark grey, light-weathering limestone. Some of the stratification surfaces are covered with branching algæ. The top layer is conglomeratic. Stratification is well marked...... *Columnaria alveolata?*, *C. halli*, *Streptelasma profundum*.	3	6	17	0
12	Fine-grained, pure, crystalline limestone with abundant "Birdseyes"..	......	11	13	6
11	Dense, partly crystallized limestone. The upper limit of the bed is sharp, the lower is irregular. "Birdseyes" present....... *Tetradium cellulosum*, *T. clarki*, *T. fibratum*, *T. racemosum*, *Rafinesquina grandis*, *Strophomena incurvata*, *Zygospira recurvirostris*, *Cyrtodonta huronensis*, *C. subcarinata*, *Holopea similis*, *Hormotoma gracilis*, *H.* sp. ind., *Liospira peneplana*, *Lophospira bicincta*, *L. perangulata*, *Trochonemella montrealensis*, *Trochonema* cf. *T. umbilicatum*, *Cycloceras* sp., *Spyroceras cylindratum*, curved cephalopods, *Encrinurus vigilans*, *Ceraurus pleurexanthemus*, *Isotelus gigas?*, *Pterygometopus harrisi*, *P.* sp.	2	9	12	7
10	Crystallized, well-stratified limestone. Crossbedding is apparent *Stromatocerium rugosum*.	......	10	9	10
9	Fine-grained, dove-coloured limestone. Numerous fossil fragments..	......	4	9	0

Bed Nos.	Top of Section	Thickness			
		Individual		Cumulative	
		Ft.	In.	Ft.	In.
	Top of Lowville—Concluded				
8	Fine-grained, dove-coloured, unfossiliferous limestone with "Birdseyes"..	1	4	8	8
7	Shaly limestone. Numerous fossil fragments..................	......	1	7	4
6	Dark grey, fossiliferous limestone............................ *Tetradium cellulosum, T. fibratum, T. racemosum, Cyrtodonta subcarinata, Hormotoma gracilis, Trochonemella montrealensis, Isotelus gigas?*.	1	1	7	3
5	Impure limestone with shaly partings. Partly oolitic........... *Stromatocerium rugosum, Tetradium fibratum, Cycloceras* sp., *Bathyurus extans*.	......	2	5	0
4	Limestone composed almost wholly of unidentified bryozoa.. *Stromatocerium rugosum, Tetradium fibratum*.	......	2	5	0
3	Impure limestone with considerable variation. Towards the base of the bed the limestone is sandy, near the middle "Birdseyes" are common. Small, secondary crystals of pyrite present.. *Stromatocerium canadense* cf. var. *minimum*.	1	8	4	10
2	Fossiliferous limestone, dove-coloured, with an abundance of crystalline calcite.. *Tetradium cellulosum*.	1	10	3	2
1	Pure, dove-coloured limestone, containing practically no fossils..	1	4	1	4
	Base of Section				

Beds P.C. 1 to P.C. 13 are grouped by the writer as Lowville. The characteristic " Birdseye " effect, found in P.C. 2 and intermittently upward to and including P.C. 12, is good evidence in favour of this view. *Tetradium cellulosum* (Hall), which is characteristic of this formation, is found in abundance as high as P.C. 11. Bed P.C. 14 is typical Leray. The position of a fine-grained, light-weathering bed (P.C. 13) is uncertain. It is considered, however, to be the top of the Lowville. The top of this bed, which is conglomeratic, might well represent a slight erosional disconformity, although other direct evidence that this is so is lacking. It does, however, mark the boundary between two diverse types of sediments. The succeeding beds are coarser grained, massive, and thick-bedded, whereas the underlying strata are characteristically thin bedded, indicating instability of sedimentation. In general fossils are fewer, but the beds contain an abundance of brachiopods and some large cephalopods. The presence of chert in the topmost bed of the escarpment is characteristic of the Upper Leray; in fact the whole formation conforms well with that described by Cushing as occurring along the course of the Black River[1] (1911, page 142). The chert bed is elsewhere generally restricted to the uppermost few feet of the Leray and indicates that the top of the present escarpment is not far from the original upper boundary of the Leray. This is further supported by the evidence offered by *Hesperorthis tricenaria,* which in this locality is also confined to the uppermost Leray.

[1] *See* References cited, p. 130.

DEVITO QUARRY, POINTE CLAIRE

This quarry is situated on the east side of Cartier street nearly opposite the golf course escarpment. A thickness of 31 feet 7 inches of strata is exposed. The lower beds, totalling 11 feet, are members of the Pamelia formation, followed by the Lowville (16 feet, 11 inches). The topmost strata exposed (3 feet, 9 inches) is the basal bed of the Leray. The description of the beds is given below.

Bed Nos.	Top of Section	Thickness			
		Individual		Cumulative	
		Ft.	In.	Ft.	In.
	Top of Section				
22	Well-stratified, light-weathering, dark grey limestone containing sandy, irregularly horizontal, buff-weathering layers....... *Hesperorthis* sp., *Pionodema sinuata*, *P.* sp., *Rafinesquina alternata*, *R. clara*, *R. minnesotensis*, *Strophomena incurvata*, *Cycloceras decrescens?*	3	9	31	7
	Base of Leray				
	Top of Lowville				
21	Medium grey, pale buff, rubbly weathering limestone........... *Tetradium cellulosum*, *T. racemosum*, *Rafinesquina alternata*, *Zygospira recurvirostris*, *Hormotoma gracilis*, *Lophospira perangulata*, *Cameroceras? multicameratum*, *Sactoceras pictolineatum*, *Isotelus gigas*, *Encrinurus vigilans*, *Ceraurus pleurexanthemus*.	1	5	27	10
20	Oolitic limestone in which crossbedding is apparent. Numerous crinoid stems........	1	0	26	5
19	Light-weathering, oolitic limestone. Crossbedded. Contact with bed 18 irregular........	......	5	25	5
18	Buff-weathering, fine-grained limestone, pebbly in spots. The lower 4 inches show good stratification. Fossils scarce......	1	0	25	0
17	Light-weathering, crystalline and shaly limestone........ *Tetradium cellulosum*, *T. fibratum*, *T. racemosum*.	......	7	24	0
16	Well-stratified, fine-grained limestone........ *Tetradium cellulosum*.	......	1	23	4
15	Well-stratified, buff-weathering limestone........ *Tetradium cellulosum*, *Zygospira recurvirostris*, *Hormotoma gracilis*, *Lophospira bicincta*, *L. perangulata*, *Cameroceras? multicameratum*, *Sactoceras josephianum?*, numerous large and small cephalopods, *Bathyurus* sp.	1	7	23	3
14	Dark grey, fossiliferous limestone, shaly towards the middle of the bed........ *Tetradium cellulosum*, *Cycloceras decrescens*.	......	9	21	8
13	Massive, fossiliferous limestone. A 3-inch, brown-weathering band is in the middle of this bed........ *Tetradium cellulosum*, *T. syringoporoides*.	2	8	20	11
12	Pure dove-coloured and dark, sugary limestone make up the bed. Two pebbly zones occur. Stratification is more distinct towards the base........ *Tetradium cellulosum*, *Bathyurus extans*, ostracods.	3	8	18	3
11	Dark grey, light-weathering, well-stratified limestone with fossil fragments........	......	6	14	7
10	Fine-grained, dove-coloured, fossiliferous limestone........	1	4	14	1

Bed Nos.	Top of Section	Thickness Individual Ft.	In.	Thickness Cumulative Ft.	In.
	Top of Lowville—Concluded				
9	Shaly parting..........	......	......	......	......
8	Shaly limestone intercalated towards the base with layers of oolitic, dove-coloured limestone. Intraformational conglomerate with dove-coloured pebbles occurs in the middle of the bed..........	1	8	12	9
	Tetradium cellulosum.				
	Base of Lowville				
	Top of Pamelia				
7	Shaly parting..........	......	1	11	1
6	Pure, fine-grained, dull greyish green, smooth-breaking limestone. Pyrite appears on its joint faces. Weathers a rusty colour..........	3	11	11	0
	Lingula sp. ind.				
5	Shaly limestone..........	......	5	7	1
4	Fine-grained, dull, greyish green limestone. Smooth breaking. Rusty weathering. Analyses have shown a high magnesian content..........	1	7	6	8
3	Light grey, shaly limestone, breaking with conchoidal fractures	1	4	5	1
2	Well-stratified, impure limestone..........	......	5	3	9
1	Light grey, crumbly, shaly limestone..........	3	4	3	4
	Base of Section				

The crumbly, shaly character of some of the limestone and the dolomitic nature of other limestones in the lower part of this section (beds 1 to 7) show that these strata are closely allied to the Pamelia formation described by Miss Wilson as occurring in the vicinity of Ottawa (1932a, pp. 136-137). The sandy layers she mentions, however, are not present here. Dr. Raymond's statement that the Pamelia does not extend eastward beyond L'Orignal must be modified in the light of the presence of the formation in this quarry.

The boundary between the Pamelia and the succeeding Lowville is not an unconformity. However, the lithologic change is very apparent. The line between the Lowville and the Pamelia has been arbitrarily placed on top of shaly layer, bed 7.

Though the " Birdseye " effect is not apparent in the succeeding, alternating, thick- and thin-bedded limestones, other characteristics definitely ascribe them to the Lowville formation. Intercalations of dove-weathering, oolitic limestone between layers of shaly limestone, and the presence of *Tetradium cellulosum* found as high as bed 21, were the data relied upon in the identification of the beds of this formation. The presence of cherty plates and the buff-weathering, sandy layers in bed 22, definitely indicate that it is a member of the Leray. The boundary between the Lowville and the Leray is fixed, therefore, between these two beds.

ST. VINCENT DE PAUL QUARRY

This quarry is situated on Ile Jesu, about 8 miles northeast of Pont Viau and approximately 3 miles west of the village of St. Vincent de Paul. The quarry is owned by the Montreal Construction Company, and at present is not used. The total thickness of the strata exposed here is approximately 88 feet, but the strata referable to the Black River make up only 46 feet. In order to obtain a complete section from the lowest to the highest stratum of the entire section it was necessary to make five subsections at various points within the quarry. Two dark-coloured beds which form prominent horizon markers throughout the quarry were of great aid in building up the section in the field. These will be designated here as the lower, and upper, black bands.

The formations with their calculated thicknesses are listed below:

	Feet	Inches
Trenton..	6	6
Leray..	23	6
Lowville..	13	4
Pamelia..	9	5
Upper Chazy..	35	9
Total..	80	6

Bed Nos.	Top of Section	Thickness: Individual Ft.	In.	Thickness: Cumulative Ft.	In.
	Top of Section				
58	Coarsely crystalline, sandy, or fragmental limestone, brown weathering..	6	6	88	6
	Base of Trenton				
	Top of Leray				
57	Massive. grey limestone containing fragments of gasteropods....	1	0	82	0
56	Massive, grey limestone with gasteropods......................	2	6	81	0
55	Grey, richly fossiliferous limestone. Curved and coiled cephalopods...	......	2	78	6
54	Fine-grained, grey, dove-weathering limestone with fragments of fossils and occasional plates of chert.................... *Columnaria halli, Cycloceras decrescens, Spyroceras cylindricum.*	1	6	78	4
53	Fine-grained, black limestone with conchoidal fracture..........	......	8	76	10
	Intrusive Trap Sill				
52	Several thin beds of fine-grained, dark limestone, similar to bed 53.. *Hormotoma gracilis, H. subangulata, H. wilsoni, Liospira larvata?, L.* cf. *micula, L.* cf. *vitruvia, Lophospira bicincta, L.* cf. *oweni, Helicotoma* sp., *Cycloceras* cf. *decrescens*, curved and coiled cephalopods.	4	2	76	2
51	Dark grey, light-weathering limestone containing an abundance of chert nodules and plates arranged in layers. Fossils mostly restricted to its upper weathered surface............ *Columnaria halli, Streptelasma profundum, Hormotoma gracilis, H. wilsoni, Isotelus gigas.*	3	11	72	0

Bed Nos.	Top of Section	Thickness			
		Individual		Cumulative	
		Ft.	In.	Ft.	In.
50	Sandy, fossiliferous limestone	......	2	68	1
	Streptelasma profundum, Pionodema sinuata, Rafinesquina alternata, R. grandis, Strophomena incurvata, Actinoceras billingsi, Isotelus gigas, trilobite fragments.				
49	Dark grey, sparsely fossiliferous limestone	......	4	67	11
	Columnaria halli, Rhynchotrema increbescens, Strophomena sp.				
48	Sandy, light-weathering limestone	......	4	67	7
47	Dark grey, light-weathering limestone	......	4	67	3
	Hebertella sp., *Pionodema sinuata, Rafinesquina alternata, R. grandis, R. minnesotensis, R. williamsi, Strophomena incurvata, S. corrugata, S. emaciata, S. irregularis, Rhynchotrema increbescens, Actinoceras billingsi,* trilobite fragments.				
46	Sandy, well-stratified limestone	......	6	66	11
45	Dark grey, light-weathering limestone	......	9	66	5
	Columnaria halli, Rafinesquina alternata, R. minnesotensis, R. wagneri, Actinoceras billingsi, Gonioceras anceps.				
44	Dark grey, light-weathering limestone	1	9	65	8
	Streptelasma corniculum?, S. profundum, Columnaria halli, Stromatocerium canadense, Dinorthis sp., *Strophomena incurvata, Rhynchotrema increbescens, Lophospira bicincta, Phragmolites* sp., *Gonioceras anceps, Ormoceras* sp., *Sactoceras josephianum, Ceraurus pleurexanthemus,* crinoid stems.				
43	Pure, fine-grained, grey limestone	1	7	63	11
	Columnaria halli, Streptelasma profundum, Rafinesquina minnesotensis, R. wagneri, Hormotoma gracilis.				
42	Pure, fine-grained, dark-weathering limestone	1	8	62	4
	Streptelasma corniculum?, worm tubes.				
41	Shaly bed, sandy towards the base	......	8	60	8
	Rhynchotrema increbescens, bryozoa.				
40	Shaly bed with bryozoa and trilobite fragments	......	2	60	0
39	Dark-coloured, light-weathering limestone	1	4	59	10
	Columnaria halli, trilobite fragments, worm tubes.				
	Base of Leray				
	Top of Lowville				
38	(Upper black band) Rubbly fossiliferous limestone	......	9	58	6
	Streptelasma corniculum, Tetradium cellulosum, Rafinesquina minnesotensis, Strophomena incurvata, Zygospira sp.				
37	Shale and shaly limestone	......	2	57	9
	Rhynchotrema increbescens, Ormoceras sp., *Sactoceras* cf. *josephianum,* bryozoa.				
36	Grey limestone		4	57	7
	Strophomena incurvata, Zygospira sp.				
35	Shaly parting with bryozoans	......	......	......	......
34	Well-stratified, oolitic limestone	......	3	57	03
33	Shaly parting	......	......	......	......
32	Unstratified limestone with shaly partings	1	3	56	11
	Tetradium cellulosum, trilobite fragments.				
31	Brown-weathering, rubbly limestone	......	2	55	8

Bed Nos.	Top of Section	Thickness Individual Ft.	In.	Thickness Cumulative Ft.	In.
30	Rubbly weathering limestone becoming shaly towards the top of the bed......... *Tetradium fibratum.*	.....	6	55	6
29	Dark, fossiliferous limestone.........	.....	5	55	0
28	Dark, fossiliferous limestone......... *Tetradium cellulosum, T. fibratum, Sactoceras* cf. *josephianum.*	1	0	54	6
27	(Lower black band) Upper 4 inches composed of shale, lower part, of shaly limestone......... *Tetradium clarki, T. fibratum, Cameroceras* cf. *multicameratum, Cycloceras decrescens*, bryozoans.	.....	10	53	6
26	Fine-grained, grey-weathering, typical "Birdseye" limestone.... *Tetradium cellulosum*, trilobite fragments.	1	4	52	8
25	Rubbly weathering limestone.........	.....	5	51	4
24	Unstratified, oolitic limestone......... *Tetradium cellulosum, Zygospira* sp.	.....	7	50	11
23	Sandy limestone.........	.....	3	50	4
22	Shaly parting.........	.....	1	50	1
21	Fine-grained, well-stratified, oolitic limestone with shaly partings.........	3	2	50	0
20	Shaly parting.........	.....	.....	.....	.....
19	Fine-grained, oolitic limestone.........	.....	5	46	10
18	Fine-grained, oolitic limestone.........	.....	1	46	5
17	Fine-grained, oolitic, crystalline limestone.........	.....	7	46	3
16	Fine-grained, fossiliferous limestone with shaly parting in the middle of the bed. Typical "Birdseye" limestone....... *Bathyurus extans?*	.....	6	45	8
	Base of Lowville				
	Top of Pamelia				
15	Fine-grained, brown-weathering, dolomitic limestone.........	1	0	45	2
14	Shaly bed with green, shaly partings.........	.....	2	44	2
13	Fine-grained, sandy limestone with many thin partings of green shale.........	.....	7	44	0
12	Fine-grained, sandy dolomite with intraformational conglomerate in the middle. Analyses show high magnesium content.........	1	0	43	5
11	Greenish grey, blocky weathering shale with no apparent stratification.........	1	8	42	5
10	Shaly bed.........	.....	9	40	9
9	Well-stratified, blocky weathering, cherty shale. Similar to bed 7.........	.....	6	40	0
8	Shaly bed.........	1	6	39	6
7	Sandy, magnesian limestone weathering into red-coloured blocks a few inches thick.........	2	3	38	0
	Base of Pamelia				
	Top of Chazy				
6	Black, shaly bed.........	1	0	35	9
5	Shaly sandstone.........	1	0	34	9
4	Shaly bed, hard and fossiliferous.........	.....	5	33	9
3	Sandy limestone. *Camarotoechia plena*.........	1	4	33	4
2	Alternating shale and limestone containing *Camarotoechia*......	2	0	32	0
1	Typical, upper Chazy limestone.........	30	0	30	0
	Base of Section				

The Chazy-Pamelia boundary was placed at a disconformity existing between beds 6 and 7. *Camarotoechia,* an index fossil for the Chazy, does not occur above 3, but the overlying, unfossiliferous, shaly, and sandy material up to the contact is closely similar to known Chazy and bears little resemblance to the Pamelia above.

The Pamelia here is similar to the Pamelia of Ottawa valley (Wilson, 1932, pages 137-139). The formation includes the beds 7 to 15, and is made up of buff-weathering, heavy-bedded, dolomitic limestone and thin-bedded, sandy shale. Bed 16, a typical "Birdseye" layer, is definitely Lowville. The Pamelia-Lowville boundary is, therefore, placed between beds 15 and 16. There is no evidence of an unconformity between these two layers.

The Lowville is well developed here. It consists of thick- and thin-bedded, dove-coloured, oolitic limestone, separated by thin, shaly layers. The "Birdseye" type of limestone is common. The formation is very fossiliferous, but the specimens in the more massive beds are so fragmentary that they are useless for palæontological study. Most of the fauna was collected from the shaly layers and the rubbly weathering limestone.

The Lowville-Leray boundary was placed just above bed 38, the "upper black band"; this is the uppermost stratum in which occurs *Tetradium cellulosum,* the index fossil of the Lowville. The succeeding dark-coloured, light-weathering, generally massive beds are members of the Leray formation. The presence of chert-plates and nodules in its upper members, and the cup corals, *Columnaria,* and distinctive gasteropods and cephalopods, show it to be closely similar to the Leray at typical exposures along the Black River in New York state. Bed 52 is made up of several thin layers; this gives it a Trenton aspect, but the thin bedding is probably fracturing caused by the injection of a sill just above. Beds above the sill are identical both lithologically and palæontologically with those below it, and are typically Leray.

The boundary between the Leray and the Trenton is placed between beds 57 and 58, where the massive, dark, light-weathering, and fine-grained, Leray limestone gives way to a coarsely crystalline, sandy, brownish limestone with fragments of numerous Trenton species.

GENERAL OBSERVATIONS

PAMELIA FORMATION

Dr. Raymond stated (1912) that the Pamelia thinned out eastward from Ottawa, not extending beyond L'Orignal, and that at Montreal and vicinity the Lowville rested directly on the Upper Chazy. The present work, however, shows that at St. Vincent de Paul, where both the Lowville and the Chazy are exposed, there are, between the uppermost typical Chazy, characterized by *Camarotoechia,* and the lowest Lowville, with *Tetradium cellulosum,* 9 feet 6 inches of yellow-weathering, dolomitic limestone interstratified with shaly limestone. The lithology of these beds corresponds exactly with the description of Pamelia of Ottawa valley, and it is here considered that they represent the thin edge of the Pamelia. Farther west identical beds were discovered at Pointe Claire, in the Devito quarry, where they also underlie the lowest Lowville.

No evidence of erosion was noticed on the upper surface of the Pamelia, which indicates that a complete section of the formation is exposed. Near Ottawa the thickness is somewhat more than 65 feet, near Montreal it is only about 10 feet. The presence of shaly bands indicates that this formation was deposited in a shallow eastward extension of the Pamelia Sea, which in all probability did not extend much farther east than Montreal.

The thinning of the beds eastward indicates that the deposits in the Pamelia Sea overlapped from the west, whereas those of the Chazy Sea suggest an advance from the southeast. There seems to have been no connexion between the two seas. This conclusion is borne out by the study of the fauna of the Pamelia, which shows close relationship with that of the Lowville, whereas it is totally different from that of the Chazy. It is, therefore, suggested that the Chazy Sea invaded Quebec and Ontario around the north flank of the Adirondack mass, from the present position of lake Champlain, extending as far westward as the Frontenac axis. At the close of the Chazy time, because of the tilting or warping of this part of the continent, the sea became shallow and finally withdrew to the southeast. During its last stages thick, shaly beds were deposited near Montreal, replete with large *Camarotoechias*. Almost immediately, for practically no evidence of erosion can be noticed, a reverse tilt allowed the Pamelia Sea to advance from the west and to extend at least as far as the island of Montreal. An entirely new fauna similar to that of the Black River inhabited this sea farther west, although the local Pamelia is practically barren of fossils. The water was shallow with a fluctuating shore-line. Beds of dolomitic limestone were deposited, interstratified with shaly limestone. In Lowville times the sea deepened and conditions changed sufficiently to stop further deposition of dolomitic limestone, but not sufficiently to alter entirely the characteristics of animals inhabiting it.

In the St. Vincent de Paul quarry the uppermost thin and sandy Chazy beds containing *Camarotoechia* are separated from the typical Pamelia by a foot or so of shaly material within which the boundary between the two formations is to be found. The erosional disconformity is masked over the greater part of the contact by the shaly nature of the upper Chazy, but the sand in the lowest Pamelia is an additional indication of its presence. The dolomitic limestone is followed by sandy layers interbedded with a few thin layers of limestone with shaly partings. These gradually give place to dark, impure, shaly beds and heavy, dolomitic layers. In most instances the shaly, as well as the dolomitic, beds, weather rusty because of the presence of abundant pyrite. The presence of the pyrite, and some black, carbonaceous shale, indicates a muddy sea in which organic decay was prevalent. Benthonic life could not have been prolific in such an environment. The almost total absence of fossils throughout the formation bears out this conclusion.

An intraformational conglomerate in bed 12, St. Vincent de Paul quarry, in the middle of the Pamelia, indicates that deposition was not continuous. Since it is essentially a shallow-water deposit slight oscillations of level might bring about emergence.

The Pamelia-Lowville contact is very definite, but there was apparently no cessation of deposition. The boundary has been placed at the top of the last brown-weathering, dolomitic layer, the succeeding Lowville member being grey, dense, typical "Birdseye" limestone with scattered fragments of fossils.

LOWVILLE FORMATION

The Lowville in this locality is made up of thick and thin beds of fine-grained or oolitic limestone, weathering dove-grey. Between these layers are many dark, shaly partings. The limestone is full of fossils, which are too fragmentary to permit complete identification, in most cases showing only on slightly weathered surfaces. Better-preserved specimens are found in the shaly partings. The presence of *Phytopsis tubulosum* gives the characteristic "Birdseye" effect to many of the beds.

The determination of the Lowville-Pamelia boundary is made fairly easy by the marked difference in lithology of the two formations. Such, however, is not the case with the Lowville-Leray contact. The change from the grey, thin-bedded limestone of the Lowville to the darker and thicker bedded Leray limestone is generally obvious, but can not be seen everywhere. For this reason all beds containing *Tetradium cellulosum* are considered to belong to the Lowville and those beds above them that are distinctly of the Lowville lithological type. The thickness of the Lowville in this region is about 16 feet. Near Ottawa it is 30 feet thick. Like the Pamelia it thins eastward.

LERAY FORMATION

As mentioned above, the Lowville-Leray boundary is not sharp, and some doubt may exist (within a foot or two) as to where the line should be drawn. The Leray-Trenton contact is more definite both lithologically and palæontologically. In the St. Vincent de Paul quarry the lowest Trenton beds are dark, sandy, and coarsely crystalline, so differ materially from the dense, light-weathering Leray. The thickness of the Leray varies from 21 feet at Pointe Claire to 23 feet 6 inches at St. Vincent de Paul. Raymond reports a maximum thickness of 40 feet in the vicinity of Ottawa. It is apparent, then, that this formation thins eastward toward Montreal.

The formation is made up of thick beds of dark, dense, light-weathering limestone. It contains numerous fossils in a fair state of preservation. The distinctive features of the Leray are nodules and plates of black chert, and irregularly horizontal, brownish, sandy layers in the massive limestone beds. It is believed by the author that the chert is epigenetic as it usually is found in connexion with fractures in the limestone, hence was probably deposited by underground waters.

The characteristic fossils of the Leray are such cephalopods as *Actinoceras billingsi* and *Gonioceras anceps,* the brachiopods *Hesperorthis tricenaria, Pionodema, Strophomenidae,* and an assemblage of gasteropods including *Hormotoma gracilis, Liospira,* and *Helicotoma.*

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