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MEMOIR 83

No. 70, GEOLOGICAL SERIES

Upper Ordovician Formations in Ontario and Quebec

RY A. F. Foerste



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CONTENTS.

	PAGE
Preface	iv

CHAPTER I.

Upper Ordovician of New York state	1
Nomenclature	1
Fauna	5
Utica	5
Lorraine	6
A provisional terminology for the New York upper Ordovician	
strata	12

CHAPTER II.

The	Lorraine and underlying formations in Ontario and Quebec	14
	Quebec and Eastern Ontario	14
	Nicolet River section	14
	Chambiy Canton	41
	Mouth of the Rivière des Hurons	43
	St. Hilaire	45
	Petite Caroline	48
	St. Hugues or Yamaska river	50
	St. Hyacinthe	53
	Breault, on Bécancour river	56
	St. Augustin, southwest of Quebec.	57
	Montmorency fails	58
	Relative stratigraphic position of some of the Quebec Province horizons	59
	Navan	62
	Vars	62
	Hawthorne	65
	Ramsay station	66
	Concluding remarks.	67
	Western Ontario	67
	Between Georgian bay and Lake Ontario	71
	Toronto	71
	Weston	74
	Relative stratigraphic position of certain Lorraine exposures in southern Ontario	76
	Workman brook, southeast of Meaford.	78

	FAUE
Manitoulin island	82
South of Clay cliff	82
Sheguiandah road, 3 miles south of Little Current	85
Bass Lake road, south of Little Current	89
Indian village, southwest of Little Current	91
Tamarack point	91
Gorrel point, northeast of Gore bay	91
General observations on the Lorraine of Ontario and Quebec	93

CHAPTER III.

Richmond formation in Ontario and Quebec	96
Waynesville and Whitewater	96
Western Ontario	97
Manitoulin island	97
Northwest of Kagawong 31 miles	105
Northwest of Kagawong 11 miles	106
Southwest of Kagawong on Gore Bay road	107
South of Kagawong	108
Kagawong falls	109
South end of Kagawong	110
Northeast of Gore bay	111
South end of Gore bay	111
West side of Gore bay	112
Northeast of Gore bay	112
Norinwest of Gore bay	113
South of Honora	114
Road west of Indian village southwest of Little Current	115
Crossroad southwest of Little Current	116
Bass Lake road, south from Little Current	118
Northwest of Manitowaning	120
Southeast of Manitowaning	122
Southwest of Wekwemikong	123
Northwest of Wekwemikong	124
Clay cliff	124
General remarks on the Richmond of Manitoulin island	126
Between Georgian bay and Lake Ontario	127
Workman brook, southeast of Meaford	127
South of Mountain lake, northwest of Meaford	128
Cape Rich road, north of Meaford	129
Oakville	130
Streetsville	132
Concluding remarks	136
Eastern Ontario and Quebec	138
Vars	138
Edwards station	140

ü

	iii
	PAGE
General observations on the upper Richmond of Vars and	
Edwards station	140
Nicolet River section	141
Rivière des Hurons, 4 miles northeast of Chambly basin	150
St. Hilaire	152
St. Hugues	155
Snake island, Lake St. John	155
Anticosti element in the Richmond fauna	159
Queenston formation	162
Western Ontario	162
Between Georgian bay and Lake Ontario	162
Oakville	162
Northwest of Meaford	164
Correlation of Queenston strata with upper Richmond	
strata on Manitoulin island	168
Eastern Ontario and Quebec	172
Vars	172
Nicolet River section	173
General remarks on Queenston shale	174

CHAPTER IV.

Distribution and range of species	
Table of geographical distribution and geological range of species	178
List of localities	266
Index	271

ILLUSTRATIONS.

1.	Portion of Quebec, showing fossil localities	15
2.	Sketch map of the east bank of the Nicolet river between 2	
	and 4 miles southwest of Ste. Monique, showing rock	
	exposures	16
3.	Yamaska river, southwest shore near St. Hugues, Quebec	52
4.	Plan of river bed below dam at St. Hyacinthe, Quebec	54
5.	Portion of eastern Ontario showing fossil localities	63
6.	Portion of western Ontario showing fossil localities	72
7.	Portion of Manitoulin island showing fossil localities	83
8.	Diagram illustrating supposed equivalence of the Queenston	
	formation of Meaford with the Upper Richmond (White-	
	water and Saluda) formations on Manitoulin island	169
	1. 2. 3. 4. 5. 6. 7. 8.	 Portion of Quebec, showing fossil localities



PREFACE.

The provinces of Ontario and Quebec offer a fertile field for geological investigation. The problems involved often are of more than local interest. Their solution would be welcomed not only by the geologists of Canada, but also by those of the neighbouring states on the south.

One of these problems is the geological history of the later Ordovician strata in Ontario and Quebec. This problem involves not only the unravelling of the order of succession of these strata, and their correlation with formations elsewhere, but also the determination of the conditions under which these strata were deposited, the source of the faunas which inhabited the seas at the time of their deposition, and the direction of migration of these faunas.

All of these lines of investigation have received attention, and to give due credit to the numerous investigators would require a voluminous bibliography. Billings, Whiteaves, Nicholson, and Ami have made many contributions to our knowledge of the fossils. Logan, Bell, Ells, and Low made valuable contributions to our knowledge of the stratigraphy. Grabau has given special attention to the conditions under which the sediments were deposited, while Ulrich and Schuchert have followed the lines of migration of the faunas. The investigations recorded on the following pages, therefore, are merely an attempt to seek additional information which might serve in the future solution of the problems involved.

•

as by Nickles. At the time this pamphlet was published, the Cincinnatian rocks were divided into three major divisions. In descending order, these were:

> Richmond group. Lorraine group. Utica group.

The first name, Richmond, did not involve any comparison with New York formations. The second and third names, Lorraine and Utica, were expressions of an opinion that the middle and lower parts of the Cincinnatian measures, as here defined, could be correlated with certain well-known New York strata, whose faunas were described in the "Palæontology of New York."

To the writer, this correlation never appeared very obvious. The very abundant fauna of the lower and middle parts of the Cincinnatian section of the Ohio valley is but scantily represented in New York state, while the characteristic Utica and Lorraine faunas of New York find representatives in the Cincinnatian areas at only a few narrow horizons. The two faunas appear to have been deposited in two basins, which most of the time must have been quite distinct. For this reason it was deemed inadvisable to retain the New York names for the Cincinnatian groups. Therefore Orton's name, Eden, was revived for the lower group, and the name Maysville¹ was proposed for the middle group, as typically exposed in Ohio, Indiana, and Kentucky.

However, if the New York and Ohio later Ordovician formations be regarded as having been deposited in distinct basins, it becomes a matter of interest to determine to which of these two basins the later Ordovician deposits along the northwestern shores of Lake Ontario belong. These deposits evidently occupy an intermediate position, geographically, between the Lorraine and Utica areas, east of Lake Ontario, in New York, and the Richmond, Maysville, and Eden areas in Ohio, Indiana, and Kentucky.

Moreover, the labours of Ulrich demonstrate that the Richmond of the Mississippi valley and thence westward contain faunal elements quite distinct from the typical Richmond of the Ohio River valley. It becomes a matter of interest, therefore, to trace the boundaries between the Ohio and the Mississippi

¹ Science, Vol. XX11, p. 149, 1905.

basins during Richmond time. This interest is increased by the fact that the western Richmond is known to extend as far east as Lake Michigan, on the eastern border of Wisconsin, the northeastern part of Illinois, and also as far as the southwestern corner of the same state, along the Mississippi, while the Ohio Richmond extends westward across half the width of the state of Indiana, along its southern boundary. Is it the Ohio or the Mississippi type of Richmond which occurs on Manitoulin and Drummond islands, and on the southern shores of Georgian bay? To which type of Richmond do the deposits along the southern shores of Georgian bay, and west of Toronto belong?

Again, ever since the investigations on the Anticosti fauna by Billings it was known that Richmond strata occurred on Anticosti, and it was regarded as practically certain that Richmond faunas existed also on Snake island in Lake St. John. Can any considerable portion of the Anticosti type of Richmond be traced to Snake island, or even farther westward?

The St. Lawrence valley has long bee', known to contain numerous exposures of strata apparently referable to the Utica and Lorraine of New York. At the western extremity of these later Ordovician areas, a short distance east of Ottawa, the exposures are only about 115 miles distant from the Lorraine gorge in New York. To what extent do the Lorraine and Utica elements of the New York faunas dominate in the apparently corresponding strata along the St. Lawrence valley?

These are some of the problems awaiting solution. It will be more conducive to a proper understanding of the following pages, however, to state that the writer, in his field work, attempted as much as possible to confine himself to a study of the distribution of the Richmond strata, and the order of succession of their faunas. All observations on the underlying Lorraine faunas were made merely while seeking outcrops of Richmond strata. The territory covered was so large that concentration on the Richmond part of the problem was considered desirable.

The field work was in the nature of a reconnaissance. It was desired to locate those territories which would promise the best results when the later detailed investigations were undertaken. It must be evident, therefore, that the following pages are to be regarded as merely preliminary to further study.

It should be emphasized that in these pages it is attempted merely to indicate to what extent it is possible to discover the elements of the Lorraine faunas of New York and of the Cincinnatian faunas of Ohio, Indiana, and Kentucky in the upper Ordovician sections of Ontario and Quebec. It is not attempted a the present state of our knowledge to impose either the New York or the Cincinnatian names of divisions and subdivisions of upper Ordovician strata on Canadian geology, but merely to state to what extent progress in correlation of the various strata in these different states and provinces has been made and where the uncertainties still lie.

The writer is under great obligations to Mr. R. W. Brock for enabling him to carry on these investigations under the auspices of the Canadian Geological Survey. It was with his encouragement that these investigations were begun, and it is hoped that they may prove of some service even in the preliminary stages of the work. The writer is also under great obligations to Dr. Ulrich and Dr. Bassler who have always placed their extensive knowledge of American Palæozoic rocks at the writer's disposal. He is also under obligations to Miss A. E. Wilson for the laborious work in preparing the fossil lists at the end of this report.

viii

Upper Ordovician Formations of Ontario and Quebec.

'HAPTER I.

UPPER ORDOVICIAN OF NEW YORK STATE.

NOMENCLATURE.

The state of New York was a pioneer in the classification of Palæozoic strata into divisions and subdivisions, in the development of a nomenclature adequate to indicate the various degrees of division, and in the publication of a sufficient number of illustrations of fossils to make possible the ready identification of each of these divisions. The result is that the classification of Palæozoic strata proposed for the state of New York became a standard for all other states, and was adopted also in Canada.

It cannot be said, however, that in the naming of the various subdivisions the claims of priority were adhered to slavishly. This was shown, for instance, in the discarding of the term Salmon River, proposed by Conrad in 1839. This term included about the same series of strata as that for which the name Hudson River was long used in New York geology. In the Annual Report of the Geological Survey of New York for 1838, Conrad recognized the following divisions:

Saliferous rock of Eaton (including the Medina red sandstone).

Olive sandstone and slate cut through by Salmon river in Oswego county.

Black limestone and shale of Trenton falls, embracing the Birdseye and Calciferous sandrock of Eaton.

In the Annual Report for 1839, Conrad used for these divisions the following terms:

Niagara sandstone, red (including the Medina).

Salmon River sandstone, olive.

Trenton group, including Trenton limestone and slate; Mohawk limestone; Grey limestone and sparry veins; Grey calcareous sandstone. The following fossils were listed from the Salmon River sandstone:

Pterinea carinata (= Byssonychia radiata) Pterinea planulata (= Clidophorus planulatus) Pterinea modiolaris (= Modiolopsis modiolaris) Cyrtolites ornatus

The same classification of the strata was used by Conrad in the Annual Report for 1840.

Anyone familiar with New York stratigraphy will recognize the fact that Conrad applied the term Salmon River to the s' ata later included by Hall in the Hudson River group. In describing *Cyclonema bilix*, from Richmond, Indiana, he gives its horizon as limestone of the age of the rocks of the Salmon River series, New York.

None of the other geologists followed Conrad in his use of the term Salmon River. Vanuxem, in the Annual Report for 1840, employed the term in a very different sense, or at least with a very restricted application. This is shown by the following classification:

Medina sandstone (called red sandstone of Oswego in the Annual Report for 1839).

Salmon River sandstone (including only the practically untossiliferous sandstone forming the falls of the Salmon river, and corresponding strata elsewhere).

Pulaski shales (shales of Salmon river of former reports).

Frankfort slate.

Black slate or shale (later called Utica by Emmons).

Trenton limestone.

Birdseye limestone.

Mohawk limestone.

In this classification the name Salmon River was retained for that part of Conrad's section in which, as a palæontologist, he was least interested, and all the fossiliferous part of the Salmon River section was used to form the new division, the *Pulaski* shales. This was done notwithstanding the fact that Conrad based the adoption of the name Salmon River upon the presence of a distinct fauna which he himself began to describe, and which Vanuem was obliged to name in order to designate what was meant by the term *Pulaski*. Pulaski was the largest village on the Salmon river.

25

The term *Frankfori* was applied to strata exposed in the Trenton Falls be n, so far to the east of the sections along the Salmon river, that it is not known yet whether any representative of the true Frankfort shale occurs as far west as Oswego and Jefferson counties. That Vanuxem had no clear knowledge as to where to draw the line between the Frankfort and the Pulaski shales is shown by his reference of Whitall's quarry, near Rome, to the Frankfort.

In the final report, published in 1842, Vanuxem adopted the following terminology:

Medina. Grey sandstone of Oswego. Hudson River group. Pulaski. Frankfort. Utica. Trenton.

In this list it will be noticed that he used the term Grey sandstone of Oswego, in place of Salmon River sandstone of his 1840 report, ignoring his own use of the term Red sandstone of Oswego for an entirely different formation in 1839. The term Hudson River group was made to include both the Pulaski and the Frankfort shales, but omitting the Grey sandstone of Oswego, which was placed above the Hudson River. This application of the term Hudson River to strata in western New York has proved most unfortunate since the type localities of the true Hudson River group, along the liudson river, in eastern New York, belong not only to an entirely different basin of deposition, but to a much lower horizon, the pical Hudson River group consisting almost entirely of Trenton shales, and, therefore, lying below, rather than above the Utica shale. Whatever may be considered the value of the term Hudson River, when applied to Trenton strata in the type areas, along the Hudson river, there can be no hesitancy in declaring the term improper for the upper Ordovician strata in the more western arca, east of Lake Ontario, which belong to a much higher horizon. The name Utica, for the black shale overlying the Trenton, was adopted in 1842 both by Vanuxem and Emmons. In that part of the final report, published in 1842 by Emmons, the following classification was adopted:

> Grey sandstone. Lorraine shales. Utica slate. Trenton limestone.

In this list the term *Lorraine* was adopted in place of Pulaski shales because at Lorraine, in addition to the Pulaski shales, are seen those lower strata which are not exposed at Pulaski. He evidently included under this term all of the strata ranging from the base of the unfossiliferous grey sandstone section, at Salmon River falls, and at corresponding horizons elsewhere, down to the top of the Utica slate, as exposed in the Lorraine gorge. In this sense, the term Lorraine has the same significance as the term Hudson River, as incorrectly applied by Vanuxem to upper Ordovician strata in the areas adjacent to Lake Ontario. Hence the term Lorraine should replace the term Hudson River as formerly applied incorrectly to strata above the Utica, in western New York.

The true significance of the term Hudson River was not fully appreciated until Dr. Rudolf Ruedemann published his studies on the "Lower Siluric Shales of the Mohawk Valley," in 1912. Then it became evident that three basins of deposition may be recognized in that part of New York crossed by this valley. In the eastern basin along the Hudson river no strata above the lower Trenton have been recognized. In the middle basin, extending westward from the vicinity of the Hudson river, the great mass of shales all belongs to the Trenton, with the exception of the comparatively insignificant mass called by Ruedemann, the Indian Ladder shale. The latter possibly might be correlated with the strata exposed in the lower part of the gorge at Lorraine, but these beds certainly never were intended to serve as typical representatives of the Hudson River group by those who brought this name into prominence. In fact, the term Hudson River can have no significance except for strata comparable with those found in the vicinity of the Hudson river, and these are of Trenton, or even earlier age. As a term for

upper Ordovician strata overlying the Utica, the name Hudson River is entirely inappropriate, and no excuse exists for its further retention with that significance.

FAUNA.

UTICA.

The Utica of New York is more restricted in its distribution than formerly supposed. According to Dr. Ruedemann it does not enter the Schenectady and Levis basins in the eastern parts of that state. Nevertheless the Utica fauna may be regarded as an Atlantic invasion, the location of the channel admitting this invasion being still unknown.

The typical Utica of New York includes the following characteristic species:

 Climacograptus typicalis.
 Mastigograptus simplex.

 Dicranograptus nicholsoni.
 Mastigograptus tenuiramosus.

 Glossograptus quadrimucronatus short, long-spined variety.
 Pleurograptus linearis.

 Leptograptus annectans.
 Cyathophycus reticulatum.

The following species are rare in the underlying Canajoharie (Trenton) shale, but become dominant forms in the Utica:

Climacograptus putillus. Lasiograptus eucharis. Triarthrus becki.

The following species are equally common in both shales:

Leptobolus insignis. Lingula curta.

2

Fissile black shales, lithologically identical with the typical Utica of New York, are widely distributed in Canada. They occur along the channel north of Manitoulin island, in Lake Huron, and thence southeastward to the southern shores of Georgian bay. East of Toronto, at Whitby, they are exposed along the northern shores of Lake Ontario. Numerous exposures occur in the vicinity of Ottawa and thence eastward. Along the St. Lawrence valley they occur northeastward as far as Beauport, east of Quebec. Northward, this fauna occurs as far as Lake St. John. On the island of Anticosti it is represented in the Macastey black shales.

In the lower part of these shales Ogygites canadensis is present. At higher elevations Triarthrus spinosus and Triarthrus glaber occur. The first two of these species are widely distributed in Canada. Their entire absence in the typical Utica of New York suggests deposition of the Canadian deposits in a different basin. Possibly, there is also a difference in age, the lower Canadian black shales being older than the typical Utica of New York. For the lower Canadian black shales, as exposed along Georgian bay, Prof. Raymond proposed the name Collingwood shales.

LORRAINE.

It is unfortunate that Conrad's term, Salmon River, was ignored and that the name Hudson River gained such wide currency in the geology not only of New York but also of many other states, and of Canada. It is unfortunate, also, that the term Lorraine has come into general use, since the palæontological labours of Conrad in reality established the first sound basis for the classification of New York rocks, and there was no doubt as to what strata he intended to have included under the term Salmon River. As a matter of fact, however, the term Lorraine has grown into general use and will be found not only in the geology of various parts of the United States but also in that of Canada. It, therefore, becomes important to determine just what the name Lorraine implies.

what the name containe implice. At the village of Lorraine, in Jefferson county, New York, the following fossils occur in the creek in the northeastern corner

of the village: Heterocrinus columnals. Glyptocrinus columnals. Cornulites of straight free type. Pholidops subtruncata. Dalmanella of testudinaria group. Glyptorthis crispata. Rafinesquina alternata, flat form.

Plectambonites sericeus. Catazyga erratica. Byssonychia radiata. Clidophorus planulatus. Colpomya faba-pusilla. Cuneamya scapha-brevior. Ctenodonta lorrainensis. Modiolopsis of concentrica group. Lyrodesma poststriatum. Archinacella pulaskiensis. Cyrtolites ornatus.

Hormotoma gracilis-sublaxa. Trinucleus concentricus. Calymene sp.

At a moderately higher horizon, 2 miles eastward, on the road to Worthville, the same species as in the preceding list are found, with the addition of

> Ischyrodonta curta Sinuites cancellata.

At a slightly higher horizon, at Worthville, the following are added to the list, still associated with *Trinucleus concentricus:*

> Rafinesquina nasuta. Modiolopsis modiolaris. Orthodesma nasutum.

At still higher horizons, east of Worthville, Ischyrodonta curta, associated with Modiolopsis modiolaris, and Orthodesma nasutum, becomes more common, and P-finesquina mucronata is added to the list.

Still higher horizons are exposed at the Bennett bridge, about a mile down stream from the Salmon River falls. Here the following species occur:

Rafinesquina alternata. Rafinesquina mucronata. (No Plectambonites or Dalmanella was noted.) Byssonychia radiata. Pholadomorpha pholadiformis. Orthodesma nasutum. Lyrodesma poststriatum. Archinacella pulaskiensis.

The highest fossiliferous strata occur within a short distance of the base of the Salmon River falls. Here the collowing species occur:

> Glyptocrinus columnals. Pholidops subtruncata. (Dalmanella and Plectambonites absent.) Rafinesquina mucronata. Rafinesquina alternata. Catazyga erratica. Byssonychia radiata.

Modiolopsis modiolaris. Pholadomorpha pholadiformis. Ischyrodonta curta. Clidophorus planulatus. Lyrodesma poststriatum. Cyrtolites ornatus. Isotelus sp. (No Trinucleus.)

7

To the preceding lists of fossils from the immediate vicinity of Lorraine and thence eastward as far as Worthville, where Trinucleus concentricus still is present, the following may be added from the "Paleontology of New York," Volume I:

Buthotrephis subnodosa, central parts of group.

Diplograptus peosta, olive or green slates of group. Lingula rectilateralis, soft argillaceous shales in lower part of group. Dalmanella centrilineata (young of common form belonging to testudinaria group in the higher parts of group, associated with

"Orthis testudinaria, Trinucleus, and crinoid columns").

Zygospira sp. (Atrypa increbescens = incorrect determination) shales of group.

Modiolopsis anodontoides, upper arenaceous part of the group. Cymatonota parallela, soft shaly parts of group. Orthoceras lamellosum.

In this list, Diplograptus peosta (pristis, pars), Lingula rectilateralis, and Zygospira sp., probably came from the lower shaly parts of the group, in the gulf northwest of the village. Dalmanella centrilineata probably came from the Trinucleus horizon within the northeastern edge ' the village. Modiolopsis . the higher lands in the imanodontoides may have come f mediate vicinity of the valage. Buthotrephis subnodosa, and Cymatonota parallela may have come from horizons a short distance below the level of the exposures within the limits of the village, since it is evident that Trinucleus was regarded by Hall as ranging into the higher parts of the group. As a matter of fact, Trinucleus, Dalmanella, and Plectambonites are unknown at present from the horizons in the upper part of the group as exposed from the vicinity of Bennett Bridge and thence eastward up the Salmon river to the great falls, nor are they known from equivalent exposures elsewhere in New York. It is evident that Hall used the expression, "higher parts of the group," so as to include also distinctly lower horizons than those exposed at the Bennett bridge.

During this ascent in the geological scale, from the creek within the limits of Lorraine village to the highest fossiliferous strata at the base of the Salmon River falls, no striking lithological changes are noted. The quantity of arenaceous material increases rather gradually, and this continues into the practically unfossiliferous sandstone section forming the Salmon River falls, so that there appears no lithological reason for regarding the Salmon River Falls sandstone as a distinct formation. It is merely the upper less fossiliferous part of the underlying Lorraine section. Moreover, no abrupt faunal change is noted anywhere. The disappearance of certain species and the introduction of others occur usually singly, so that no faunal break can be utilized in the discrimination of subdivisions of the Lorraine.

The Pulaski section, as exposed east of Pulaski, as far as the railway bridge, a mile east of town, corresponds to that part of the Lorraine section seen in the vicinity of Worthville and thence eastward for about a mile. The following species were found east of Pulaski:

Cornulites sp. Lingula sp. Schizocrania filosa. Dalmanella of testudinaria group. Plectambonites sericeus. Rafinesquina alternata. Rafinesquina nasuta. Rafinesquina mucronata. Cornulites sp. Byssonychia radiata. Colpomya faba-pusilla.

Modiolopsis modiolaris. Orthodesma pulaskiense. Cymatonota pholadis. Ischyrodonta curta. Clidophorus planulatus. Lyrodesma poststriatum. Cuneamya cl. elliptica. Archinacella pulaskiensis. Cyrtolites ornatus. Trinucleus concentricus. Calymene sp.

To this list of fossils from Pulaski, the following may be added from the "Paleontology of New York," Volume I:

> Buthotrephis subnodosa, central parts of group. Pterinea demissa, higher parts of group. Cymatonota parallela, soft shaly parts of group. Hormotoma gracilis-sublaxa, throughout the group. Clathro. pira subconica, central parts of group. Archinacella pulaskiensis, argillaceous and calcareous parts of group. Sinuites cancellata, rare in lower shaly parts, common in central parts. Trocholites planorbiformis, central parts.

Orthoceras coralliferum, shales and sandstones of group. Orthoceras lamellosum.

Ormoceras crebriseptum, shaly calcareous strata of group.

In this list the various references of the fossils to lower, middle, and higher parts of the group may be of little value, since in the immediate vicinity of Pulaski, from the railway bridge one mile east of town to the exposures a mile down stream west of town, the rocks dip westward at a rate only moderately less than the rate of fall of the stream, so that the total thickness of the section exposed is only moderate.

It is quite evident that the preceding lists of fossils from the vicinity of Lorraine, Worthville, Pulaski, Bennett Bridge, and the Salmon River falls, do not suggest the presence of a Richmond fauna within the Lorraine formation of New York, unless the occurrence of *Pholadomorpha pholadiformis* at the Bennett Bridge locality be regarded as sufficient to identify the upper part of the Lorraine as Richmond, even when unsupported by the presence of σ' ier fossils elsewhere regarded as typical of the Richmond. As will be noted later, strata closely resembling the Lorraine and containing *Pholadomorpha pholadiformis* immediately underlie the Waynesville division of the Richmond in both the provinces of Quebec and Ontario, and appear to correspond to strata in the Maysville formation.

The term Lorraine was proposed by Emmons because at Lorraine are exposed the lower strata not seen at Pulaski. These lower strata include those shales in the gulf northwest of the village which overlie the *Triarthrus becki* horizon^a at the base of the gulf, near its mouth. As far up as *Triarthrus becki* could be found, the shales at the bottom were identified by Emmons as Utica.

No detailed investigations of this lower part of the Lorraine section, within the gulf, were made by the writer. Some years ago, Doctors Ulrich and Ruedemann went the entire length of the gulf, quite an arduous undertaking, and came to the conclusion that the entire section, up to within a short distance of the level of Lorraine village, corresponded approximately to the *Eden* division of the Cincinnatian series of rocks. The overlying strata, however, including those from the level at Pulaski to the top of the fossiliferous zones at the Salmon River falls, appear to be later than any part of the Eden at Cincinnati and apparently correspond to Maysville strata. The uppermost horizens, containing *Pholadomorpha pholadiformis*, belong much higher than the Eden, but perhaps not sufficiently high to be included in the Richmond. This suggests the division of the Lorraine into at least two divisions, an upper and a lower one, the *lower* including the *Eden* part.

For the upper division the name Pulaski can be retained, but the lower, Eden, division cannot be identified with the Frankfort, now that the fossil content of the Frankfort has been worked out by Dr. Ruedemann.¹ The Frankfort shale, at its type locality, holds an impoverished Utica fauna with some Trenton elements retained which are not known in the Utica. Dr. Ruedemann lists from the typical Frankfort the following species:

Climacograptus typicalis. Prasopora sp. Lingula sp. Leptobolus insignis. Orbiculoidea tenuistriata. Dalmanella testudinaria mut. Dinorthis pectinella. Rhynchotrema inaequivaloe. Camarotoechia sp. Modiolopsis sp. Cf.Serpulites longissimus, Murchison. Orthoceras sp. Triarthrus becki. Trinucleus concentricus.

No strata containing Dinorthis pectinella, Rhynchotrema inaequivalve, or Camarotoechia have been found in the lower part of the Lorraine gulf. A form of Climacograptus having the thecae and growth of C. typicalis, but the dimensions of C. putillus, occurs in the black shales south of Allandale, a short distance west of the mouth of the Lorraine gulf, but these strata are referred to the Utica. The following fauna was collected here:

Climacograptus typicalis var. Glossograptus quadrimucronatuspostremus.

Mastigograptus cf. tenuiramosus. Cornulites sp., attached laterally. Schizocrania filosa. Leptobolus insignis. Zygospira sp. Orthoceras sp. Tríarthrus becki. Trinucleus concentricus.

Triarthrus becki, Trinucleus concentricus, and Glossograptus quadrimucronatus-postremus, range up the stream to the mouth of the gulf. The graptolites were determined by Dr. Ruedemann. No evidence of the presence of typical Frankfort shales has been secured so far, and, therefore, the correlation of any part of the shales in the Lorraine gulf section with the Frankfort is regarded as inadvisable. This leaves the Eden part of the Lor-

¹ The Lower Siluric Shales of the Mohawk valley, N.Y. State Bull. 162, pages 34-37.

raine section without a name. Even if the Frimefort beds be of later age than the Utica, this does not establish the age of the lower Lorraine shales as Frankfort. Moreover, until better evidence than any adduced so far is secured, the Frankfort may be regarded as above the Utica but below the typical Eden. Since Dr. Ruedemann intends to make a special study of the Lorraine of New York, the writer will leave the lower Lorraine division unnamed. At present, the typical Frankfort is unknown west of Rome, which is 45 miles distant from the nearest exposures of the strata immediately overlying the Utica in the area east of Lake Ontario.

A PROVISIONAL TERMINOLOGY FOR THE NEW YORK UPPER ORDOVICIAN STRATA.

According to the preceding observations it is not unlikely that the term Lorraine does not properly include the Frankfort, since typical Frankfort shales may not occur in the vicinity of the village of Lorraine. It certainly was not intended to include under this term the grey sandstone exposed at the Salmon River falls and at Oswego. It will be noted that Vanuxem in his final report, also excluded the "Grey sandstone of Oswego" from the Hudson River group, although recognizing its position below the Medina. However, the lithological change from the top of the fossiliferous part of the Lorraine into the overlying unfossiliferous sandstone is so gradual that there seems no good reason, at present known, for placing the sandstone in a different formation, although this sandstone might be regarded as an upper division of a single formation, also including the typical Lorraine. If the term Lorraine is to be retained, as a substitute for Salmon River, when the latter term is used in its original sense, it seems necessary to extend the significance of the term Lorraine upward at least sufficiently to include the "Grey sandstone of Oswego."

If the term Salmon River is not to be used in its original extended sense, then there is no reason why it should not be utilized in its restricted sense, as employed by Vanuxem in 1840. If the "Red sandstone of Oswego" represents a higher horizon than

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the "Grey sandstone of Oswego," then the latter term certainly does not have priority, and the term Oswego cannot supersede Salmon River as a designation for the unfossiliferous sandstones at the top of the Lorraine formation, as here extended. This gives the following classification for the New York rocks here under consideration:

> Medina. Lorraine....

Salmon River sandstone. Pulaski shales and sandstones. Lower Lorraine shales, unnamed (Near Eden of Cincinnatian). Unnamed group Frankfort. Utica.

Trenton.

In western New York, the Queens on red clay shales intervene between the Medina and the Lorraine; at various localities in Ontario and Quebec, the lower or Waynesville division of the Richmond intervenes between the Queenston and the Lorraine; and the Salmon River sandstone is absent, so that in Canada the succession becomes:

Pulaski.

Medina. Queenston

Whitewater and Saluda divisions of the Richmond.

Waynesville division of Richmond. Lorraine.....

Unnamed division (Near Eden of Cincinnatian).

Utica shale of New York. Collingwood. Trenton.

This classification retains objectionable features; but it represents an effort to preserve as much as possible the terms proposed by the early investigators of New York geology, without discarding the term Lorraine which has grown into such general use.

CHAPTER II.

THE LORRAINE AND UNDERLYING FORMATIONS IN ONTARIO AND QUEBEC.

QUEBEC AND EASTERN ONTARIO.

In attempting to trace Lorraine strata northward, into Canada, the supposed equivalents of the Pulaski division appear to have a wide distribution, far greater than in New York. Scattered exposures, of small area, occur at various localities

Scattered exposures, or sinch accer of ottain and second province of Ontario. east of Ottawa, as far east as Vars, in the province of Ontario. Exposures occur also at various localities east of Montreal, including Chambly Canton, and St. Hilaire. About halfway between Montreal and Quebec, Lorraine strata occur on the lower parts of the Nicolet and Bécancour rivers. Dr. Ami has identified Lorraine strata along the southern side of the St. Lawrence river, almost as far east as the city of Quebec, but these exposures have not been seen by the writer. Sufficient, however, is known to indicate a wide areal distribution of the Lorraine east of Ottawa and in the province of Quebec.

NICOLET RIVER SECTION.

The relations of these Lorraine strata to the overlying formations are shown best along the Nicolet river, about halfway between Montreal and Quebec, at a point about 2½ miles south of Ste. Monique station (Figures 1 and 2). Here the base of the Queenston red clay shales is underlaid by richly fossiliferous strata referred to the Waynesville division of the Richmond, and the latter are underlaid in turn by strata referred to the Lorraine. In the upper part of the Lorraine *Pholadomorpha pholadiformis* and forms similar to *Modiolopsis concentrica* are present, associated with *Pterinea demissa*. At this upper or *Pholadomorpha* horizon no *Plectambonites sericeus* was noticed, aithough it is
found in the lower part of the overlying Richmond and also at lower levels in the Lorraine. Dalmanella also is not recorded as present from the upper part of the Lorraine section, unless it occurs at the extreme top; it is very abundant, however, from those parts of the Lorraine which underlie the Pholadomorpha zone.



Figure 1. Portion of Quebec, showing fossil localities.

The following species have a considerable range throughout the Lorraine along the Nicolet river:

Heterocrinus column	nals.
Glyptocrinus column	als.
Cornulites, straight f	iree form.
Rafinesquina mucron	ata.
Rafinesquina alterna	ta, flat form.
Zygospira cf. modest	B .
Pholidops subtruncal	la.

Byssonychia radiata. Cymatonota sp. Clidophorus praevolutus. Ctenodonta lorrainensis. Archinacella puloskiensis. Sinuites cancellata. Lophospira cf. bowdeni.



The more exact distribution of the various species, as far as known, is given in the following detailed account of the Nicolet River section. Of course, the citations of *Heterocrinus* and *Glyptocrinus* columnate can have no value excepting as they indicate an impressi produced by their frequent occurrence. In the absence of the heads of the crinoids, the finding of the columnals does not warrant the use of these fragments of the stems in correlation.

The Nicolet river enters the St. Lawrence from the south at a place about 9 miles southwest of Three Rivers, Quebec. The section about to be described may be reached from Ste. Monique station on the Nicolet branch of the Intercolonial railway. From this station a road leads southwest and in a distance of 11 miles joins a road roughly parallel to the Nicolet river. The river road follows a southeast course and 11 miles from the point where the road from the railway station joins, it reaches a strong easterly bend of the Nicolet river near the home of Honore Auger. Directly opposite the Honore Auger home, the Queenston red shales are exposed and a short distance southeastward, at a bluff along the bend of the river, the contact between the Queenston and the underlying, richly fossiliferous Richmond strata, is exposed. Detailed sections were measured from the base of the Queenston, through the fossiliferous Richmond and down into the underlying Lorraine. The Queenston is regarded as also of Richmond age. In the following accounts of the Nicolet River sections the detailed description of the immediately underlying richly fossiliferous strata definitely known to be of Richmond age is reserved for a later section of this report (pages 141-150).

The following sections are a study only of the vertical distribution of the fossil life. No attempt was made in the field to secure an accurate record of the lithological character of the strata. Such statements as here are recorded are based chiefly on memory and indicate only the chief characteristics of the strata involved. In the case of the Nicolet River section, first described, it may be added that the argillaceous shale in that part of the section which extends from layer Y to layer W, is more or less calcareous, and at certain levels tends to merge into an impure limestone. By far the greater part of the underlying strata insists of soft clay shale, with only occasional hard, impure limesto to layers interbedded. Toward the lower part of the

and all of the basal part of the section consists of comparatively thin-bedded sandy shales or shaly sandstones.

Section No. 1, at Bluff Southwest of Home of Honore Auger.

	Т	hickness	Total
		feet.	thickness.1
	Red shales underlain by blue shales, forming the basa part of the Queenston (Upper Richmond)	1 	
	Mainly argillaceous shale with some interbedded limestone forming the Upper part of the Waynes ville (Lower Rich-mond) Section	- . 57 <u>}</u>	571
V)	Zone W, top of <i>Strophomena hecuba</i> zone Limestone Base of exposure at southern end of cliff.	. 2 . 1	59 3 60

(V

Proceeding from this cliff due southward along the base of the hill at the eastern edge of the field, the mouth of a narrow, steep gully is reached, giving an excellent exposure of part of the preceding section, and also exposing some of the underlying strata. The description of this gully section, section No. 2, follows.

Section No. 2, Along Gully, South of Section No. 1.

		Thickness feet	Total thickness.
	Mainly argillaceous shale with some interbedd limestone corresponding, stratigraphically, the lower part of section No. 1. All of the stra- in this section No. 2 belong to the Waynesvi	ed to ta lle	
	member of the Richmond	22	
(w)	Zone W top of Strophomena hecuba zone	21	591
,	Mainly argillaceous shale	361	96
(T)	Zone T. highest horizon for Catazyga headi	11	971
` -'	Mainly argillaceous shale	81	106
	Base of measured part of gully section.		

In the following measured sections, some of the fossiliferous horizons were too thin to be measured separately, but their relative position is indicated by inserting the list of fossils present at the proper points between the measured parts of the sections. In addition, some of the more important fossil horizons are indicated by letters.

That part of the general section extending from zone (T) downwards is exposed also along the steep hill-side about 100 yards south of the mouth of the gully. Here the following section is shown:

Section N: 3, Hillside Section, South of Gully.

		Th	ickness	Total thickness
	Cross will d limen use hitse		ICCL.	(Incancae.
(T)	Zone 1 highest horizon for Catazyga headi Mainly wells would also belonging to the Wa nesville member of the Richmond, and described el where in this report. Only the upper part of th	y- se-	2	97 1
	interval is exposed in section No. 2		54}	152
	Argillaceous shale Thin layer with Catazyga headi abundant, Strophome	 na	2	154
(S)	planumbona rare Argillaceous shale with Catazyga headi abundant. T specimens of Rhynchotrema perlamellosum occurr in a loose slab at this horizon, associated wi Strophomena planumbona and Catazyga headi. It probable that this slab was practically at original level. This zone S forms the base of th part of the section which may be referred definite to the Waynesville division of the Richmond. T immediately underlying strata are not yet definite referred either to the overlying Richmond or to t	wo ed ith iss its at ely 'he ely		
	Shalw strata		4	160
	Thin layer with Catazyga headi abundant Argillaceous shale Harder limestone with Plectambonites sericeus comm Shaly strata	 1011	9 13	169 169 182
	Not exposed	en	16]	199
	recta and pholadis, near the middle		14	213
	Bed poorly exposed		20	233
(R)	Shales with Catasyga headi very abundant, Bysson chia radiata and with occasional specimens Cyrtolites ornatus, Clathrospira subconica, a	ny- of	T	
	Byssonychia		51	238

The Catazyga headi horizon (R) may be found as follows: From the home of Honore Auger follow the road on the east side of the river southward to two barns on the west side of the road,

a short distance before reaching a low, wooded moraine. Take the lane passing between the barns and follow it westward until it passes down the hill at the margin of the river. The top of the hill here is fully 130 feet above the river. The horizon (R) occurs where the rapidly descending road approaches the northern end of the long, continuous, and very steep bluff exposures which line the river bank for more than a mile southward. Its vertical distance above the river here = 60 feet. This *Catazyga headi* horizon occurs $139\frac{1}{2}$ feet below the top of the highest horizon at which this species is seen and the species is found at numerous other levels at different distances below level (R).

Zone (S), containing Strophomena planumbona and Rhynchotrema perlamellosum is the lowest horizon at which forms definitely suggesting the Waynesville phase of the Richmond are known to occur. Below zone (R) the rock assumes a very Lorraine-like appearance and holds Lorraine forms. The affiliations of the strata between zones (S) and (R) have not yet been determined. The Catazyga occurring at horizon (R) is the typical Catazyga headi, such as occurs in the lower part of the Waynesville section in western Ontario and in the middle part of the Waynesville in Ohio, Indiana, and Kentucky. It is not the Catazyga erratica of the Lorraine of New York, However, no other species definitely suggesting Waynesville affinities is known to occur in these beds.

Along the wagon road mentioned at the end of the description of the preceding section (section 3) the following strata are exposed, duplicating the lower part of that section.

	Section 4.	Thickness	Total
		feet.	thickness
	Argillaceous shale with Pterinea demissa and Bysson	1y-	
	chia	7 ew	2123
	Argillaceous shale with PholidAs subrugata Rafa	23	235
	quina alternata, Byssonychia radiata	3	238
(R)	Top of argillaceous shale exposed at margin of blu south of wagon road, with Catazyga headi very co mon. Also a few Rafinesquina alternata, Pholida	ıff, m- ops	
	subtruncata		238

The presence of *Hebertella occidentalis* in considerable numbors, associated with *Catazyga headi*, was noted also in the area 18 miles east of Ottawa, at an exposure occurring about a mile west of Vars and a quarter of a mile north of the railway. Here also the *Hebertella occidentalis* horizon is regarded as underlying the more typical Waynesville zone, the latter being suggested by the presence of *Strophomena fluctuosa* along the creek about a quarter of a mile south of the railway where it crosses the same country road as that on which the *Hebertella* locality is situated.

The layer (R) of section 4 corresponds to the layer (R) in the hill-side exposure, section No. 3, previously described. At and above this horizon, occasional specimens of *Clathrospira* subconica are seen. Below the layer (R) at various levels, the following species occur: *Cornulites flexuosus* of the Lorraine as figured by Hail, *Psiloconcha sinuata* or a distorted species, *Eotomaria, Bythocypris cylindrica*, and *Ctenobolbina ciliata*.

From the western end of the wagon road mentioned in connexion with the description of sections 3 and 4, a high, abrupt bluff extends more than a mile southward, up the river, forming its eastern bank. This exposure is so long and includes such a great thickness of strata, that the description will be divided more or less arbitrarily into parts, each part consisting of strata presenting some characteristic in common.

In descending order the following zones are discussed in the $N' \rightarrow t$ River section:

lomorpha zone. s zone. Leplaena zone. Trinucleus zone.

3

In the province of Quebec Pholadomorpha pholadiformis occurs both above and below the Pholadomorpha zone: above, it occurs at numerous localities in strata definitely referred to the Waynesville member of the Richmond; below, it occurs in the Proetus zone at the mouth of the Rivière des Hurons, east of Chamb' asin. The Pholadomorpha zone is merely that part of the section which lies below the lowest strata definitely referred to the Waynesville and above the highest strata containing *Proetus chambliensis*. Eventually it may be included definitely in the lower part of the Richmond section.

The Proetus zone extends from the highest strata containing Proetus chambliensis to the highest zone containing Leptaena ir venusta. Occasional specimens of Proetus occur in the upper part of the underlying zone. At the mouth of the Rivière des Hurons, Strophomena t'anumbona occurs in this zone.

The Leptaena zone extends from the highest strata containing Leptaena invenusto to the highest strata containing Trinucleus concentricus. Leptaena also ranges through a considerable part of the underlying Trinucleus zone.

The Trinucleus zone includes all of the Nicolet section known at present beneath the highest layers containing Trinucleus concentricus. Judging from the St. Hyacinthe section, Triarthrus becki ranges through the greater part of this zone, although known only at its top in the Nicolet River section.

It is not known at present what s*ratigraphic value these faunal zones have, since not enough exposures at different localities have been examined to determine their vertical and geographic range of variation. However, they express cur present state of knowledge of faunal zones in the so-called Lorraine of eastern Canada.

No unconformity or distinct lithological break has been nc fixed in any part of the Nicolet River section, not even at the base of the Queenston red shale, nor are the palæontological breaks as sharply demarcated as the names of these zones might suggest. In describing a part of the section as Richmond and a part as Lorraine no definite line of demarcation must be assumed. Only those strata definitely referred for some reason to the Richmond are described as Richmond and the remainder are allowed to remain under the term Lorraine. Eventually the upper part of these so-called Lorraine strata, especially the *Pholadomorpha* zone, may be added definitely to the Richmond, but the meagre bryozoan evidence at present appears, according to Ulrich, to be against such a procedure.

The first part of the long bluff section on the Nicolet river consists of those strata which contain *Pholadomorpha pholadi*formis, and a species resembling *Modir'* psis concentrica. These strata overlie the *Proetus chambliensis* horizons described under section 6. They are correlated provisionally with the upper part of the Lorraine of New York, as seen at Bennett Bridge and below the Salmon River falls.

Section 5.

	1	hickness	Total
		feet. t	hickness
(S)	Lowest strata containing Strophomena planumbona and Rhynchotrema perlamellosum (Base of strata re- ferred definitely to the Waynesville member of the		
	Richmond)	• • • • • •	156
	Argillaceous shale exposed on the hill-side, in section 3, previously described	82	238
(R)	Argillaceous shale exposed at margin of bluff, south of		
(,	wagon road, Catazyga headi very common	3	239
	Shaly strata with Zygospira modesta, Pholidops subtrun- cata very common, and Clidophorus praevolutus few; forming the top of the Pholadomorpha pholadiformis		
	Quebec	51	244
(Q)	Shaly strata with heavy sandstone layer, fine-grained, at the base. <i>Pholidops</i> common, <i>Dalmar lla</i> , <i>Ra-</i> finesquing mucronata.	3	2 1
	Shaly strata with <i>Pholidops subtruncata</i> , and a form of Cymptonata between recta and pholadis	181	266
	Argillaceous shale, not accessible here, measured by dropping a weight at the end of a string, at the nor- thern edge of the long bluff. Sandstone layers, of the Lorraine type, occur in several conspicuous layers interbedded with the upper part of the shale and form a total thickness of about 2 feet in this part of		
	the section. Total thickness of this interval	22	288
(P)	Conspicuous sandstone layer at the base of the pre- ceding strata. A hard sandstone layer which has fallen from the cliff, apparently from some point between layers (Q) and (P), contains the following fossils: Zygospira modesta, Catazyga headi, Pierinea demissa, Whitella resembling obliquata, and a Modio- lobsis resembling concentrica.		

Argillaceous shale. At this level, various loose slabs of rock have fal from the cliff, whose origin apparently is son where below layer (P), but they may have co from a higher source. In these slabs the follow	Thickness feet. 91 llen me- ome ing <i>ps</i> ;	Total thickness 297
Argillaceous shale At this level, various loose slabs of rock have fal from the cliff, whose origin apparently is son where below layer (P), but they may have co from a higher source. In these slabs the follow	91 llen me- ome ing <i>ps;</i>	297
Cornulites flexuosus, Catazyga, and Pholido, Catazyga and Hebertella; Catazyga, Rafinesqu mucronata, Zygospira modesta and Cymatonota rather large size for this genus; Catazyga, a Ctenobolbina ciliata; Zygospira modesta, Pho domorpha pholadiformis, Pterinea demissa, a Mou lopsis resembling concentrica, and Calymene. Argillaceous shale, with the following species: Bu zoans, Glyptocrinus columnals, Rafinesquina altern.	of and ola- dio- ryo- ata,	
Clidophorus, Clenodonia lorrainensis, Byssonya radiala, and Isotelus At this level, loose slabs of rock occur, contair Hebertella, Rafinesquina mucronata, Catazyga he Clenodonta lorrainensis, Byssonychia radiala, s Modiolopsis concentrica.	chia 5 ¹ / ₁ ning eadi, and	303
Argillaceous shale. (Lowest heavy sandstone layer, opposite a large cial boulder, forms the base of this interval Argillaceous shale. (Base of another hard layer occ	gla-). curs	305
at bottom of this interval.)	6}	312
Argillaceous shale.	5 5 18 46	317 335 381
 Fossils in loose rock fragments at the base of immediately overlying interval: Crinoid column with radiating striæ, Glyptocrinus columnals, H nesquina alternata, R. mucronata, Zygospira mode Pholadomorpha pholadiformis. This horizon is 225.5 feet below the lowest hor containing Strophomena planumbona, and R. chotrema perlamcllosam, and while it is not cer that Pholadomorpha pholadiformis occurs at low a horizon as this, it is at least possible. Very fresh talus along this interval, probably ne at its original level, and containing Glyptor columnals, Zygospira modesta, Rafinesquina ternata, large Cymatonota, and Clidophorus 	the nals Rafi- esta, izon hyn- train t as early inus al- 27	408

	Thickness	Total
Argillaceous shale with the following fossils in loc fragments of rock, probably nearly in situ: Corn lites flexuosus Lorraine form, Rafinesquina mucrona very common, Zygospira modesta, Catazyga hea very rare, Lophospira beatrice, and Ctenodonta la	teet. se uu- ula di or-	thicknes
Argillaceous shale with fossils of any kind very scarc among these are: Glyptocrinus columnals, crino columnal with radiating striæ, Cornulites flexuosu Catazyga scarce, Byssonychia, Clidophorus an	51 1 :e, id <i>is</i> , nd	460
Calymene Argillaceous shale nearly unfossiliferous From the talus lying along the overlying interval, a evidently loose blocks fallen from some horizon fa above this level, the following fossils were collecter Rafinesquina alternata and Cyclonema bilix: Phol domorpha pholadiformis, Modiolopsis concentric and Calymene; Rafinesquina alternata, Strophomen- planumbona, Str. hecuba, and Catazwa.	48 63 ill ur d: a- a, a, aa	508 571
Argillaceous shale with few fossils, including Cten donta, Clidophorus, Orthoceras, and Calymene	<i>o</i> - 	631
Fossils very rare here. A moderate twist in th rocks, not a fault	ne 18	649
Fossils rare; Glyptocrinus columnals and Pholidops situ	in . 29	678
Fossils rare, including crinoid columna's with radiatin striæ: Heterocrinus columnals, Pholidops subtrui cata, Dalmanella, Plectambonites sericeus large, Z gospira modesta, Catazyga headi, tall Ctenodonte Byssonychia radiata in situ here, Protowarthia (Base of strata provisionally left in upper Lo.	ig v- y- . 16½ r-	694]
raine.) Highest strata containing Proetus chambliensi 538-5 feet below lowest Strophomena Manumbon	s,	
and Rhynchotrema perlamellosum horizon		694 <u>1</u>

The chief feature of that part of the section which lies between horizon (R) and the top of the zone in which Proetus chambliensis occurs is the presence of Pholadomorpha pholadiformis and of a *Modiolopsis* resembling concentrica, in the upper third of this interval. Since Pholadomorpha pholadiformis

(N)

occurs in the Waynesville member of the Richmond in the Nicolet River section, ranging from 40 to 60 feet beneath the top of the strata referred to this member, it is possible that this species eventually may be found also in the interval between horizons (S) and (R), where st.ata occur whose affinities to the rocks above and below must be regarded as doubtful for the present. Since typical Modiolopsis concentrica associated with Pholadomorpha pholadiformis, ranges from the base to the top of the Waynesville in Ohio and Indiana, and even occurs in the Liberty member of the Richmond in those states, it is possible that the similar form found in the Nicolet River section also eventually will be found in the intermediate strata, between horizons (S) and (R). In that case the strata between (S) and (R) could readily be included in the same subdivision as those intervening between (R) and the top of the Proetus chambliensis zone, since they resemble the latter lithologically, consisting chiefly of argillaceous shale, while the Waynesville part of the section tends to be more calcareous, especially toward the top. It must be admitted, however, that there is no distinct lithological break at the base of the strata here assigned to the Waynesville. On the contrary, the transition from the more argillaceous and shaly strata below to more calcareous layers above is quite gradual and the strongly calcareous elements do not appear until quite a distance above the horizons at which undoubted Waynesville fossils make their first appearance. Hence, the lithology cannot be utilized in suggesting where the limits between Richmond and Lorraine are to be drawn, in this Nicolet River section.

Those strata below layer (R), in which Pholadomorpha pholadiformis and the Modiolopsis resembling concentrica occur, are correlated provisionally with the upper parts of the Lorraine section of New York, as exposed between Bennett Bridge and the base of the Salmon River falls. It must be admitted, however, that this correlation is based upon very insufficient grounds, since such characteristic upper Lorraine species as Modiolopsis modiolaris, Orthodesma nasutum, and Ischyrodonta curta have not been found so far at this supposed Lorraine Pholadomorpha horizon, beneath the undoubted Waynesville strata, in the Nicolet River section, although Ischyrodonta curta is known in association with Catazyga erratica and Pholadomorpha Pholadiformis, below a horizon containing Catazyga erratica and Orthodesma nasutum at Weston, north west of Toronto.

Until recently, the presence of Pholadomorpha pholadiformis and of a Modiolopsis resembling concentrica would have been regarded as sufficient to identify the containing strata as Richmond. In Ohio, Indiana, and Kentucky these species are not known in the Arnheim, but range from the lower part of the Waynesville member of the Richmond to the top of this member and into the lower parts of the overlying Liberty member. It is rue that Modiolopsis corrugata and Modiolopsis sulcata, which evidently are merely distorted specimens of Pholadomorpha pholadiformis, were described by Miller and Faber, in 1892. as coming from near the top of the hills or on the hills at Cincinnati, Ohio, but the museum labels, accompanying the types, at Chicago university, give their origin as in Warren county, Ohio, and there is no reason for believing that these Warren County specimens have come from any horizon lower than the Waynesville member of the Richmond.

The reference of these strata in the Nicolet River section. below horizon (R), in which Pholadomorpha pholadiformis occurs, to the upper Lorraine, is based chiefly upon the occurrence of a few species of bryozoans in association with Pholadomorpha pholadiformis and Modiolopsis concentrica at several localities in the more western parts of the province of Ontario, quite remote both from the areas in the province of Quebec, here under discussion, and also from the typical Lorraine of New York. For instance, at various localities on Manitoulin island, including the exposures 2 miles northeast of the village of Gore Bay, various localities between 2 and 3 miles south and southwest of Little Current, and also the exposures along the shore between 2 and 3 miles north of Wekwemikongsing, strata, lithologically resembling the Lorraine of New York, occur below more calcareous strata in which an undoubted Waynesville fauna is present. In the upper part of these Lorraine-like strata, Pholadomorpha pholadiformis and a Modiolopsis resembling concentrica occur, as in the corresponding zone in the Nicolet River section. A similar succession of faunas and of lithological conditions is noted also in the vicinity of Meaford, on the southern shore of Georgian bay. From this lower or Lorraine *Pholadomorpha* zone, on Manitoulin island and near Meaford, a few bryozoans were collected and submitted to Dr. E. O. Ulrich. All of these suggested to him affinities with species occurring near the Bellevue horizon, near the middle of the Maysville, in Ohio, rather than with any known Richmond species.

For the present, therefore, it seems necessary to identify the Lorraine-like strata, containing Pholadomorpha pholadiformis, on Manitoulin island, and along the southern shores of Georgian bay, as equivalent to Maysville, rather than to Richmond strata. Since similar conclusions were drawn by Dr. Ulrich regarding the stratigraphical position of the Pholadomorpha pholadiformis zone at the Bennett Bridge locality, in the Lorraine of New York, it seems possible to correlate the Lorrainelike strata of Manitoulin island and of the southern part of Georgian bay with the upper part of the typical Lorraine of New York. It should be noted, however, that at these localities in western Ontario, as well as in the Nicolet River section, the typical Lorraine species. Modiolopsis modiolaris, Orthodesma nasular, and Ischwoodonta curta, are absent. The first species is a rept also in the Lorraine-like strata of the inte mediate areas; for instance, at Streetsville, and along the Humber river, west of Toronto, but Orthodesma nasutum and Ischyrodonta curta are present in the Pholadomorpha zone at Weston, northwest of Toronto.

If the correlation of the Lorraine-like strata, on Manitoulin island, near Meaford, and at Streetsville, with the typical upper Lorraine of New York, be accepted provisionally, then the identification of the lithologically similar *Pholadomorpha pholadiformis* containing strata in the Nicolet River section as upper Lorraine may be accepted more readily, since these strata in the Nicolet River section not only occur in a similar position, beneath an uedoubted Waynesville fauna, but also contain a fauna sufficiently similar to that of the so-called Lorraine of western Ontario to permit correlation with the latter.

It is quite evident that there is not sufficient known regarding the fauna of the Pholadomorpha pholadiformis zone in the Lorraine-like strata of either the province of Ouebec or that of Ontario to place the identification of this horizon with the upper Lorraine of New York and the middle Maysville of Ohio and Indiana beyond all question. However, since this fact has become apparent, no opportunity for sufficient further research to lead to conclusive results has been found, and the correlations here suggested are presented with all the elements of uncertainty which must remain until more data have been accumulated. It should be observed, however, that such few data as have been collected recently, in the vicinity of St. Hilaire and along the Rivière des Hurons, favour the Richmond, rather than the Lorraine age of some of the Pholadomorpha containing strata formerly regarded as Lorraine. At the former locality, Streptelasma rusticum, Strophomena planumbona, and Str. hecuba were found in this association, and the two species of Strophomena here cited occurred at the latter locality; so that it is becoming increasingly probable that eventually a considerable part of those Pholadomorpha containing strata will be referred definitely to the Richmond.

Returning to a consideration of the Lorraine-like Pholadomorpha pholadiformis zone, below horizon (R), in the Nicolet River section, the following facts may be noted. Pholidops subtruncata, Rafinesquina mucronata, Clidophorus praevolutus, and Ctenodonta lorrainensis are abundant and range also to far lower levels. At certain horizons a form intermediate between Cymatonota recta and C. pholadis occurs. Catazyga headi also appears to have a great vertical range. It is abundant 77 feet below the Strophomena planumbona horizon. The specimens in the loose slabs between 130 and 140 feet below the Strophomena planumbona horizon indicate the presence of Catazyga headi also at some interval below the 2382-foot level. Occasional specimens probably occur between 250 and 350 feet below the Strophomena planumbona horizon. The specimens near the 571-foot level may have dropped from a much higher level, but those at the 694¹-foot level undoubtedly are in place.

In the description of the still lower parts of the section it will be found that *Catazyga headi* has a very great vertical range, passing at still lower levels into *Catazyga erratica*.

Owing to the steepness of the bluff along most of this line of outcrop, the fossils are found chiefly in the talus and their stratigraphical value must be determined by the lithological character of the talus and the nature of that part of the bluff at which the specimens were collected, but, as a rule, the conditions here are very favourable for determining the general characteristics of the section. The dip of the strata along the bluff is so great that the various layers usually disappear within a distance of several hundred yards, and often within a much smaller distance, depending not only upon the dip of the strata but also upon the height of the bluff. Specimens collected from loose material always are described as such.

In the following continuation of the description of the Nicolet River section, the interval between the last mentioned layer (N) in the previously described part of the section and the lowest *Strophomena planumbona* zone, at the base of the undoubted member of the Richmond, is indicated. The layer (N) forms the top of the *Proctus chambliensis* division of the Lorraine. Since a part of this division is well exposed along the Richelieu river, at Chambly Canton, 15 miles east of Montreal, and no other much better section is known, it may also be called provisionally the Chambly member of the Lorraine, as exposed in the province of Quebec.

Section No. 6

		hickness	lotal
		feet.	thickness.
(S)	Lowest strata containing Strophomena planumbon	10	
	and Rhynchotrema perlamellosum		156
	Interval	5381	694
	Top of Proclus Chambliensis Zone of the Lorraine		6941
(N)	Argillaceous shale with Glyptocrinus columnals, Het rocrinus columnals, Pholidops subtruncata, Dalma ella, Rafinesquina alternata, Plectambonites serices Catasvea headi. Ctenodonta ci. filistriata. Bysson	le- n- 15,	

	т	hickness feet.	Total thickness
	chia, Clenodonta lorrainensis, Cymatonota near recta, Pterinea demissa, Proetus chambliensis fragments. This part of the section is due southwest of the home of Alfred Lambert, about a mile south of the home of		2021
	Honore Auger Argillaceous shale with Glyptocrinus and Heterocrinus columnals, Pholidops, Dalmanella, Plectambonites large, Zygospira modesta, Catasyga, Byssonychia radiatu large, Clidophorus planulatus, Ctenodonta lorrainensis, Pterinea demissa small, Archinacella pulaskiensis, Sinuites cancellata, Calymene, and	33	1213
	Proetus chambliensis rather common Thin layer full of Catasyga headi, 580 feet below lowest Rhynchotrema perlamellosum and Stro- phomena planumbona.	14	7413
	Argillaceous shale with Catazyga headi in place in the middle. Also Pholidops, Dalmanella, Plectambonites large, Zygospira modesta; Proetus chambliensis	22	7611
	Argillaceous shale with Heterocrinus columnals, Pho-		1054
M)	lidops, Catasyga, and with Proetus not rare Argillaceous shele with Catasyga headi abundant near the middle, associated with Glyptocrinus columnals Aspidopora (A. spinulosa, Ulrich, unpublished spec- ies from the Eden group in Ohio), Calymene, and large Isotelus. Near the base of this interva Catasyga is associated with the same Aspidopora and Heterocrinus columnals, also columnals with radiating striæ, Cornulites flexuosus of the Lorraine	27	7908
L)	type of Hall, and Dalmanella Argillaceous shale with Aspidopora (spinulosa) no rare, Rafinesquina mucronata rare, Cornulite flexuosus, and Dalmanella very common. At the base of this interval there is a limestone layer with Catasyga abundant, Plectambonites large and common, Byssonychia, and crinoid columnals with	. 42 t s e h 1 h	832
	radiating striæ Argillaceous shale with thin limestone layers com taining large specimens of <i>Plectambonites</i> , and num erous specimens of <i>Catazyga headi</i> in the middle an upper layers. In the lower part the followin species occur: <i>Glyptocrinus</i> columnals, columnal	. 22 - - d g s	8541

		nickness	1 otai
		feet.	thickness
	with radiating striæ, and Catasyga. At the ba of the interval Whitella resembling obliquata ar	se ad	
	Proetus chambliensis occur	. 34	8881
	manella, Plectambonites, Rafinesquina mucronat	a,	
	Catazyga. Very large gneiss boulder here	. 24	912
	Argillaceous shale with Glyptocrinus and Heterocrinu columnals, Cornulites flexuosus, Dalmanella an	us Id	
	bonites, Zygospira modesta, Catazyga, Pholidop	m- s,	
	Calymene, and Proetus chambliensis	. 29	9413
	Argillaceous shale	. 40	981
)	Leptaena common in thin limestone layer, about a	n	
	Highest horizon at which <i>Leptaena</i> has been foun	d hana	•••
	and Rhynchotrema berlamellosum laver	00166	0811
	and any first the postalle to only the year to the second se		-019

(K

32

The chief feature of that part of the Nicolet River section which lies between layers (N) and (K), and which here is described as section No. 6, is the great vertical range of *Proelus chambliensis*. Between layers (N) and (K) this vertical range amounts to 287 feet, and here the species is most common, but occasional specimens have been found as low as 182 feet below the top of layer (K), giving a total vertical range of 467 feet for this trilobite. Section No. 6, therefore, includes that part of the *Proelus chambliensis* zone which lies above the highest known *Leptaena* zone.

Rafinesquina mucronata has not been found lower than 50 feet below the uppermost Leplaena layer (K). Clenodonta lorrainensis was not recorded below the 741}-foot level. A brachial valve of some species of Strophomena, 27 mm. wide, presenting an excellent cast of the interior, was found in situ near the 706-foot level. A lamellibranch suggesting Cuneamya and resembling Cuneamya scapha at least in outline, occurs near the Aspidopora horizons near the 800-foot level.

Calazyga apparently ranges throughout section 6, but is especially abundant at the 741 $\frac{1}{2}$, 810, 830, 854 $\frac{1}{2}$, and 875-foot levels. Below the uppermost Leptaena layer (K), there is a long interval, of nearly 400 feet, in which *Catazyga* is unknown at present, but it is found again at still lower levels. *Pholidops* ranges to considerably lower levels than the base of section 6.

Whether the crinoid columnals and the various species of Dalmanella, Plectambonites, Zygospira, Sinuites, Clidophorus, Byssonychia, Cymatonota, Whitella, and Cornulites, found in the Nicolet River section, have any diagnostic value in separating these strata into minor divisions has not been determined as yet.

The Aspidopora spinulosa mentioned at several horizons, in the description of section 6, is a form regarded by Ulrich as having affinities with an unpublished species found in the Eden This conviction is confirmed by the presence of Dekaof Ohio. yella ulrichi which was identified by Ulrich from among material collected at the same horizon. Dekayella ulrichi is one of the most typical fossils of the Eden of Ohio, Indiana, and Kentucky, ranging throughout this group of strata, and usually occurring in great abundance. Hence the Proetus chambliensis zone of the Nicolet River section is provisionally correlated with the Eden. The same Aspidopora spinulosa occurs also in the exposures along the Richelieu river at Chambly Canton. Here it is associated with a form identified by Ulrich as Bythopora arctipora, another characteristic Eden form. These identifications by Ulrich also suggest the Eden affinities of that part of the Nicolet River section in which Proclus chambliensis is present.

The abundant presence of *Proetus chambliensis* in these supposed Eden beds is of interest since a closely related, if not identical species, *Proetus spurlocki*, Meek, occurs in the Southgate member of the typical Eden in Ohio. This Southgate member forms the middle part of the Eden and lies above that part of the Eden in which *Trinucleus concentricus* is abundant. Moreover, *Rafinesquina mucronata* is closely related to, if not identical with that form in the middle Eden which was identified by Nickles, in his "Geology of Cincinnati," with *Rafinesquina squamula* James, although the types of the latter species were described as occurring at an elevation of 350 feet above the Ohio river, at Cincinnati, and, therefore, were found in the Fairmount division of the Maysville. *Pholidops subtruncata* is much more closely related to *Pholidops cincinnatiensis* than its descriptive name would suggest, since the subtruncate outline is not as constant a character as the specific name would suggest, even within the type area of that species. In the vicinity of Cincinnati, *Pholidops cincinnatiensis* ranges through the lower and middle Eden.

The presence of *Leptaena* in the lower parts of the extended *Proetus chambliensis* horizon, along the Nicolet river, finds its counterpart in the presence of *Leptaena gibbosa* James, in the Economy or lower Eden member in Ohio and Kentucky which, however, is very different from the species found in the Nicolet River section.

The brachiopoda appear to corroborate the evidence presented by the few bryozoans so far identified, so that the Eden age of the *Proetus chambliensis* beds may be accepted tentatively. It should be noted, however, that the *Catazyga* ranging throughout the *Proetus chambliensis* zone on the Nicolet river apparently is the *Catazyga headi* and not the *Catazyga erratica*, although a special study of these Catazygas should be made. Moreover, the collections belonging to the Canadian Geological Survey contain a specimen of *Pholadomorpha* and several specimens of a species of *Strophomena* resembling *planumbona*, which are labelled as coming from Chambly; and both species are known to occur at the southern end of the body of water known as the Chambly basin, at the mouth of the Rivière des Hurons. Here only the *Proetus chambliensis* beds are exposed, while the fossils mentioned have hitherto been regarded as characteristic Richmond forms.

No very exact correlation of the *Proetus chambliensis* beds with any part of the typical Lorraine of New York is possible at present. None of the more characteristic forms belonging to the Pulaski division of the Lorraine, such as *Modiolopsis modiolaris, Ischyrodonta curta*, or *Glyptorthis crispata* Emmons, have been found in the province of Quebec. If the *Proetus chambliensis* beds have any equivalents within the Lorraine of New York, they probably will be found below the typical Pulaski beds, in the lower half of the Lorraine. Such beds are exposed within the gorge, northwest of the village of Lorraine, but the fauna of this lower part of the Lorraine section requires further study. In the following continuation of the description of the Nicolet River section, the interval from the lowest *Strophomena* planumbona layer (S) to the highest level for *Leptaena* (K) is indicated.

Section 7.

	Th	ickness feet.	Total thickness.
(S)	Lowest strata containing Strophomena planumbona and Rhynchotrema perlamellosum		156
	Interval	825.5	
	Top of the Leptaena Zone of the Lorraine.		
	Although the overlying zone is here called the <i>Proetus</i> zone, the range of <i>Proetus chambliensis</i> extends fully 182 feet below the top of the Lep- taena zone.		
(K)	Highest level containing Leplaena of rhomboidalis group, in a layer, unmeasured, only a few inches thick. At this Leplaena horizon a large specimen of		
	Pterotheca pentagona was found Argillaceous shales containing Glyptocrinus columnals, columnals with radially arranged striæ, Pholidops, large specimens of Plectambonites sericeus, By mych radiata, and Sinuites. At the base, Dalmanella and Rafinesquina mucronata occur associated with	ia	981
	long crinoid stems Exposures in the bed of the river, containing Pholi- dops, Dalmanella, Plectambonites, numerous frag-	50	1,0311
	ments of Proetus chambliensis, all near base The following strata occur south of mouth of gully opposite home of Francois Cloutier: Argillaceous shale, with exposures chiefly in river bed. Heterocrinus columnals, Cornulites flexuosus, Plec- tambonites large, Dalmanella, Byssonychia radiata,	75	1,106]
	and Sinuites cancellata Fossils few. Glyptocrinus and Heterocrinus columnals, Cornulites flexuosus, Pholidops, Dalmanella, Plec- tambonites. Sinuites, and numerous fragments of	26	1,1321
(J)	Proetus	31	1,163
	perlamellosum horizon).		
	Fossils few. Dalmanella, and Byssonychia. Whitello was found in place 5 feet below top of this interval	32	1,1951

	36		
	1	hickness	Total thickness.
(I)	Fossils few. Heterocrinus columnals, Pholidops, Da manella, Byssonychia radiata. Near the base of th section Conference suggesting Eden affinities.	ul- lis C-	
	curs	33	1,2281
	uites, and Calymene	24 24- th	1,252
	numerous plications, and Calymene Argillaceous shale with Phylloporina common in a the layer at the top, and Coeloclema in another thin lay at the middle of the section. Also Heterocrim	28 in rer us	1,2801
	columnais, Datmaneda columnais, Dysonychia radak common, and Calymene Argillaceous shale with few fossils. Helerocrin columnals with radiating striæ occur in overlyi interval. Chiefly fine-grained sandstone. Even t shale here is sandy; this is true also of the ov bying shales as far as layer (1) and to a certain	43 us ng he er-	1,323
	tent, even as far as layer (K)	31 Va.	1,3541
	Whitella, Sinuites, also a large form of Cymatonoto	32	1,3861
	Dalmanella, and Byssonychia radiata	27 Ha,	1,4131
(H)	Byssonychia, Whitella, Sinuites, Hormotoma suble Second Leplaena horizon, thin layer, unmeasur 1 280.5 foot holow lowest Strohomena chanumb	exa 32 ed,	1,445
	and Rhynchotrema perlamellosum	ery and	1,4453
	apparently with Catazyga very rare Argillaceous shale with Cornulites flexuosus, Dalm	22 an-	1,4671
(G)	ella, and Byssonychia Third horizon, unmeasured, with Leptaena comm associated with Dalmanella common, and F tambonites, Byssonychia few; 1,343.5 feet bel	32 on, <i>lec</i> - ow	1,499
	lowest Strophomena planumbona and Rhynchotro	ma	1 4001
	perlamellosum layer Sandy shales, with Dalmanella, Plectambonites	51	1,5501
(F)	Catazyga erratica horizon, thin layer, not measure 1,394.5 feet below lowest Strophomena planumb	ona	1 5501
	and Rhyncholrema perlamellosum layer	•••	1,550%

The chief feature of this part of the Nicolet River section is the great vertical range of *Leptaeno*. although at considerable intervals. Between layers (K) and (G) the interval is about 520 feet, but *Leptaena* occurs also 125 feet, and 310 feet lower, giving a total of 830 feet for the known vertical range of this fossil in the Nicolet River section. Only two bryozoans were identified from this horizon. The *Coeloclema* suggests Eden affinities. The *Phylloporina* is a new species, with numerous pits and is most closely related, among described species, to *Ph. trentonensis* Ulrich. The graptolites, in the lower part of the section, belong to the group of *Glossograptus* (*Orthograptus*) quadrimucronatus, and have no diagnostic value since this group has a very long vertical range.

The occurrence of Pterotheca pentagona, associated with Proetus chambliensis, at the top of the section, is of interest since the same species occurs in the Proetus chambliensis zone, also, along the Richelieu river, at Chambly Canton. Both Proetus chambliensis and Rafinesquina mucronata seem to be absent at all horizons below the upper part of the Leptaena zone. Catazyga erratica is known at present only from laver (F) at the base of section 7. It may occur slightly higher, but apparently is replaced by Cataz" . headi in all the higher parts of the Nicolet distribution is quite disconcerting in all River section. of the so-called Lorraine of the Nicolet attempts at cor.el. River section with my part of the typical Lorraine of New York, since in New York Catazyga erratica has a considerable distribution in the typical Pulaski member of the Lorraine. However, if the Proetus chambliensis zone be regarded as below the Pulaski member of the New York Lorraine, then the Leptaena zones of the Nicolet River section must belong to still lower horizons.

The Leptaena zones of the Nicolet River section appear to be represented also in southern Ontario, for instance at the Don Valley brick-yards, in the eastern part of Toronto. Here Leptaena is associated with bryozoans regarded by both Ulrich and Bassler as of Eden age. It has already been stated that in Ohio and Kentucky the only form of Leptaena known from Cincinnatian

strata below the level of the Richmond occurs in the lower or Economy member of the Eden.

In the following part of the description of the Nicolet River section the interval between the lowest Strophomena planumbona layers and the top of this part of the section is indicated.

	Section 8.		m
	Th	ickness	lotal
		feet.	thickness.
(S)	Lowest layers containing Strophomena planumbona and Rhynchotrema perlamellosum	 1,3941	156
	Trinucleur Concentrica Zone of the Lorraine.		
	Irinuceus Concentrics Lone of the		1.5503
(F)	Catasyga erratica horizon Sandy strata with very few fossils, chiefly Dalmanello	75	1,626
(E)	Top of Fourth horizon with Leplaena common Interval with sandy shales as above, with Leplaena common, at various intervals, both in the sandstone and in limestone. Byssonychia radiata common		1,020
	I nere are a few innestone layers are thin-sheeted	. 50	1,676
	Same sandy shale as above. Talus from a gully This layer unmeasured, with <i>Trinucleus</i> in place	. 37	1,713
	associated with Glyptocrinus, Heterocrinus columnals, Cornulites flexuosus, Dalmanella, and Plectambonites. This is the highest level at which Trinuc cleus is known at present in this section, 1,557 feedbarrens, Strochamena, clasumbona, and Rhyn	- - !- !t	
	chotrema perlamellosum layer	 1-	1,713
	ophorus, Hormotoma sublaxa	. 50	1,763
(C)	Sandy shale with a few criticid steins, and being ella Thin layer, unmeasured, with Triarthrus becki rar	. 51 e,	1,814
(0)	associated with Calymene, 1,658 feet below lower	st 17-	
	lamellosum laver		1,814
	Sandy shales with Dalmanella and Trinucleus	46	1,860
(B)	of Leptaena associated with several good spectrue of Leptaena associated with Cymatonota pholod Trinucleus, and Calymene, 1,704 feet below low	is, est	
	Strophomena planumbona and Khynchottema p		1,860

		Thickness	Total
		feet.	thickness
	Sandy shale with Trinucleus and Dalmanella	60	1,920
	Sandy shales	75	1,995
· ·	poor specimens of Catasyga and Leptaena; also with	th	
	Dalmanella and Aspidopora Thin layer, unmeasured, with Trinucleus comm	44 on.	2,039
	some having long genal spines		2,039
	Sandy shales and sandstones not well exposed for c	ol-	
	lecting: too steep. Dalmanella	50 th	2,089
	long genal spine	41	2,130
	Somewhat more argillaceous strata. Dalmanel.	la,	
	Sandy shales with Dalmanella, Clidophorus, Cter	32 10-	2,102
	donia common	42	2,204
	Sandy shales, fossils few. Dalmanella, Trinucle	11.5	
	common	68	2,272
	Sandy shales, lossils few, including Trinucleus	52	2,324
	Sandy shales, fossils few	80 ne	2,404
	specimen 20 mm. wide	75	2,479
	Sandy shales, fossils few, including Trinucleus	34	2,513
	(A strong fold or anticline occurs at this point in t	he	
	section, 2,357 leet below the lowest Strophorie	na	
	layers, or 2,513 feet below the base of the Oues	- -	
	ston shales.)		

The chief feature in that part of the section which underlies the *Catazyga erratica* horizon is the presence of *Trinucleus*. As a matter of fact, the highest level for *Trinucleus* known at present' is 140 feet below this *Catazyga erratica* horizon, but it very likely will be discovered eventually at still higher horizons. The present known range of *Trinucleus*, to the base of the actually measured part of the Nicolet River section, is 800 feet, but it undoubtedly has a ver, considerable range below the limits of this part of the section. *Triarthrus becki* is known in the Nicolet River section only at an horizon about 188 feet below the *Catazyga* erratica horizon. In other words it is known only from the upper part of the *Trinucleus* zone. South of the dam at St.

39

(A

Hyacinthe, however, it has a range of at least 700 feet in the Trinucleus zone, associated with Leptaena. For the present, however, it is assumed that the Triarthrus becki horizon in the Nicolet River section corresponds also to the horizon exposed on the Yamaska river, 2 miles northwest of St. Hugues, since at the latter locality Triarthrus becki is associated with both Trinucleus concentricus and Leptaena. Triarihrus and Trinucleus have also been found in the exposures east of Breault, on the western side of the Bécancour river, 14 miles southeast of Three Rivers.

The exposures immediately southwest of Petite Caroline station, 25 miles east of Montreal, contain Leptaena. Trinucleus was not found by the writer although he made long and diligent search for this fossil at this locality, but its presence here is reported by J. J. O'Neill.1

The Catazyga at the Petite Caroline locality may prove to be Catazyga erratica, but the specimens seen, although common at certain horizons, were too distorted for exact determination. For the present, the Petite Caroline locality is referred to the upper part of the Trinucleus zone.

At the river exposures below the dam at St. Hyacinthe, Trinucleus concentricus associated with Triarthrus becki and Leptaena is rather common. Hence the Nicolet River section also is referred to the upper part of the Trinucleus zone.

Later in this report it is stated that it is believed the bryozoans will be of immenseservice in the task of making correlations. The great section along the Nicolet river does not offer, however, much information at present, since the bryozoans have not been collected as yet. Among the few specimens submitted from the Proetus chambliensis zone between 5381 and 8251 feet below the base of the Waynesville member of the Richmond, Dr. E. O. Ulrich identified:

Aspidopora spinulosa (Not described).

Dekayella ulrichi. . . . All Eden, at Cincinnati.

From the corresponding Process zone at Chambly Canton, he identified:

Aspidopora spinulosa (Not described).

Bythopora arctipora. . . . All Eden, at Cincinnati.

St. Hilaire (Beloeil) and Rougemont Mountains, Quebec. Memoir 43, Geol. Surv , Canada, p. 14, 1914.

The Aspidopora was most common along the Nicolet river between the 7901 and 8321-foot levels, and the Dekayella ulrichi came from about the same level. The highest level at which the variety of Leptaena rhomboidalis occurs in this section is 825 feet below the Waynesville. The lowest level for Proetus is at 1,007 feet below the Waynesville and near the 1,072-foot level below the same horizon, Coeloclema occurred. While the exact species was not determined, the presence of the genus Coeloclema suggested Eden affinities. At the 1,2801-foot level, (1,125 feet beneath the Waynesville) a species of Phylloporing, nearest trentonensis, was found, and near the 1,300-foot level, the Coeloclema occurred again. Graptolites are common between the 1,3861-foot and 1,4131-foot levels. They belong to the Orthograptus quadrimucronatus group. Another horizon for Leptaena occurs at the 1,4451-foot level and still another at the 1,4991-foot level. Catazyga erratica occurs at the 1,626-foot level, another Leptaena horizon at the 1,676-foot level, and Trinucleus at the 1,713-foot level. Triarthrus becki is rare at the 1,814-foot level (1,653 feet below the Waynesville). Trinucleus is common down to the 2.515-foot horizon at base of the measured section; how far below this level, has not been determined.

At the *Trinucleus* horizon along the Bécancour river, threefourths of a mile east of Breault station, *Coeloclema commune* was found, suggesting Eden affinities, but *Coeloclema* is known now also from the Cynthiana formation in central Kentucky, below the level of the Eden.

Judging from the preceding data, Maysville strata can form only a comparatively small part of the Nicolet River section, although possibly forming a thicker zone than in the New York section. The greater part of the section evidently corresponds to the Eden of the Ohio section.

CHAMBLY CANTON.

Chambly Canton (Figure 1) is located on the Central Vermont railway, 15 miles east of Montreal. A road leads northeastward from the railway station to the bank of the Richelieu river, a short distance below the dam. The exposures extended from here northwestward, along the western shore of the river, to the point where the river enlarges for 1¹/₂ miles, forming Chambly basin. The strata show very little dip. Towards the dam, for a distance of several hundred yards, the strata consist chiefly of shale, penetrated almost horizontally by a dyke. Farther west, toward the entrance of the river into the basin, considerable more fine-grained sandstone is interbedded, but fossils are not so abundant here. Most of the fossils were collected along the eastern half of the shale exposure. These shales have a dark grey or greyish black colour, and at certain horizons are richly fossiliferous. The fauna undoubtedly is much greater than that here listed, since the list here given is the result of only two hours of collecting.

> Glyptocrinus columnals. Heterocrinus columnals. Glossograptus (Orthograptus) quadrimucronatus-approximatus. Aspidopora spinulosa (not described). Bythopora (arctipora according to Ulrich). Columnals with numerous radiating striæ. Pholidops subtruncata, common. Dalmanella sp., seen only in the sandstones, westward. Plectambonites sericeus large, very common. Rafinesquina mucronala, common. Rafinesquina alternata, 32 mm long, and very flat. Catasyga headi, very common. Zygospira modesta, few. Byssonychia radiata, in the sandstones, westward. Byssonychia with fine radiating plications, in the shales. Clidophorus praevolutus, common. Ctenodonta lorrainensis, several. Clenodonta sp., nearest simulatrix in outline. Cienodonia sp., nearest albertina in outline. Colpomya (Modiolopsis) faba-pusilla. Cymatonota recta, several. Lyrodesma poststriatum, common. Lamellibranch resembling Modiolopsis concentrica. Pterinea demissa, 35 mm. in height. Rhysimya small, resembling compressa in outline, but with sharply defined postumbonal radiating striæ. Rhytimya orhana. Clenodonta ci. filistriata.

Archinacella pulaskiensis.

Eotomaria sp. nearest canalifera. Hormotoma with no trace of surface markings, small form. Sinuites cancellaua. Spyroceras resembling bilineatum but much larger, and more rapidly tapering. Proetus chambliensis.

Bythocypris cylindrica.

The types of Pholadomorpha chambliensis, Orthodesma approximatum, Clidophorus praevolutus, Pterotheca pentagona, and Technophorus punctostriatus-quincuncialis are based upon specimens in the collections of the Geological Survey, and are there labelled as coming from Chambly.

The chief features to be noted in this fauna are the presence of an abundance of *Proetus chambliensis*, *Catazyga headi*, and *Rafinesquina mucronata* and the absence of *Leptaena rhomboidalis*. This suggests an equivalence to that part of the Lorraine section on the Nicolet river which has been called the *Proetus chambliensis* zone. This zone extends from 538 to 825 feet below the lowest *Strophomena planumbona* and *Rhynchotrema perlamellosum* horizon. The associated fauna includes *Pholidops subtruncata*, *Ctenodonta lorrainensis*, *Archinacella pulaskiensis*, and an undescribed *Aspidopora* belonging to same species as one found at the same horizon in the Nicolet River section. No specimens of *Trinucleus* or of *Triarthrus* were found in the Chambly Canton section.

MOUTH OF THE RIVIÈRE DES HURONS. (Figure 1.)

Exposures occur also north of Chambly Canton, at the mouth of the Rivière des Hurons. Here the strata are well exposed on the southern side of the river, where it turns strongly westward immediately before flowing into Chambly basin. The dip of the strata is southeastward, and some of the strata continue to be exposed along the line of strike up the river as far as the first bridge. Beyond this point other exposures occur as far as the first road on the east which joins the road following the Rivière des Hurons. About halfway between the bridge and the strong bend of the river, at its mouth, Strophomena planumbona is very common in several thin layers which occupy a zone about 3½ feet thick. This Strophomena zone contains also Catazyga headi, and Proetus chambliensis.

The Stroph viena planumbona zone may be recognized also at the best of the river. Here Pholadomorpha pholadiformis was fere associated in the same slab with Pholidops subtruncatus, Cinepherus praevolutus, Ctenodonta lorrainensis, and Technopheres purcuncialis. Pholadomorpha pholadiformis occurred a spin the exposures north of the bridge. Among the other fossis for the the strong bend in the river, near its mouth, are Daimer dia contradivation? Rafinesquina alternata, Plectambonite, critects it was clata radiata, and Pterinea demissa.

It is provable that Pholadomorpha chambliensis (No. 2069 in Collection of Calla Surv., Can.) described by the writer from the Chambly are , is - be regarded merely as another of the various synonyms of Pholadomorpha pholadiformis. It is certain that the latter species has a great vertical range in the so-called Lorraine of Quebec. The specimens of Strophomena planumbona found at the mouth of the Rivière des Hurons cannot be distinguished from typical specimens found in the Richmond in the Cincinnatian areas of Ohio and Indiana. In this respect the specimens differ from those figured by the writer in the Bulletin of Denison University (No. 8404 in Coll. of Geol. Surv., Can.) the latter being more convex and somewhat triangular anteriorly. The Pterotheca pentagona described by the writer from the Chambly area unquestionably came from the Technophorus quincuncialis zone. The types of all of these forms probably were obtained not on the western side of the Richelieu river, at Chambly Canton, but on the eastern side, at the mouth of the Rivière des Hurons.

It is evident that the presence of *Pholadomorpha pholadi*formis and Strophomena planumbona in horizons as low as the *Proetus* zone will make the recognition of the latter almost impossible where only small exposures with meagre faunas are at hand. Since also a form resembling Modiolopsis concentrica was found in the Proetus zone in the Chambly area, it is evident that a meagre representation of the Proetus chambliensis fauna may have a decided Richmond aspect to one familiar with the Ordovician faunas in the Cincinnatian areas of Ohio and Indiana. As far as *Strophomena planumbona* is concerned, however, it should be remembered that this species is represented already in the Trenton of Kentucky by the closely similar form described by the writer as *Strophomena ulrichi*, hence similar forms are to be expected somewhere within the great mass of strata intervening between the Trenton and the Richmond, at least in other areas, although unknown from these intermediate strata in the region surrounding Cincinnati.

ST. HILAIRE.

St. Hilaire station (Figure 1) is on the Grand Trunk railway, about 18 miles northeast of Montreal. It is on the eastern side of the Richelieu river, 8 miles northeast of Chambly Canton station. From the station a road leads off southeastward up the hill. for a distance of three-quarters of a mile, and then turns southwards rather abruptly. About half a mile southeast of the station, along the northeastern side of the road, the shallow drainage ditch exposes dark grey or blackish argillaceous shales, containing the following fossils:

> Heterocrinus columnals. Cornulites sp. (=Lorraine form of Tentaculites flexuosus, Hall). Pholidops subtruncata. Dalmanella. Zygospira modesta. Bysson ychia radiata. Clidophorus planulatus or praevolutus. Ctenodonta lorrainensis. Cymatonola recta. Psiloconcha inornata. Plerinea demissa, 15 mm. high. Rhytimya cf. radiata or compressa. Rhytimya with outline suggesting Cuneamya scapha, but with no distinctly defined lunule; median sulcus less oblique, shell higher, and more abruptly truncated than in Rh. products; no radiate granulose lines. Pholadomorpha pholadiformis. Cyrtolites ornatus. Ctenobolbina ciliata. Ceratopsis oculifera.

It may be said that this fauna definitely belongs below the *Strophomena planumbona* horizon, as exposed in the Nicolet River section, and is regarded, provisionally, as below the Waynesville member of the Richmond. It is regarded also as definitely above the horizons at which *Proetus* is so abundant. This would place the road side exposure southeast of St. Hilaire station somewhere between the *Strophomena planumbona* horizon at the base of the Waynesville member in the Nicolet River section and the top of the *Proetus* horizon, 500 feet beneath.

After the most careful search, no specimens of Trinucleus were found in the Nicolet River section above an horizon located 1,500 feet below the Strophomena planumbona level. In these circumstances it is difficult to believe in those identifications of Trinucleus in which apparently it is found associated with fossils indicating a much higher horizon. Unless enough of the specimen is at hand to certify undoubtedly to its trilobitic character, it is necessary to remember that everything which suggests the pitted border of a Trinucleus is not to be accepted at once as a genuine trilobitic fragment. This statement would be unnecessary if it were not for the fact that an unusually large-celled disk-shaped bryozoan occurs at and above the Chambly horizon, whose weathered surface occasionally resembles at first sight the pitted surface of Trinucleus, and the imprint of which is even more deceptive. Hence the occurrence of Trinucleus in any strata belonging to the Chambly or Proetus chambliensis zone is to be received with considerable scepticism in the absence of specimens whose origin is undoubted.

In the "Geology of St. Bruno Mountain," by John A. Dresser, published in 1910 as Memoir No. 7 by the Geological Survey, the following fossils, collected at St. Hilaire by R. Harvie, are identified by Dr. E. O. Ulrich:

> Paleschara beani (James). Pholidops cincinnatiensis Hall. Rafinesquina (?) sp. nov. Byssonychia, cfr. B. suberecta Ulrich. Ctenodonta, sp. nov. Near C. pectunculoides, and C. cingulata. Ctenodonta, sp. indet. Small, of the C. levata group. Clidophorus, sp. nov. Near C. planulatus (Conrad).

Psiloconcha sinuata Ulrich. Psiloconcha, sp. nov., var 1. Psiloconcha, sp. nov., var. 2. Pholadomorpha pholadiformis ? (Hall). A fragment. Whitella, sp. nov. (Near W. quadrangularis.) Whitella, sp. nov. (Near W. sterlingensis and W. obliquata.) Isotelus, cfr. I. gigas (pygidium). Ctenobolbina ciliata (Emmons) var.

In the Nicolet River section, species of Whitella, near Wh. quadrangularis and Wh. obliquata occur not only above the Strophomena planumbona horizon, but also between 85 and 130 feet below the Strophomena planumbona horizon, associated with Pholadomorpha pholadiformis. Similar Whitellas, however, occur also at much lower horizons; for instance, at 730, 1,000, 1,200, and 1,300 feet below the Strophomena planumbona horizon, and Whitellas are very abundant in the Trinucleus zone below the dam at St. Hyacinthe. Hence the presence of Whitellas having a Richmond facies in the St. Hilaire area does not necessarily establish the horizon as definitely of Richmond age.

In the report on "St. Hilaire (Beloeil) and Rougemont Mountains, Quebec," by J. J. O'Neill, published in 1914 as Memoir 43 by the Geological Survey, Canada, the following fossils from St. Hilaire station determined under the supervision of Professor Charles Schuchert are recorded:

> Stomatopora. Sp. undet. Paleschara beani James. Tubiculous annelids. Cornulites richmondensis Miller? Pholidops subtruncata Hall, or Ph. cincinnatiensis Hall. Rafinesquina alternata Emmons. Zygospira modesta Hall. Pterinea demissa Conrad. Byssonychia suberecta Ulrich. Psiloconcha sinuata Ulrich. Psiloconcha subovalis Ulrich. Psiloconcha inornata Ulrich. Modiolopsis concentrica Hall and Whitfield. Pholadomorpha pholadiformis Hall. Whitella, three species, undet. Rhytimya radiata Ulrich.

Cymatonota semistriata Ulrich. Cymatonota recta Ulrich. Ctenodonta pectunculoides Hall. Ctenodonta, sp. undet., of the C. levata group. Clidophorus n.sp., near C. planulatus. Cyrtolites ornatus Conrad. Isotelus gigas DeKay ? Ctenobolbina ciliata Emmons ?

In these lists, it is probable that the new species of Rafinesquina is the form described recently by the present writer as Rafinesquina mucronata. The Psiloconcha sinuata may be the form recently described as the variety borealis of that species. The Clidophorus near planulatus may be the form recently described as Clidophorus praevolutus. The Clenodonta near C. pectunculoides and C. cingulata probably is the form recently described as Cl. lorrainensis.

With such long lists of fossils it might appear that the identification of the horizon at St. Hilaire should be an easy matter. Unfortunately most of the fossils listed appear to have very long vertical ranges and so their value for more exact identification of horizons is lessened. As far as may be judged from these additional lists, the St. Hilaire strata correspond to those *Pholadomorpha pholadiformis* horizons in the Nicolet River section which are beneath the lowest *Strophomena planumbona* and *Rhynchotrema perlamellosum* horizon at that locality. Apparently similar strata are well exposed along the Rivière des Hurons, several miles southwest of St. Jean Baptiste, and in the St. Bruno Mountain area, judging from the collections in the possession of the Geological Survey.

PETITE CAROLINE.

Rougemont station is located on the St. Cesaire branch of the Central Vermont railway, about 24 miles east of Montreal, and 11 miles east of Chamblv Canton station. From here a road proceeds 2½ miles northeastward to Petite Caroline station (Figure 1). Near a farmhouse about a quarter of a mile before reaching this station, there is a considerable exposure of horn-

stone on the western side of the road, the volcanic area lying farther westward. This hornstone has been quarried sufficiently to reveal a number of fairly fossiliferous horizons, and no doubt if the collector were present while quarrying is going on a considerable fauna could be collected. The following specimens were secured from the solid rock, to avoid the possibility of picking up fragments carried here by glacial action.

> Glyptocrinus columnals. Heterocrinus columnals. Columnals with radiating striæ. Cornulites flexuosus, Lorraine form of Hall. Dalmanella, common. Plectambonites sericeus, very common. Rafinesquina alternata, one specimen. Leptaena sp. of the rhomboidalis group. Catasyga headi, very common. Eotomaria. Calymene, common.

In the Nicolet River section, Leptaena occurs 825, 1,290-1,345, 1,480, and 1,700 feet below the Strophomena planumbona horizon. The highest horizon for Trinucleus so far discovered occurs 1,560 feet below this Strophomena planumbona horizon. The fauna so far collected does not warrant the definite assignment of the Petite Caroline locality to any of these Leptaena horizons, but provisionally it is placed near the top of the Trinucleus horizon since Leptaena is fairly common at the 1,676foot level in the Nicolet River section and ranges through several hundred feet of the Trinucleus zone as exposed at St. Hyacinthe.

In the report on "St. Hilaire (Beloeil) and Rougemont Mountains, Quebec," Memoir 43 of the Geological Survey, published in 1914, the following fauna, as identified by Professor Charles Schuchert, and found in the locality one-fourth of a mile south of the Petite Caroline station, are recorded:

> Crinoidal columnals very abundant. Dalmanella testudinaria Dalman. Plectambonites sericeus Sowerby. Catazyga anticosciensis Billings? (probably erratica Hall.) Clidophorus, sp. undet. Calymene callicephala Green. Trinucleus concentricus Eaton.

ST. HUGUES OR YAMASKA RIVER.

St. Hugues (Figure 1) is 39 miles northeast of Montreal, on the St. Hyacinthe and St. Guillaume branch of the Canadian Pacific railway, and 12 miles north of St. Hyacinthe. A short distance northwest of the station, a road passes southwest towards the Yamaska river, and half a mile from the railway it reaches the river road turning off northwestward. The river road is in a bad condition but serves to lead the visitor to the river banks about a mile down stream, where the best exposures in this vicinity are found. The locality is a little more than a mile below the mouth of the Chibouet river, on the northeastern side of the river, directly opposite a point where a road comes down the hill from the western side of the river.

The rock is chiefly shale and argillaceous limestone. Here the following fossils were found; occasionally all of those here listed occur in the same slab.

> Crinoid columnals. Dalmanella "testudinaria," very common. Plectambonites sericeus, large. Leptaena invenusta Foerate. Catazyga erratica. Clidophorus, sp. nov. resembling neglectus in outline. Lyrodesma poststriatum. Cyrtolites ornatus. Calymene sp. Triaribrus becki, common in certain layers. Trinucleus concentricus, common in certain layers.

Recently, Mr. R. Harvie, of the Geological Survey, has made a special study of the exposures on the western side of the Yamaska river, from the ferry landing west of St. Hugues for a distance of about 2 miles northward. Fossils were collected at three localities. Locality A is located at the bend of the river about a mile north of the ferry landing, and is about opposite the locality from which the fossils listed above were collected. Locality B lies about a quarter of a mile farther upstream, and nearer the crest of an anticline whose axis crosses the river about a third of a mile below the ferry landing, as indicated upon
the accompanying sketch map (Figure 3). Hence locality B represents fossils from some horizon lower than that at A. Locality C, about 2 miles below the ferry landing, lies south of a syncline intervening between localities A and C, and its relative position with reference to locality A is unknown.

The following fossils were collected by Mr. Harvie at the localities mentioned.

Localities.	A .	B .	С.
Coeloclema commune		x	
Dalmanella "testudinaria"			x
Glyblorthis sp	. .	x	1
Plectambonites sericeus	x		
Leptaena invenusta	x		
Catasyga erratica	x		
Byssonychia radiata		x	1
Colbomva faba	1	x	
Cymatonota pholadis		x	1
Whitella rotund form		x	1
Whitella complanata		x	
Clidophorus planulatus			x
Archinacella pulaskiensis		x	
Sinuites cancellata	1	x	
Pterotheca sp		x	
Isotelus with genal spine 20 mm. long		x	
Triarthrus becki	x	x	x
Trinucleus concentricus		x	

From these lists it is evident that the localities at St. Hugues correspond to the *Trinucleus* zone, as exposed in the Nicolet River section. The *Coeloclema* is found also in the *Leptaena* zone in the Nicolet River section and its presence suggests Eden affinities. The presence of *Pterotheca* in the St. Hugues area is noteworthy, since in the Nicolet River section this genus was represented by a specimen occurring at the top of the *Leptaena* zone. Only fragments of the *Glyptorthis* are known and these represent a more coarsely plicated species than *Glypt*orthis crispata, Emmons.





ST. HYACINTHE.

St. Hyacinthe (Figure 1) is 30 miles northeast of Montreal. The main part of the town is on the western side of the Yamaska river, and south of the Grand Trunk railway, but a bridge crosses the river east of the town and connects with the station on the St. Hyacinthe and St. Guillaume branch of the Canadian Pacific railway. Exposures begin southwest of this bridge, a short distance beyond the mouth of two streams entering the river from the southeast, and extend as far as a dam crossing the river south of the town.

Fossils were collected in the river bed itself, in a single limestone layer located near the northern limit of this line of exposures, and about 15 feet from the eastern margin of the river at low water. Here the following fossils were found.

Heterocrinus columnals. Dalmanella "testudinaria" very common. Byssonychia radiata, very common. Cymatonota pholadis. Clionychia curta (sp. nov.)

5

Lyrodesma poststriatum. Modiolopsis, small species. Cyrtolites subplanus. Lophospira sp. nov., with tall spire Trinucleus concentricus, very common.

Recently Mr. R. Harvie, of the Geological Survey, has made a study of that part of the exposures in the bed of the river which begins at the western angle of the dam and continues down the river a short distance beyond the highway bridge, where the measured part of the section terminates at a major fault, indicated upon the accompanying sketch map (Figure 4). The rocks dip down stream, away from the dam, so that the bottom of the section is at the dam, and the highest part of the measured section is at the major fault. Several minor faults and dykes of igneous rocks are present. The total thickness of the section is 720 feet. Fossils were collected at the localities 1–7, within 10 feet (above and below) of the points indicated by the numbers at the head of the accompanying list of fossils. The direction and amount of dip of the strata investigated by Mr. Harvie also are indicated on the map.



Figure 4. Plan of river bed below the dam at St. Hyacinthe, Quebec.

54

Locality number Distance above base of section	1 20	2 110	3A 150- 220	3 230	4 340	5 460	6 560	7 640
Ohiocrinus cf. geniculatus Ulrich						x		
Lingula				x				
Dalmanella "testudinaria" Dalman				x	x	x	x	
Leplaena invenusta Foerste	x		x	x	x			
Catasyga erratica Hall	x		x					
Zygospira modesta Hall	x							
Byssonychia radiata Hall		x			x			
Clionychia curta Foerste (sp. nov.)				x				
Colpomya faba Conrad					x		x	x
Cymatonota pholadis Conrad	x	x	x	x	x			
Clidophorus planulatus Conrad	x				The second secon			x
Clidophorus brevis Foerste (sp. nov.)	x	x	x		x			x
Lyrodesma poststriatum Emmons	x							
Cuneamya scapha-brevior Foerste							x	
Archinacella pulaskiensis Foerste		x		x				
Sinuites cancellata Hall			x	x		x		
Cyrtolites cf. parrus Ulrich				x		x I		
Trinucleus concentricus Eaton			x	x	x	- x		
Triarthrus becki Green		T	x	-			x	
Calymene callicephala Green	••••		x	x				

List of Fossils Found in the Section Immediately Below the Dam at St. Hyacinthe.

From this list it is evident that the tauna collected by Harvie belongs to the *Trinucleus* zone of the Nicolet River section. Moreover, the major fault at the top of the measured part of the section cannot have been attended with a very great throw, since the fossils collected by the writer farther north, and listed as coming from the northern limit of exposures in the river bed, evidently belong to the same fauna.

The most striking feature of this section at St. Hyacinthe, compared with the corresponding section on the Nicolet river, is the great range of *Triarthrus becki*. As a matter of fact, however, *Triarthrus becki* and *Trinucleus concentricus* range in New York state downward into the Trenton, so that the extended range of *Triarthrus becki* at St. Hyacinthe would not be noteworthy, were it not for the limited range of this species in the Nicolet River section.

The presence of an Ohiocrinus of the geniculatus type also is of interest, since the specimen found can not be distinguished from the species of Ohiocrinus found in the Eden strata at Tamarack point, west of Little Current, on Manitoulin island, in Lake Huron, and the latter differs from Ohiocrinus geniculatus, Ulrich, from the lower Eden, at Cincinnati, Ohio, only in its larger size. The Catazyga is of the erratica type, and the general fauna resembles the Lorraine of New York sufficiently to indicate that the Trenton must lie at still lower horizons than anything exposed at St. Hyacinthe. Cyrtolites parcus Ulrich, occurs in the upper part of the Cynthiana formation at Covington, Kentucky, opposite Cincinnati, Ohio.

BREAULT, ON BÉCANCOUR RIVER.

Breault station (Figure 1) is located 75 miles northeast of Montreal, and 14 miles southeast of Three Rivers, on the Three Rivers and Arthabaska branch of the Grand Trunk railway. The village consists only of a few houses, and a road leads northeastward to a gully entering the Bécancour river less than a mile from the station. Exposures occur at various points in the bottom of this gully, and the following fossils were found toward the upper part of this set of exposures.

> Glyptocrinus columnals. Heterocrinus columnals. Coeloclema commune (determined by Ulrich). Dalmanella "testudinaria." Glyptorthis sp. Byssonychia radiato. Clidophorus. Modiolopsis. Triarthrus becki. Trinucleus concentricus, common.

Much better exposures occur one-eighth of a mile down the river from the mouth of the gully, and elsewhere along the stream, but have not been studied as yet. The Breault locality probably corresponds to the *Trinucleus* zone as exposed in the Nicolet River section, and as exposed also along the Yamaska river, northwest of St. Hugues and at St. Hyacinthe.

ST. AUGUSTIN, SOUTHWEST OF QUEBEC.

(Figure 1.)

F^{if}ty-six miles northeast of the Breault locality on the Bécz .cour river, is St. Augustin, a railway station on the north shot. of the St. Lawrence, about 12 miles southwest of Quebec. East of the railway station, argillaceous shales with graptolites are exposed. West of the mouth of the creek which serves as an outlet for Lac Calvaire, the graptolites are accompanied by *Dalmanella*. Directly south of the west end of Lac Calvaire, along the railway, the following fossils are found:

> Graptolites common. Crinoid columnals. Hallopora sigillarioides. Hemiphragma sp. (determined by Ulrich). Dalmanella, very common. Plectambonites plicatellus, common in certain layers. Zygospira. Rhynchotrema, large form like increbescens. Trisucleus sp. with long genal spines. Trisarthrus becki, not rare.

About an eighth of a mile farther eastward, one-third of a mile before reaching the contact with the Sillery, a conglomerate is exposed, containing the following species:

Streptelasma. Dalmanella. Hebertella. Plectambonites sericeus, large, common. Rhynchotrema.

This conglomerate is believed to belong to the Trenton, and the overlying argillaceous shales to horizons corresponding to the lower part of the Cincinnatian section in Ohio. It is recognized, of course, that a much more extended examination of these beds must be made before definite correlation of these shales east of St. Augustin with Cincinnatian strata be accepted. There is a possibility of these shales turning out to be Trenton, but their Trenton age could not be recognized from the few fossils secured. The total thickness of these shales must be at least several hundred feet, and they certainly belong below the lowest strata so far studied along the Nicolet river, thus greatly augmenting the total thickness of strata supposed to have equivalents in the Cincinnatian section.

It is becoming evident that *Trinucleus concentricus* and *Triarthrus becki* either range through considerable parts of both the lower "Hudson river" and Trenton rocks, or that they are represented in both series of strata at least by closely similar forms, so far not differentiated in the field. Under these conditions it will probably require a very careful collecting of the graptolite and bryozoan elements in the fauna to determine the age of the argillaceous shales east of St. Augustin.

MONTMORENCY FALLS.

(Figure 1.)

The same statement may be made regarding the exposures 6 miles northeast of Quebec, at the Montmorency falls. Here several hundred feet of fissile black shales, such as usually are regarded as representing the typical Utica, rest against the more or less faulted Trenton, and are overlaid, southeastward, along the railway, by softer clay shales containing graptolites and *Triarthrus becki*. Until recently, no one would have doubted the Utica age of the fissile black shales or the Eden age of the overlying strata, but now, apparently, owing to the study by Dr. Ruedemann of lithologically similar strata in the Mohawk valley of New York, the age of these Canadian strata is once more sufficiently in doubt to make further investigation desirable, although the Utica age of Montmorency Falls shales is provisionally taken for granted. In view of the considerable exposures of shales along the St. Lawrence near Quebec, overlying undoubted Trenton limestones, it seems possible that the total thickness of strata in the province of Quebec, corresponding to the Cincinnatian section in Ohio, Indiana, and Kentucky, not including the Queenston shales, may equal 4,000 feet, and including the Queenston may equal 5,000 feet.

RELATIVE STRATIGRAPHIC POSITION OF SOME OF THE QUEBEC PROVINCE HORIZONS.

The following is a crude attempt to indicate the relative position of the various faunas discussed in this report, using the Nicolet River section as a standard of comparison. Being only a first attempt, based upon data so far secured, it is, of course, subject to considerable error, but nevertheless may serve as a guide to future research.

No attempt has been made to indicate the relative positions of the St. Augustin, and Montmorency Falls faunas, but both are regarded as belonging far below the base of the Nicolet River section.

0 feet-Base of Queenston.

- 0 feet-Top of Zygospira kentuckiensis sone, at top of Nicolet River section; exposed also 11 miles southwest of Vars and 2 miles southwest of Hawthorne.
- 55— 100 feet—Erratic blocks northwest of St. Hugues, at St. Hilaire, 12 miles southeast of the village and at Rivière des Hurons, at Strophomena hecuba zone.
- 100- 156 feet-Blocks on hill-side east of St. Hilaire, at Strophomena planumbona zone. Probable horizon also of the Strophomena fluctuosa zone west of Vars.
- 245- 400 feet-At St. Hilaire southeast of station, in Pholadomorpha zone.

700-1,000 feet-At Chambly Canton, and mouth of Rivière des Huron in Proetus sone. Here belong also the exposures 2 miles

northwest of Vars, and west of Hawthorne. 1,700-2,050 feet-At St. Hyacinthe, St. Hugues, and Breault, in Trinucleus zone, including also Triarthrus and Leptaena. The Petite Caroline locality probably also belongs here.

Referring now to the published geological maps of the territory here discussed, the Montreal, Quebec, and Three Rivers sheets, it will be noticed that these determinations fall in very well also with the structure as already unravelled by earlier investigators.

The Ordovician area south of the St. Lawrence river is folded in a direction approximately but not strictly parallel to the Appalachian folding farther southeastward. At present, however, the evidences of this folding are chiefly local, and few of the axes of either the synclines or of the anticlines have been traced for long distances.

Only in case of those synclines which are occupied by remnants of the formerly widespread red Queenston shales, do the published geological maps of this area give any suggestion as to the width and length of any of these synclines.

The most western of the Queenston red clay shale areas mapped in the province of Quebec enters the area of the Montreal sheet (No. 571) from the north. The centre of this area crosses the St. Francis area about 4 miles southeast of Pierreville. The syncline evidently has a southwesterly direction, and in the map the Queenston beds terminate at the David river, about 8 miles north of St. Hugues. Recently, however, the red Queenston shales were struck in the borings for gas in the vicinity of St. Amable, between 4 and 6 miles north of St. Hyacinthe, on the western side of the railway. Here fully 1,000 feet of Queenston beds have been penetrated, and since only glacial deposits cover these beds their original thickness probably was greater.

Connecting the St. Amable localities with the Queenston red shale area, as mapped on the St. Francis river, the syncline should cross the Yamaska river in range III, about $2\frac{1}{2}$ miles northwest of St. Hugues. As far as known, no exposures occur here. The most western exposures mapped by Harvie are about 2 miles west of the mouth of the Chibouet river and belong to the *Trinucleus* zone of the Lorraine. Moreover, the dips in this area indicate a syncline about $1\frac{1}{2}$ miles west of the Chibouet river, and a small anticline about half a mile from the mouth of this river.

However, at St. Hyacinthe the rocks dip distinctly southeast, while the axis of the Pierreville syncline is known to be northwest of St. Hyacinthe, suggesting a narrow synclinal structure here, possibly not exceeding 7 or 8 miles in width. The eastern boundary of the Pierreville syncline is indicated by the presence of the *Trinucleus* division of the Lorraine at St. Hugues, St. Hyacinthe, and east of Rougemont mountain.

The axis of a second syncline occupied by Queenston strata crosses the Nicolet river in the vicinity of Ste. Monique, and according to the map the Queenston shales continue for a distance of 11 miles southwest. About 2 miles southeast of Ste. Monique these Queenston shales are underlaid by fossiliferous strata dipping northwest and the syncline terminates at an anticline whose axis lies about 3 miles southeast of Ste. Monique. Between the southern end of the Nicolet syncline and the northern end of the Pierreville syncline there probably is an anticline, the evidence for which is buried by glacial deposits. The width of the Nicolet syncline may not exceed 7 miles.

Northeastward the Queenston shales occupying the Nicolet syncline are not indicated beyond the Gentilly river, but a third syncline is indicated on the Quebec sheet, No. 375, by a Queenston area beginning about 2 miles west of Forestdale on the Gentilly river and extending northeastward for a distance of 21 miles crossing the Petite Rivière du Chene.

The indentations of Ordovician strata in the Archæan outline north of the St. Lawrence river north of Grondines and Les Ecureuils may indicate prolongations of the Nicolet and Du Chene synclines.

It will be noticed that the Pierreville, Nicolet, and Du Chene synclines have a more northerly direction than the St. Lawrence and Champlain fault. Apparently the resistance offered by the Archæan mass north of the St. Lawrence river to the thrust of the rocks from the southeast produced first folding and then faulting.

Farther southward in the province of Quebec, the Nicolet and Pierreville synclines may terminate in shallow troughs not including the Queenston. So far the evidence for this is not very clear, but the presence of Richmond strata east and southeast of St. Hilaire Station, and on the Rivière des Hurons, 4 miles northeast of Chambly basin, accompanied by the presence of the *Trinucleus* zone of the Lorraine at St. Hugues, St. Hyacinthe, and east of Rougemont mountain at least lends colour to such a suggestion.

The trough of the Pierreville syncline apparently rises toward St. Hilaire and Chambly.

Synclinal structure, judging from the Montreal sheet, dominates the structure of the Ordovician area as far as the Napierville area, 25 miles southwest of Chambly Canton.

NAVAN.

Navan station (Figure 5) is nearly 11 miles east of Ottawa, on the Canadian Pacific line to Montreal (Figure 5); the village is at the crossroads less than a mile northeastward. Continuing along the same road northeast of the village, exposures of the Collingwood black shale with Triarthrus spinosus are met. This shale, formerly identified with the Utica of New York, overlies the Trenton limestone, but the contacts are not seen here. Nearly 2 miles northeast of Navan station, a crossroad turns off southeastward, between concessions VII and VIII, and exposes more of the Collingwood black shale, both north and south of the railway. Half a mile south of the railway, between lots 13 and 14, at a road corner, the basal beds of the strata regarded as equivalent to one of the lower horizons in the Cincinnati group. consisting of brownish argillaceous strata containing Pleciambonites sericeus, are found. Dalmanella and Triarthrus becki occur 11 miles southeast of this road corner, at the bridge across Bear creek, along the road leading southeast to Vars. These lower strata correspond to the lower Eden of the Cincinnatian sections in Ohio and neighbouring states.

VARS.

Two miles and one-half southeast of the road corner at which the lowest exposures regarded as having equivalents in the Cincinnatian section of Ohio, Indiana, and Kentucky occur, at a road crossing between concessions VII and VIII, and 11 miles south of the bridge mentioned in the preceding lines, there are several good exposures of clay shales interbedded with fine-



grained, harder, siliceous, shaly layers. The locality may be reached also by going from Vars station (Figure 5). 15 miles east of Ottawa, on the Grand Trunk railway, first three-fourths of a mile westward along the railway track and then a mile northwestward, to the road crossing mentioned above. The strata are richly fossiliferous here. Some fossils were collected at a bridge, west of the road crossing; others were found south of the crossing. The following is a list of the species seen:

Glyptocrinus columnals. Bryozoan impressions. Dalmanella sp. Rafinesquina mucronals Plectambonites sericeus. Zygospira ruodesta. Pholidops subtruncata. Byssonychia radiata. Clidophorus praevolutus. Cymatonota pholadis, near recta, Ulrich. Cunsamya cf. neglecta Hall, non Meek. Lyrodesma poststriatum. Psilonychia sinuata. Rhytimya granulosa. Eotomaria nearest canalifera. Acidaspis free cheek. Calymene sp. Proetus chambliensis. Bythocypris cylindrica. Ctenobolbina cf. ciliata.

The horizon at which these fossils were obtained is regarded as considerably below the lowest strata containing *Pholadomorpha pholadiformis* and *Modiolopsis concentrica*. On the other hand, it is regarded also as distinctly above those horizons in the Cincinnatian sections in which *Leptaena* occurs associated with *Trinucleus* and *Triarthrus*. For the present, it is correlated with the upper part of the *Proetus* horizon, as exposed at Chambly. Along the Nicolet river, this horizon belongs about 600 feet below the lowest *Strophomena planumbona* zone, which occurs at the base of the strata there correlated with the Waynesville of Ohio.

Three-fourths of a mile southeast of the road corner last discussed, south of a stream crossing, there is another fossil locality. It may be reached by going from Vars three-fourths of a mile westward, along the railway track, and then nearly half a mile northwest along the road.

At this locality, sandy, shaly, fine-grained strata occur interbedded with clay, on both sides of the road. The following species were found: Glyptocrinus columnals. Rafinesquina mucronata, Plectambonites sericeus. Pholidops subtruncata. Clidophor**us praevolu**tus. Pterinea demissa. Proetus chambliensis.

No difference could be noted between this fauna and that at the crossroad, nearly a mile northwestward. However, at this more southern locality there are also numerous loose blocks in the field east of the road, and some along the road itself, which are regarded as residual blocks from some higher horizon, brought in contact with rocks belonging to the *Proetus* zone by faulting. These blocks contain the following species:

Plectambonites sericeus. Hebertella occidentalis. Strophomena sulcata. Rafinesquina mucronata. Zygospira modesta. Catazyga headi. Pholidops subtruncata. Clidophorus praevolutus. Clathrospira subconica.

It is probable that these blocks are from a horizon corresponding approximately to the *Strophomena sulcata* horizon in the lower part of the richly fossiliferous Richmond zone in the Nicolet River section, between 60 and 70 feet above the lowest strata containing *Strophomena planumbona* and *Rhynchotrema perlamellosum*, but the presence of *Catasyga* suggests a somewhat lower horizon.

HAWTHORNE.

A similar fauna lacking Strophomena sulcata, however, is found also elsewhere in those strata east of Ottawa which have equivalent horizons in the Cincinnatian strata of Ohio and Indiana. For instance, along the railway a mile northwest of Hawthorne station (Figure 5), about 3 miles east of the Rideau river at Ottawa, the following species occur in the thin limestones interbedded in the clay shales:

Gipptocrinus columnals. Bryozoan casts. Cornulites. Pholidops subtruncata. Dalmanella Plectambonites sericeus. Rafinesquina mucrona!a. Hebertella occidentalis. Zygospira modesta. Ctenodonta lorrainensis. Lyrodesma poststriatum. Pterinea domissa, small. Calymene. Proetus chambliencis. Bythecypris cylindrica.

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This fauna is correlated with the *Proelus* zone of the Nicolet River section.

In the neighbouring fence corner, sandstone boulders are so numerous that it may be assumed that they were picked up in making the road bed for the railway. These sandstones are very fine-grained, of a brownish colour, and fairly soft; they evidently represent the weathered remains of the very fine-grained siliceous limestone so characteristic of the so-called Lorraine of this part of the country. Most of the sandstone slabs vary between 11 inches and 2 inches in thickness. They contain the following fauna, in addition to some of those in the preceding list, especially *Plectambonites sericeus* and *Rafinesquina mucronata*:

Hebertella occidentalis. Byssonychia radiasa. Catasyga headi. Isotelus.

Among the sand with slabs there are some limestone blocks, containing:

Plectambonites sericeus, very common. Rafinesquina mucronata. Hebertella occidentalis, common.

RAMSAY STATION.

Along the same line of railway, the New York and Ottawa, 5 miles southeast of Ottawa, is Ramsay station (Figure 5). About a mile west of the station the Ottawa pike crosses a branch of Greens creek. Following the creek westward as far as the church, the following fossils are found in the clay shales and the interbedded sandy layers or fine-grained limestones.

Glyptocrinus columnals. Heterocrinus columnals. Cornulites. Pholidops subtruncata, common. Dalmanella, common. Hebertella. Plectambonites sericeus, common. Zygospira modesta. Byssonychia radiata. Pterinea demissa. Acidaspis, free cheek.

Mr. W. R. Billings has in his possession specimens of *Catazyga headi* obtained from this locality. Lithologically the rock resembles that found in the *Proetus chambliensis* zone.

CONCLUDING REMARKS.

In examining the fauna of the various Lorraine exposures east of Ottawa, and thence northeastward as far as Quebec, the absence of the most characteristic Lorraine fossil, Modiolopsis modiolaris, is striking. Not less noteworthy is the absence of such forms as Ischyrodonta curta, Orthodesma nasutum, Glyptorthis crispata, and Rafinesquina nasuta. Moreover, the Trinucleus, so common east of Pulaski and for several miles east of Lorraine, in New York, occurs in the Lorraine of the province of Quebec only at much lower horizons. On the contrary, the Proetus chambliensis which is so common at certain horizons in the Lorraine of the province of Quebec, is unknown in the Lorraine of New York, and must be at least very rare, there.

The conclusion seems inevitable that the Lorraine of New York and the Lorraine of Quebec and of the extreme eastern portion of Ontario represent sedimentations in different basins, sufficiently distinct to make possible the differences in fossil content here noted. The Frontenac axis which is indicated by outcrops of the Pre-Cambrian, extending in a general north and south direction through the Thousand Island region, appears to have been sufficiently developed in later Ordovician time to have separated the Quebec basin from that part of New York which borders the eastern part of Lake Ontario, and also from that part of Ontario which lies between the northern shore of Lake Ontario and Georgian bay.

WESTERN ONTARIO.

The typical Maysville fauna, with its numerous forms of *Platystrophia*, its various species of *Plectorthis*, and its *Strophomenas* of the *planoconvexa* group, is not present in Canada. The various representatives of the Maysville fauna identified so far consist chiefly of bryozoans, suggesting the presence of strata belonging somewhere between the top of the Fairmount and the typical Bellevue members. as exposed in the vicinity of Cincinnati. The number of these bryozoan species is not great. They represent a meagre incursion from the south into the region between Manitoulin island and the areas surrounding Toronto. Eastward, this Maysville bryozoan element is even more sparingly represented in the Pulaski of New York.

The lamellibranch fauna of the Pulaski of New York apparently finds close relatives in the strata which intervene between the top of the Fairmount and the base of the typical Bellevue, at Hamilton, Ohio. This appears, however, to have been a southward migration of a northern fauna rather than a northward migration of a southern one.

In general, the faunas of those Canadian strata which most nearly approach the Maysville in time, appear to have been northern faunas, possibly also in large part of northeastern origin. There is no evidence of the presence, in Ontario or Quebec, of the typical Mount Hope, Fairmount, Corryville, or Mount Auburn members of the Maysville, as represented in the Cincinnatian areas.

It is doubtful whether the typical Lorraine of New York has any wide extension in the area west of the Frontenac axis in the province of Ontario. Such typical upper Lorraine forms as Orthodesma nasutum, and Ischyrodonta curta are known within this area, only from Weston, 3 miles northwest of Toronto, although Hall figured a specimen of Ischyrodonta curta from Grimsby, along the southern shore of Lake Ontario; but this must have been an erratic specimen. Modiolopsis modiolaris, another characteristic upper Lorraine form, is not known from any part of Ontario. The only characteristic New York upper Lorraine fossil found also in the supposed Lorraine of Ontario is Pholadomorpha pholadiformis, but the value of this fossil in identifying the Lorraine in Ontario is destroyed by the fact that it occurs in the provinces of Ontario and Quebec, as well as in Ohio, Indiana, and Kentucky, also throughout the Waynesville member of the Richmond. In these circumstances, the only reason for identifying any of the strata, in Ontario, which contain Pholadomorpha and which occur beneath undoubted Richmond strata, with the Lorraine of New York instead of the Richmond of Ohio, is the fact that Dr. E. O. Ulrich determined the bryozoans in the Pholadomorpha zone of the so-called Lorraine, which occur beneath undoubted Richmond strata, on

Manitoulin island, and at corresponding horizons near Meaford, on the south shore of Georgian bay, as of middle Maysville rather than of Richmond age. It is, therefore, chiefly these bryozoa which suggest the Maysville age of those *Pholadomorpha*-containing beds in the province of Ontario which have the lithological aspect of Lorraine strata. In making these statements, however, I wish to emphasize the fact that only a few species of bryozoans were found in these supposed Lorraine strata in Ontario, and that further collections might modify considerably conclusions based on the few species of bryozoans hitherto collected. These further collections of bryozoan material I have not had the opportunity, so far, to make.

The element of doubt as to the correctness of the correlation of the upper part of the Lorraine-appearing strata in Ontario with the top of the Lorraine in New York is increased also by the presence of some of the other fossils associated with *Pholadomorpha* in these strata. For instance, north of the railway bridge at the southeastern end of Streetsville, 18 miles west of Toronto, *Opisthoptera fissicosta*, a typical Richmond form, is seen in the upper part of the Lorraine-like strata, and *Strophomena sulcata* another typical Richmond form, occurs at least 50 feet lower in the section. In fact, the Lorraine-like *Pholadomorpha* zone at Streetsville may be referred definitely to the Richmond.

This upper Lorraine-like zone appears to contain a considerable fauna and it is exposed at a sufficient number of localities in southern Ontario to invite further study. In the valley of the Humber river, on the western side of Toronto, there must be some good upper Lorraine exposures since a considerable number of species from this locality are represented in the collections of the Royal Ontario National Museum at Toronto. Exposures occur also at other localities northwest of Toronto, along the southern shore of Georgian bay, and on Manitoulin island. However, I have had no opportunity to give these more than a very superficial examination. In general, it may be stated that while it is not regarded as impossible that *Pholadomorpha* may occur in strata of Maysville as well as in those of Richmond age, it is probable that further research will place at least the upper part of these so-called Lorraine Pholadomorpha-containing strata more or less definitely in the Richmond.

The lower parts of the supposed Lorraine of Ontario are well exposed at numerous localities near Toronto, on the south shore of Georgian bay, and on Manitoulin island. These require, however, much further study. Indeed, their study can scarcely be said to have begun. Enough has been seen to indicate that they contain a considerable fauna, including bryozoans. The present state of knowledge scarcely warrants any attempt to correlate these lower strata with definite parts of the New York Lorraine section. The possibility of correlation of some parts of the southern Ontario Lorraine with a part of the Lorraine as exposed in the province of Quebec is suggested by the exposure in the Don Valley brick-yards, in the eastern part of Toronto. Here there is a zone at which a Leplaena of the rhomboidalis group is associated with Catazyga erratica and Trinucleus concentricus. This association of fossils is strongly suggestive of that between 1,395 and 1,550 feet below the lowest horizon containing Strophomena planumbona and Rhynchotrema perlamellosum, in the Nicolet River section. The associated bryozoan fauna suggests Eden and lower Maysville affinities. It is possible that when these faunas are carefully collected they may be found distinctly separable into an upper, Maysville, and a lower, Eden, zone, but so far the bryozoans have been collected indiscriminately, and it is fortunate that they have attracted sufficient attention on the part of local collectors to have been preserved at all. Evidently much remains to be learned regarding the supposed Lorraine strata of the province of Ontario. At present, the chief point of interest so far suggested by previous studies appears to be the fact that the Lorraine of Ontario presents much more in common with the Eden and Maysville of Ohio, Indiana, and Kentucky, than with the Lorraine of the province of Quebec, while it presents scarcely anything which might be called characteristic in common with the typical Lorraine of New York, unless the exposures at Weston, northwest of Toronto, are regarded as an exception.

Catazyga erratica has a very restricted vertical distribution in the Lorraine of Ontario. Glyptorthis crispata is unknown there. Even such common New York forms as Pholidops subtruncata, Archinacella pulaskiensis, Clidophorus planulatus, Colpomya faba-pusilla, and Ctenodonta lorrainensis, either are absent or are sufficiently rare not to have been found as yet.

Calcareous strata are more common in the Lorraine of Ontario than in the typical Lorraine of New York, and it is in association with these calcareous strata that the bryozoans become more numerous. It is chiefly the bryozoans which suggest the affinity of the Canadian representatives of the Lorraine with the Maysville and Eden of Cincinnatian areas.

BETWEEN GEORGIAN BAY AND LAKE ONTARIO.

TORONTO.

So numerous are the outcrops of the upper and lower Lorraine-like strata in the vicinity of Toronto, within a radius of 20 miles (Figure 6), that eventually a very interesting fauna will be collected. It is quite evident that no serious study of these faunas nas been attempted as yet, since only a few of those species actually collected have been carefully identified.

Considering the close vicinity of the Don Valley brick-yards to Toronto, it is remarkable how little definite information is at hand regarding the vertical range of any of the species found at that locality. To unravel this will require the close attention of some one located sufficiently near the quarry to examine the material from each level in succession, while different parts of the quarry face are cut away.

At one horizon in the Don Valley brick-yard, Leptaena rhomboidalis cf. variety invenusta, occurs associated with Catazyga erratica and Trinucleus concentricus. Associated in the same layer are various bryozoa among which Dr. E. O. Ulrich identified a species of Aspidopora and one of Bythopora, both suggesting Eden affinities, and also Hallopora communis and Spatiopora maculosa, both suggesting lower Maysville relationship.

In the same manner, a miscellaneous collection of bryozoa submitted to Dr. Ray S. Bassler, from the Don Valley brick-yard quarry, by Prof. W. A. Parks, included a mixture of Eden and





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Maysville forms. The various members of the Maysville formation, in Ohio, in the order of their succession, from top to bottom, are:

> Mount Auburn. Corryville. Bellevue. Fairmount. Mount Hope.

The following species were identified by Bassler from the Don Valley brick-yard quarry:

Atactopora maculata......Fairmount member of Maysville horizon at Cincinnati.

. Mount Hope and Fairmount members.
.Mount Hope member of Maysville.
. Upper Eden to Corryville member of Maysville.
.All Eden and Mount Hope member of Maysville.
.All Eden.
.All Eden.
.Eden form.
.Eden form.
.Eden form.

Notwithstanding these careful determinations by Dr. Bassler, it is impossible at present to make even a suggestion as to where the line is to be drawn, within the Don Valley brick-yard, between the Eden and Maysville. There is no lithological change to be noted in the quarry face, suggesting an important time break, and none of the horizons for any of the species have been determined.

Dr. Bassler determined also the following species from some unknown locality near Toronto:

Spatiopora cf. maculosa....Fairmount member of Maysville. Paleschara cf. beans......Eden formation.

From Weston, 3 miles northwest of the northwestern boundary of Toronto, he identified

The upper zones of the supposed Lorraine strata in the vicinity of Toronto, are exposed on the Humber river, west of Toronto, as already indicated. The fossils found here belong to the *Pholadomorpha pholadiformis* and *Modiolopsis* cf. concentrica zone, but they have not been studied as yet.

Whitella hindi, from the vicinity of Toronto, which was described by Billings, probably came from the upper Lorraine as exposed along the Humber river.

Diplograptus hudsonicus from the Hudson river, on the lake shore at Toronto, and from Weston, was described by Nicholson. The best specimens are said to have come from flags brought to Toronto, probably from some quarry on the Humber. Along the Humber the Pholadomorpha zone in the upper part of the Lorraine is exposed, and at this horizon on Manitoulin island Diplograptus vespertinus Ruedemann, is widely distributed. At the Leptaena horizon in the lower Lorraine, at the Don Valley brick-yards, Climacograptus (Mesograptus) putillus was identified by Ruedemann. Without having access to the types of Diplograptus hudsonicus it is impossible to identify this species, but it seems possible that it may have been Diplograptus vespertinus or some other variety of Diplograptus quadrimucronatus.

WESTON.

The village of Weston (Figure 6) is located about 3 miles northwest of the present northwestern boundary of Toronto. West of the middle of the village a bridge crosses the Humber river, and exposures extend from this bridge for about a mile southward. One of the bluffs on the west side of the river has a vertical exposure of about 20 feet and another bluff on the east side exposes about 40 feet of rock and shale. The clay shale largely predominates, but the fossils can be detected most readily in the interbedded rock layers.

The following species were identified from the strata exposed along the river bank in a total section probably not exceeding 40 feet.

Plectambonites sericeus. Rafinesquina alternata, flat form. Rafinesquina mucronata. Catazyga erratica. Pterinea demissa. Byssonychia radiata-borealis. Modiolopsis concentrica. Pholadomorpha pholadiformis. Colpomya faba. Cymatonota lenior. Ischyrodonta curta Lyrodesm posstriatum. Cyrtolites ornatus. Ciathrospira subconica. Cyclonema bilix. Loxoceras with vertical colour marking on inner layers of shell. Endoceras sp. Calymene sp. Arthraria, 5 inches in length.

A'bout half a mile southwest of the bridge at Weston, along the pike following the western side of the Humber valley, and 60 feet above the level of the exposures in the river bed at the bridge, a small tile ditch at the margin of the field exposed rock containing numerous specimens of *Catazyga erratica* associated with a typical specimen of *Orthodesma nasutum* Conrad.

The presence of Ischyrodonia curta and Orthodesma nasuium in association with Catazyga erratica and Pholadomorpha pholadiformis appears to establish the presence of the upper Lorraine of New York in these exposures along the Humber river, at Weston. The Ischyrodonta curta was found on the western side of the river where a vertical exposure of about 8 feet of rock occurs a short distance down stream from the 40-foot bluff exposure on the eastern side of the river. Several specimens occurred in the same layer with Catazyge erratica, Pholadomorpha pholadiformis, Byssonychia radiata, Colpomya faba, Clidophorus planulatus, and Lyrodesma poststriatum. The Cymatonota lenior occurred just beneath. The species of bryozoa identified by Dr. R. S. Bassler from the vicinity of Weston, namely Bythopora gracilis and Hallopora sp., and regarded by him as suggestive or Maysville age, probably came from the Pholadomorpha zone in the so-called Lorraine at Weston. Several species of bryozoans, recently collected by the writer from this zone at Weston, failed to show any definite Richmond affinities. Hence the possibility remains that the lower part of the Lorraine-like strata forming the Pholadomorpha zone in Ontario may be of Maysville age, an age also favoured by Dr. Ulrich for the Pholadomorpha zone at the top of the typical Lorraine in New York.

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RELATIVE STRATIGRAPHIC POSITION OF CERTAIN LORRAINE EXPOSURES IN SOUTHERN ONTARIO.

Eventually it probably will be possible to determine more exactly the relative stratigraphic position of the various Lorraine exposures in southern Ontario. For the present the following data must suffice.

At Streetsville the fossiliferous Richmond strata immediately beneath the red Queenston shales atta an elevation of about 525 feet above sea-level. At Oakville, about 9 miles almost directly southward, the highest fossiliferous layers beneath the Queenston shales are about 330 feet above sea-level. If the same rate of dip occurs between Weston and Mimico, a distance of about 6 miles, then the strata in the river bed at the Weston bridge should occur at the lake level at Mimico, while the Orthodesma nasutum horizon, 60 feet above the river bed exposures at the Weston bridge, should occur near the railway level at Mimico.

According to well borings, the Trenton at Mimico is reached at 376 feet below sea-level, and the Trenton at Clarkson, 9.5miles southwest, is reached at 538 feet below sea-level. At the same rate of dip any rock at the level of the railway at Mimico should occur about 250 feet below the highest exposures of the fossiliferous Richmond rock beneath the Queenston at Oakville.

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If the same dips prevail in the Toronto area, then the top of the exposures at the Don Valley brick-yard, about 5 miles northeast of Mimico, should belong stratigraphically about 170 feet beneath any rocks which occur at railway level at Mimico.

If the preceding calculations have any value at all, the following conclusions may be drawn:

At Streetsville, Strophomena sulcata is rather common in some of the layers exposed at the foot of the bluff west of the Credit river, northeast of the home of William Crozier, about $1\frac{1}{2}$ miles south of the Coral zone exposure, opposite the middle of the village. According to crude Locke level measurements, this Strophomena sulcata horizon occurs about 72 feet below the Coral zone exposure. Correcting for the dip, an interval of 50 feet appears ample. The Orthodesma nasutum zone of Weston should occur about 200 feet below the Strophomena sulcata zone at Streetsville, and the Ischyrodonta curta zone at Weston may occur 80 feet below the Orthodesma nasutum zone at the same locality, making allowance for the dip.

The top of the exposure at the Don Valley brick-yard should be 170 feet beneath the Orthodesma nasutum zone at Weston, stratigraphically, or 90 feet below the Ischyrodonta curta zone at the same locality. The exact horizon for the Leptaena invenusia horizon at the brick-yard is unknown at present, but it certainly occurs some distance below the top.

The interval from the top of the exposure at the Don Valley brick-yard to the top of the Trenton is estimated at 470 feet, giving a total of 790 feet from the base of the Coral zone to the top of the Trenton, and a total of 835 feet from the base of the Queenston to the top of the Trenton.

In the Beachville well this interval between the Queenston base and Trenton top is given as 695 feet. At Clarkson, a well passed through 800 feet of these strata before reaching the Trenton, but did not begin as high as the base of the Queenston. At St. Catharines, about 35 miles south of Toronto, a well passed through 868 feet between the Queenston base and the top of the Trenton.

Probably the estimate of 835 feet given above for the total thickness of the strata between the base of the Queenston and the top of the Trenton in the Toronto area is at least approximate. The thickness of the Utica part of this section is not definitely known. Estimating it at 150 feet, the interval between the Queenston base and the top of the Utica becomes 685 feet. Moreover, the top of the Don Valley brick-yard exposures in that case should be about 320 feet above the Utica.

According to these measurements, *Pholadomorpha phola*diformis has a known vertical range of 330 feet in the Toronto area. How much farther down it may occ. is unknown, but if the top of the Don Valley brick-yard exposure occurs only 170 feet lower than the *Ischyrodonta curta* horizon at Weston then it is worth while remembering that *Pholadomorpha* is unknown at the brick-yard, and the *Trinucleus* fauna, which is a distinctly lower fauna, occurs here.

In the upper part of its range *Pholadomorpha* occurs in strata unquestionably Richmond. In the light of recent discoveries the strata at Streetsville as far down as the *Strophomena sulcata* horizon are also regarded as Richmond (see page 133). At Weston the Richmond base is not definitely located as yet. The underlying horizons, in which *Catazyga erratica*, *Orthodesma nasutum*, and *Ischyrodonta curta* occur associated with *Pholadomorpha pholadiformis* are regarded still as debatable ground, left for the present in the Lorraine, since in New York they unquestionably belong in the Lorraine.

Possibly the uppermost parts of the Lorraine section of New York, as represented at the Salmon River falls, include strata belonging stratigraphically above the *Ischyrodonta curta* and *Orthodesma nasutum* horizons, and correspond to those strata at and above the *Strophomena sulcata* horizon at Streetsville which are referred here to the lower Richmond.

In a similar manner future investigations may be expected also elsewhere to add to the Richmond division a part of the strata at present left in the upper part of the Lorraine on account of lack of evidence demanding their reference to a higher horizon.

The considerable vertical range of *Catazyga erratica* in the Toronto area also deserves some attention. At the Don Valley brick-yards it occurs at least as lowas the middle of the exposures. Estimating the interval between the top of the brick-yard exposure and the *Orthodesma nasutum* horizon at Weston at 250 feet, the vertical range of *Catazyga erratica* in the Toronto area certainly exceeds 280 feet and may equal 500 feet.

In the Meaford area, specimens of *Catazyga*, identified as *erratica*, occur as high as the lowest beds containing *Strophomena planumbona*, and it is only in the overlying beds that *Catazyga headi* has been identified with confidence.

WORKMAN BROOK, SOUTHEAST OF MEAFORD.

Along Workman brook, about 3 miles southeast of Meaford, (Figure 6), there are almost continuous exposures of strata resembling the Lorraine, but there is no great variety of fossils present, and the bryozoans appear to be confined to few species.

The base of the strata definitely referred to the Richmond is placed provisionally at the 325-foot level above the lake, where *Catazyga* occurs associated with *Strophomena planumbona* (see page 127). The upper part of the underlying strata also eventually may be referred to the Richmond, but at present the bryozoan contents suggest an earlier age. At 288 feet above the lake, according to Locke level measurements, *Orthoceras* is common, associated with numerous specimens of a species of *Stigmatella*. The same species of *Stigmatella* occurs in the overlying strata as far up as the *Strophomena planumbona* layer. Farther down stream a fence crosses the brook, and between this fence and a small wooden bridge across the brook, between 260 and 265 feet above the lake, the following species were found:

	Vertical range at	Cincinnati.
Spatiopora aspera	.Basal Bellevue.	
Discotrypa cf. elegans	.Basal Bellevue.	
Stigmatella, tubercular form, cf. nicklesi	.Basal Bellevue.	

Down stream from the small wooden bridge, between the 220 and 215-foot levels, *Stigmatella* and *Discotrypa* cf. *elegans* were found. *Taeniaster meafordensis* was very abundant in a thin layer a short distance farther down the brook. At 208 feet above the lake *Stigmatella* was present. At 203, a large *Rafinesquina* and a single well preserved *Catazyga erratica* were seen. Loose specimens of the *Stigmatella* occur as low as the 200-foot level. The bryozoans so far mentioned suggest the presence of lower Bellevue beds between the 200 and 325-foc⁺ levels along Workman brook.

At 191 feet above the lake, gasteropods are fairly abundant in a thin layer. At the 167-foot level, *Catazyga erratica* occurs associated with a large form of *Plectambonites sericeus*; and *Rafinesquina mucronata*, and a variety of *Orthodesma canaliculatum* occur at the 154-foot level. The only bryozoan found between the 167 and 189-foot levels was a species of *Eridotrypa*. The level of the driveway at the bridge crossing the brook at the pike is 142 feet above the lake, according to the Locke level. Between this 142-foot level and the lower Catazyga erratica horizon, at 167 feet, the following species were found:

	Vertical range at Cincinnati. Base of Bellevue.
Coelociema sp	Basal Bellevue.
Dekayia appressa	
Helerolrypa Cl. Injectio	Base of bellevue.
Perenopora compressa	Above the Fairmount.

The following specimens were found loose at the bridge levels along Workman brook.

Stigmatella sp.

Hallobora cf. dalei or nodulosa.....Below the Bellevue at Cinncinnati.

The bryozoans collected between the bridge level and the lower Catazyga erratica horizon, according to Dr. E. O. Ulrich, suggest lower Bellevue affinities. They belong above the Fairmount and below the ordinary Bellevue as seen at Cincinnati. but are found intercalated in the lower part of the Bellevue as exposed at Hamilton, Ohio, where the Bellevue is much thicker than at Cincinnati. This intercalated basal Bellevue in the Hamilton area appears to represent an invasion from the north.

Lying loose in the bed of Workman brook, at various levels above the bridge horizon, are slabs of arenaceous limestone, quite angular and evidently not transported far, in which Pholadomorpha pholadiformis and a form of Modiolopsis belonging to the concentrica group occur. In Ohio, these forms have long been regarded as characteri . of the lower Richmond, being especially common in the lower or Fort Ancient division of the Waynesville member. Along Workman brook, and a* various other localities in Canada, however, these or closely related forms are fairly common in strata whose bryozoan elements according to Dr. Ulrich, suggest a lower Bellevue age. To one familiar with the stratigraphic succession in Ohio this proves very disconcerting. I must frankly acknowledge that I should like to see the bryozoan evidence very much increased before accepting the conclusions to be derived from the few species known so far without a certain hesitancy, and so, I have no doubt, would Dr. Ulrich. The correlations here suggested are merely tentative, and are based upon such meagre evidence as is at hand.

Most of my notes on the Workman Brook section have been lost. The preceding account contains most of the information which is still at hand. To these notes it is possible to add only a few g netal impressions which remain in memory.

In the vicinity of the bridge across Workman brook, the strata have a Lorraine-like aspect. This aspect continues for a short distance below the level of the abutments of the bridge, the latter being estimated as standing about 132 feet above lake level. Here the comparatively unfossiliferous, Lorraine-like, arenaceous, fine-grained, thin-bedded limestones, interbedded with clay, rest upon a section in which clay shale predominates very largely. Intercalated with these clay shales are occasional, even more thinly bedded, but coarser grained limestones, which contain an Eden fauna, similar to that found at various localities beneath the Pholadomorpha zone on Manitoulin island. Descending the creek, the lower two-thirds of the Eden section consists almost entirely of clay shale, in which fossils are very rare. Trinucleus occurs in a layer about 25 feet above the lake level. No trace of the Collingwood black shale is exposed, although this shale may occur only a short distance below the lake level.

Workman brook enters the lake at the western end of the great clay cliffs west of Boucher point. In attempting to estimate the height of these cliffs by means of a Locke level, an estimate of 148 feet was made. The slopes of these clay cliffs are covered with talus from the upper layers here exposed. Numerous bryozoan fragments belonging, however, to few species, were collected. Some of these were submitted to Dr. E. O. Ulrich at the same time that the specimens from the Eden formation, $2\frac{1}{2}$ miles north of Wekwemikongsing, on the eastern shore of Manitoulin island, were being examined and both were pronounced as of essentially the same age.

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Another section is exposed in a gull, perhaps half a mile southeast of Boucher point at loca'ity 10. The base of the gully is located south of the pike. The rocks exposed in the gully belong to the *Pholadomorpha* zone or the upper part of the supposed Lorraine section. The base of the more richly fossiliferous part of the Richmond occurs 150 feet above the railway, and the latter is about 165 feet above the lake, according to the Locke level. The richly fossiliferous part of the Richmond evidently corresponds most nearly to the Waynesville member, as exposed in Ohio and Indiana, and the underlying strata have a Lorraine-like aspect and belong to the series which on Manitoulin island contain *Pholadomorpha pholadiformis*.

In the Workman Brook section at locality 7 the occurrence of Catazyga at the 349, 325, 203, and 167-foot levels is noteworthy. Of the Catazygas, those occurring at the 167, 203, and 325foot levels resemble erratica in having a broad shallow depression along the median parts of the brachial valve, but the pedicel valve is not distinctly flattened along the median parts. The Catazyga at the 349-foot level, is the species headi. If the Catazyga at the 325-foot level, where it is associated with Strophomena planumbona, were a typical form of Catazyga headi, then Catazyga here might prove a diagnostic fossil in the Meaford area, the typical Catazyga headi suggesting Richmond affinities and the forms resembling Catazyra erratica suggesting Lorraine affinities. However, I was unable to recognize the form at the 325-foot level, which I regard as a Waynesville horizon, as distinct from the Catazygas at the 203 and 167 foot levels, for which the associated bryozoans appear to suggest Lorraine affinities.

MANITOULIN ISLAND.

SOUTH OF CLAY CLIFF.

Along the eastern margin of Manitoulin island (Figure 7, locality 8), at Clay cliff, 3 miles north of Wekwemikongsing, the richly fossiliferous Waynesville beds are well exposed far above the level of the lake and the Waynesville rubble covers the entire underlying slope as far as the margin of the lake (see pages 12^{4} . $^{\circ}6$). About a quarter of a mile south of the high Waynes, we cliffs there is a much lower abrupt exposure, 30 feet



in height, in which the prevailing clays are interbedded with siliceous limestone layers, some of which weather into strata resembling the so-called Lorraine sandstones. Here Plectambonites sericeus, a small Rafinesquina, Hebertella occidentalis, Dalmanella, Zygospira modesta, Cyrtolites carinatus, Ctenodonta cf. filistriata, Lophospira tropidophora, Cornulites, Pterinea demissa, and Calymene are found.

From this locality, Dr. Ulrich identified the following species of bryozoans:

Vertical range at Cincinnati.

Vertical range at Cincinnati.

Arthropora sp.	
Bythopora dendrina	Upper Fairmount.
Dekayia pelliculata	Upper Fairmount.

On the basis of the bryozoans here collected, Dr. E. O. Ulrich refers these strata to the Maysville, somewhere near the Bellevue bed. Apparently two horizons are present, since among another series of bryozoans collected at the same locality he identified:

Amplexopora persimilis	Lower Eden.
Arthropora sp.	
Hallopora communis	All Eden.
Hallopora sigillarioides	All Eden.
Coeloclema commune	All Eden.
Dekayella ulrichi	All Eden.
Eridotrypa sp.	
Stiematella sp. cf. clavis	Eden.

This confusion of evidence apparently suggests the presence of two formations within the short vertical range of 30 feet, but no lithological changes indicating a break were noted. Of course, this part of the section requires detailed study.

Going half a mile southward along the shore toward Wekwemikongsing, the horizons intervening between this bryozoan zone and the base of the Waynesville are exposed, since the dip of the rock is southward. The upper part of this intervening zone includes fine-grained, arenaceous limestones which have a strong resemblance lithologically to the Lorraine of New York. In these limestones *Pholadomorpha pholadiformis* and
a form of Modiolopsis resembling concentrica occur associated with Byssonychia radiata, Pterinea demissa, Lyrodesma poststriatum, Clidophorus planulatus, a large Ctenodonta belonging to the pectunculoides group, Cyrtolites ornatus, and a graptolite identified by Dr. Ruedemann as Diplograptus foliaceus-vespertinus. The peculiar dumb-bell impression, described by Billings as Arthraria, is represented by specimens about 4 inches in length.

This is one of the best collecting grounds for the *Phola*domorpha zone fauna on Manitoulin island, although excellent specimens occur also in the talus dropping from the cliffs at Gorrel point, 2 miles northeast of Gore bay.

SHEGUIANDAH ROAD, 3 MILES SOUTH OF LITTLE CURRENT.

The Collingwood black shales merge so gradually into the overlying softer, more argillaceous, and lighter coloured shales, on Manitoulin island, that it is difficult to determine exactly where the line at the base of the Eden is to be drawn. This difficulty is increased by the great scarcity of fossils, at least of diagnostic fossils, near the supposed base of the Eden, on Manitoulin island and along the southern side of Georgian bay.

The richly fossiliferous zones of the Eden south of Little Current occur fully 100 feet above the typical Collingwood shales. To Dr. Ulrich, Dr. Bassler, and Prof. Nickles the bryozoans collected in these Eden zones on Manitoulin suggested the presence of the upper part of the Economy or the lower part of the middle or Southgate divisions on the Eden. The Eden fauna is not known west of Lake Huron, but it is present around Toronto, and appears to be present also in the lower half of the Lorraine, below the Pulaski zone, east of Lake Ontario, in New York, and in the lower parts of the so-called Lorraine in the eastern part of Canada, east of the Frontenac axis. It is so sparingly represented in Canadian areas that it must have been a southern invasion there from the areas surrounding Cincinnati.

Within the eastern limits of Little Current, on Manitoulin island, the base of the Collingwood shale is exposed near the upper margin of the hill and black shale exposures occur also on the

hill tops in the western part of the town. Various exposures of black shale are seen along the lake road from Little Current to Sheguiandah. About 21 miles from Little Current, the road turns directly southward, and at this point the shale becomes less black in colour, does not split so readily into large thin sheets, but is more likely to break into small angular fragments, apparently much more argillaceous than the underlying Collingwood shale. The top of the Collingwood shale is placed about 200 yards south of the bend in the road, and here occur the last specimens of Triarthrus becki. Above this horizon (locality No. 9, Figure 7) Leptobolus insignis, Orthoceras, and a small Primitia are more or less common for a vertical distance of 33 feet. Dalmanella comes in at 26 feet from the base, and becomes common at 37 feet, and, associated with a Diplograptus near peosta, probably a new species, continues to 33 feet above the Triarthrus horizon. Here the first trace of crinoidal limestone is found. Up to the 70-foot level, limestone layers are scarce, and they do not become common until the 102-foot level is reached. Between 102 and 107 feet above the Triarthrus horizon, thin limestone layers are abundant and are very fossiliferous. Bryozoan fragments are common. The following species were identified by Dr. Ulrich, Dr. Bassler, and Prof. Nickles, having been submitted to them conjointly:

Amplexopora persimilis. Hallopora sigillarioides. Coeloclema commune. Perenopora vera. Stigmatella clavis. Hemiphragma whitfieldi. Arthropora cleavelandi.

This evidently is the same fauna as that found immediately north of Clay cliff, nearly 3 miles north of Wekwemikongsing, along the eastern shore of Manitoulin island. It apparently is a middle Eden fauna. *Dalmanella* is abundant and rather large. *Byssonychia vera* is not rare. A small *Calymene* is present. The exposure is at the top of Burnett hill, 3 miles south of Little Current.

A short distance southward, there is a road crossing, and the remainder of the section here described lies along the crossroad, westward between localities 9, 45, and 49 in Figure 7. Owing

to the low gradient, the Locke level measurements are of little value. Rocks lithologically resembling the Lorraine make their appearance at the 158-foot level; here *Rafinesquina alter*nata and Byssonychia radiata are found. From the 180-foot level, the following bryozoans were identified by Dr. Ulrich:

Arthropora sp.

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the ad, ing Bythopora dendrina......Upper Fairmount and Corryville at Cincinnati. Bythopora gracilis.....Upper Fairmount and higher in the Maysville at Cincinnati.

Immediately above, at the 183-foot level, a specimen of *Pholadomorpha pholadiformis* was found in rock evidently belonging to the same stratigraphic unit as the bryozoans cited above. No other exposures are seen until the lower part of the richly fossiliferous Waynesville member of the Richmond is reached near the road from Little Current to Bass lake, at 278 feet above the *Triarthrus becki* horizon.

The association of *Pholadomorpha pholadiformis* with bryozoans suggesting a much older age than the Richmond is noteworthy. Since both of the associated forms of *Bythopora* range upward from the upper Fairmount in the Maysville at Cincinnati, their testimony does not differ greatly from that given by the bryozoans along Workman brook, which suggest a horizon for the *Pholadomorpha* zone corresponding to the lowest part of the Bellevue.

The following are the details of the section referred to above, given in descending order:

	Thickness	Total
	feet.	thickness.
Top of argillaceous limestone with Streptelasma and Str	0-	
phomena sulcata. This part of the section belongs to t	he	
Waynesville division of the Richmond, an unknown di	5-	
tance above its base. (For overlying strata see na	7e	
117 of this report). The exposures are immed	li.	
ately east of the road from Little Current to the midd	le	
of Bass lake, in lot 5 in concession IV		2781
Interval. This interval was measured along too low ar	đ	2103
long a gradient to have value	05	2791
Thin horizon with Pholadomerpha hheladiformia	. 35	2103
Interval	• ••	••
ALLC: VG	. 2	183

feet. this	kness
and the second second devices	
Thin horizon with Bythopora gracuits and denormo	
Interval	181
Thin horizon in Lorraine-like strata with Rafinesquina alter-	
Interval	158}
Clau shale and sandstone 51	133}
Can detere lavere with large Dalmanella in the more cal-	
careous layers	128
Exposures poor 10	123
The base of these exposures occurs at the intersection of the Sheguiandah road with the road between lots 10 and 11.	
Not exposed	113
Eden limestone layers including the following bryozoans, de- termined by Ulrich: Amplexopora persimilis, Hallopora	
sigillarioides, Coeloclema commune, Hemiphragma whit-	
fieldi, Perenopora vera, and Stigmatella clavis or nana, and	
a rather large Dalmanella, Byssonychia vera, Cyrtolites	108
carinatus, Sinuites cancellata, Calymene granulosa 5	107
Clay shale with very little interbedded limestone 59	102
First trace of limestone, crinoidal, only a lens an inch thick	
and a few feet long, occurs at base of this interval	•••
Dalmanella, Diplograptus peosta	43
An unknown small rhynchonelloid, same species as at	
Tamarack point, occurs at the base of this interval	•••
Diblographus peosta, Dalmanella, Leptobolus, and Bythocypris 51	37
Dalmanella, Leptobolus, Orthoceras, Bythocypris in dark and	
fairly fissile shale	32
Leptobolus	263
Leptobolus. Orthoceras, and Bythocypris 4	21
Less fissile dark shale	17
Diplograptus peosta, Leptobolus, Orthoceras, Triarthrus becki,	
200 yards south of bend in road 1	10
Black shale, grever and less fissile than the underlying	
Collingwood shale	9
Collingwood shale	0

In this section, only a 5-foot zone in which Eden clay is interbedded with richly fossiliferous limestones, is present. The underlying clays, greenish and softer above, and darker and more fissile below, have a total thickness of about 100 feet. These lower clays are also referred to the Eden section, but upon very little evidence. Only the lower half of these clays is fos-

siliferous, these fossils are confined to few species, and these species are not necessarily of Eden age. The interval between the exposed 5-foot section of Eden limestones at the top of the so-called Eden, and the lowest recognized Richmond strata is 170 feet; but this interval probably includes additional Eden strata at the base and undoubtedly includes additional Richmond strata at the top. How much of this part of the intervening section may be included in the Maysville is unknown at present.

BASS LAKE ROAD, SOUTH OF LITTLE CURRENT.

The direct road to the middle part of Bass lake goes from Little Current at first southwestward and then southward, reaching McLean hill about 1½ miles from the town. The road to Honora and West Bay turns off at the foot of the hill, and from this road corner southward (locality No. 11, Figure 7) there is a continuous exposure of clay shale for a vertical distance of 82 feet. From this point to the 100-foot level, thin layers of limestone are interbedded in the clay, and in these limestones occur the same Eden bryozoans as those listed from along the Sheguiandah road. Above this level, for some distance, the hill-side is covered by a talus of sliding material.

At the 156-foot level there is a limestone layer about one foot thick, forming a rather conspicuous outcrop along the winding road. From the exposures between the 156 and 145-foot layers, Dr. Ulrich identified:

> Arthropora sp. Bythopora dendrina. Bythopora gracilis.

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The last two species were identified also between the 145 and 136-foot levels. This evidently is the same fauna as that collected west of the Sheguiandah road, about 70 feet above the Eden bryozoan zone in the section described in the preceding pages. To Dr. Ulrich these forms resembled most those found at the top of the Fairmount member of the Maysville.

The form of *Modiolopsis* resembling *concentrica* occurs at the 157-foot level. A shallow road side spring occurs at the 168foot level. Between this level and the 173-foot level, this *Mo*. *lopsis* is rather common in loose slabs that have come a short tance down the hill-side. The slabs have an appearance like that of the Lorraine, and continue rather plentifully up to the 182-foot level. These Lorraine slabs are common in the talus covering the lower parts of the hill, and contain Rafinesquina alternata, Pholadomorpha pholadiformis, Modiolopsis of concentrica group, Pterinea demissa, and Cyrtolites ornatus. The base of the Waynesville is not well exposed, but belon?s at about the 215-foot level.

The following are the details of this section along the road from Little Current to the middle of Bass lake, at McLean hill, measured in ascending order.

Thickness

Tetal

thickness. feet. Strata regarded as the base of the known Waynesville division of the Richmond, and as probably the horizon for Hebertella insculpta, which is found only in loose blocks below this level. (For description of overlying strata see page 118 of this report). 271 215 Interval..... Thin horizon with Trematis loose..... 187 51 Interval..... Lorraine-like sandy limestone. At the bottom of this interval occurs a shallow spring along the road where it ascends the hill in a southwesterly direction. Modiolopsis concentrica occurs within 5 feet both above and 182 14 below this spring..... Lorraine-like sandy limestones..... 168 11 Thin horizon with Modiolopsis resembling concentrica Highest limestone with Datmanella..... 157 1 Interval with Bythopora dendrina and Bythopora gracilis 156 11 11 145 Interval..... Interval with loose slabs of Lorraine-like looking siliceous limestones containing Rafinesquina alternata 11 inches long, Modiolopsis concentrica, Pterinea demissa, Cyrtolites 22 134 ornatus..... 112 11 Interval..... Clay with thin limestone layers containing Hallopora onealli, Dalmanella and regarded as equivalent to the 181 101 Eden limestones in the Sheguiandah road section The thickness of the overlying Eden limestone section has not been accurately determined. 821 0 Clay shale..... Where Honora road turns off westward from road to middle of Bass lake.

In this section there is apparently an interval of 114 feet which might be referred to the Maysville. Although very uncertain, this estimate, made along a steeper gradient, probably is very much nearer the truth than the estimate of something less than 170 feet, as made from the previously described section along the Sheguiandah road between lots 10 and 11 in concession XI, and between concessions IV and V farther westward.

An estimate of 110 feet for the Eden, and 110 feet for the Maysville, probably would not be far from the facts.

The Eden limestones are well exposed also $1\frac{1}{2}$ miles north of Sheguiandah, where the road to Little Current runs in an east and west direction. A mile north of Sheguiandah, the unfossiliferous clay shales beneath the Eden limestones are well exposed.

INDIAN VILLAGE, SOUTHWEST OF LITTLE CURRENT.

Slabs of rock belonging to the Maysville formation, including *Modiolopsis concentrica*, are found also where the road to Honora turns westward from the north and south road passing between lots 15 and 16, west of the Indian village, $3\frac{1}{2}$ miles southwest of Little Current (locality No. 48, Figure 7). Near the foot of the hill, immediately south of this road corner, clay and sandy limestone, with bryozoans, occur. The road corner is 137 feet below the top of the solid limestone which contains *Calapoecia* and *Columnaria* along its upper surface, and which is regarded as belonging just beneath the Gore Bay *Columnaria* horizon (page 99). The exposures are too poor to be of value for getting a good section here.

TAMARACK POINT.

The fossiliferous Eden limestones are well exposed just above lake level along the eastern shore of Tamarack point (locality No. 12, Figure 7). At this locality various bryozoaus were collected which Ulrich identified as the following Eden species:

Amplexopora persimilis. Arthropora cicavelandi. Aspidopora cf. areolata. Bythopora arctipora. Hallopora sigillarioides. Dekayella ulrichi. Perenopora vera. Stigmatella nana. Hormotoma gracilis-ang sta. Sinuites cancellata. Lepidocoleus jamesi. Primitia centralis.

GORREL POINT, NORTHEAST OF GORE BAY.

From the village of Gore Bay, Manitoulin island, the road along the top of the cliff leads northeast to the line between concessions XIV and XV, and then turns abruptly eastward. A short distance south of this turn, a path descends the bluif, very steep for about 10 feet, and then at an easy grade for the remainder of the way to the lake. It ends at the northern end of a long stretch of high clay banks. The clay banks here consist of clay shales containing numerous graptolites identified by Dr. Ruedemann as *Diplograptus foliaceus-vespertinus*, and some of the fine-grained siliceous limestone slabs which have slipped down the steep hills contain *Pholadomorpha pholadiformis* and a *Modiolopsis* resembling *concentrica*. It might be possible to get some estimate of the thickness of the Maysville formation here.

The graptolite-bearing clay shales are overlaid by a section in which thin limestone layers full of bryozoans, and other fossils, are interbedded with the shales.

At one point, southward, these limestones form a small promontory, marked on the Geological Map No. 605, as Gorrel point (locality No. 13, Figure 7). From these limestones, Dr. Ulrich, Dr. Bassler, and Prof. Nickles identified the following bryozoans and ostracods:

> Arthropora cleavelandi. Bythopora arctipora. Bythocypris cylindrica. Jonesella crepidiformis. Primitia centralis.

This is evidently an Eden fauna, and stratigraphically it occupies the same position as the bryozoan horizons at Tamarack point, south of Little Current, along the Sheguiandah road, and one-fourth of a mile south of Clay cliff in the Cape Smith area. From some higher level, at Gorrel point, slabs containing *Pholadomorpha pholadiformis* have fallen down the cliff.

The occurrence of *Diplograptus foliaceus-vespertinu*, in the underlying clay shales is of interest since it indicates the presence of this species in the Eden as well as in the *Pholado*domorpha zone of the Maysville. It will be emembered that this mutation was listed from the *Pholadomorpha* zone along the shore between Clay cliff and Wekwemikongsing.

The Diplograptus resembling peosla, listed from the lower part of the clay shales along the Sheguiandah road, was identified by Dr. Ruedemann also from the *Trinucleus horizon* on the southern shore of Georgian bay, one mile east of Fields, a station west of Collingwood. Along Workman brook, east of Meaford, this *Trinucleus* horizon occurs 25 feet above the lake and here is regarded as lower Eden.

GENERAL OBSERVATIONS ON THE LORRAINE OF ONTARIO AND QUEBEC.

From the preceding observations it becomes evident that the richly fossiliferous Waynesville horizons of both Quebec and Ontario are underlaid by horizons, lithologically resembling the Pulaski part of the Lorraine, and .ontaining in the upper parts, at least, the lamellibranch Pholadomorpha pholadiformis. In addition to this a Modiolopsis resembling concentrica frequently is present. Catazyga is abundant at various horizons in this Lorraine-like zone in the province of Quebec and in the eastern part of Ontario. It has a considerable vertical distribution also in the vicinity of Toronto, but near Meaford it is confined to four thin layers, and in one of these it is very rare. On Manitoulin it is unknown in the Lorraine-like strata, occurring only at the base of those richly fossiliferous limestones which here are referred definitely to the Waynesville member of the Richmond. Pterinea demissa, Byssonychia radiata, Lyrodesma poststriatum, and Cyrtolites ornatus are comparatively common, but occur both in Richmond and Lorraine rocks on Manitoulin island. Associated with this Pholadomorpha pholadiformis and also in the immediately underlying horizons there are bryozoans ranging between the top of the Fairmount and the base of the ordinary Bellevue in typical Cincinnatian areas. In Ontario the Pholadomorpha zone shows some affinity, therefore, with the middle part of the Maysville formation, as exposed in Cincinnatian areas. For local purposes, the term *Wekwemikongsing* beds has been proposed for this part of the Ordovician rocks of western Ontario.

Below this *Pholadomurpha* zone comes a section of thin limestones interbedded with clay, both containing a fauna which may be correlated with the Eden of Cincinnatian areas. Along Workman brook, east of Meaford, and also at various localities near Toronto, there is a considerable thickness of similar strata beneath the *Pholadomorpha* zone which can be assigned to the Eden formation.

It is not so certain whether the clay shales underlying the richly fossiliferous Eden bryozoan horizons on Manitoulin island are to be correlated with the Eden. These lower clay shales contain a very noncommittal fauna apparently, but judging from the exposures at Meaford they may be included in the Eden at least tentatively. For these strata, extending from the top of the thin limestone section, containing an abundance of Eden bryozoans, down to the top of the black Collingwood shales, containing *Triarthrus*, the local name *Sheguiandah* beds, has been proposed.

Any further subdivision must be based upon a much fuller knowledge of the contained fauna than we now possess.

When these upper Ordovician exposures in southern and western Ontario are compared with the Eden and Maysville of Cincinnatian areas, great gaps will be noticed. Most of the Eden forms so far identified from Ontario, have a considerable vertical range in Cincinnatian localities, but such evidence as they offer is in favour of a middle Eden age. There is no evidence so far at least of the presence of the lower strata included in the Eden at Cincinnati. While strata from the lower or Fairview division of the Maysville may be present in Ontario, the evidence so far favours the view that the Fairview here is absent and that the upper Lorraine horizons of Ontario wedge in between the Fairmount and Bellevue divisions of the typical Maysville in Cincinnatian areas. No one acquainted with the faunas of the Cincinnatian rocks can fail to be impressed with the general absence of many of the most familiar upper and lower Maysville brachiopoda, bryozoans, and other forms of Cincinnatian

areas in the approximately corresponding strata of Ontario. Note for instance the general absence of such familiar forms as Platystrophia laticosta, Pl. ponderosa, Plectorthis plicatella, Pl. fissicosta, and of species of Strophomena of the planoconvexa group.

The epicontinental seas within which the Ordovician strata were deposited, evidently were much more basin-like in character than formerly supposed. The record preserved is much more fragment — than formerly suspected, and is broken often at much more irequent intervals than formerly would have been admitted. Under these conditions exact correlation usually is possible only within very narrow limits. The readiness with which the minor formation names were formerly carried over wide expanses of territory is fast disappearing. While this may prove an inconvenience to the elementary student, it is in the interest of the advance of exact science.

It is doubtful whether the use of the term Lorraine in connexion with these upper Ordovician Ontario strata can be of great value. There are too many differences and too few resemblances between the Lorraine faunas of Ontario and the typical Lorraine fauna of New York.

The use of the terms Maysville and Eden for the strata exposed in Ontario eventually may prove much monopopriate, since there appears to be a fair prospect of securing sufficient bryozoans from the supposed Lorraine strata of Ontario to permit their correlation with the Maysville and Eden formations of Ohio, Indiana, and Kentucky, at least in a general way. How sharply it will be possible to discriminate between the Maysville and Eden in the various Ontario sections can be determined only by further study. However, numerous exposures occur within easy reach of Toronto, and eventually no doubt a much greater mass of evidence will become available.

CHAPTER 111.

RICHMOND FORMATION IN ONTARIO AND OUEBEC.

Waynesville and Whitewater.

If the *Pholadomorpha pholadiformis* horizons are to be regarded as of lower Bellevue or middle Maysville age, then the immediately overlying richly fossiliferous strata, which are of upper Waynesville age, must be regarded as the lowest of the Ohio Richmond beds found in the provinces of Ontario and Quebec.

The Arnheim and lower part of the Waynesville member of the Ohio Richmond are absent. The upper part of the Waynesville, however, is widely distributed between Manitoulin island in the northern part of Lake Huron and the vicinity of Toronto, north of Lake Ontario. This Waynesville fauna is not found west of Lake Huron, and the Waynesville content becomes less in the approximately equivalent strata in the eastern part f Ontario, east of the Frontenac axis. The lower Richmond fauna of Ontario appears to be a southern invasion from the areas around Cincinnati. Mingled with the Waynesville forms, however, are other species which probably are of northern origin.

The typical Whitewater and Saluda fauna of Ohio, Indiana, and Kentucky is so sparingly represented in Canadian areas, even in the region extending from Manitoulin island to the vicinity of Toronto, at least as far as the number of characteristic species is concerned, that it seems much more probable that certain species in the Saluda fauna entered the Richmond areas around Cincinnati from the north than that they entered Canadian areas from the south. These forms include such species as *Beatricea*, *Tetradium*, *Columnaria*, and *Calapoecia*. In general, corals and other massive lime-secreting organisms are to be regarded as characteristic of southern faunas, and suggest Gulf of Mexico rather than Boreal invasions; however, the wide dispersion of the fossils here mentioned and their large and vigorous growth northward, during Richmond times, suggests the possibility of a ifferent centre of distribution during the deposition of the Richmond.

That the general Richmond fauna of Ontario and Quebec did not enter by the St. Lawrence channel is suggested by the very different combination of faunas found in the Richmond of Anticosti island.

WESTERN ONTARIO.

MANITOULIN ISLAND.

Everywhere on Manitoulin island (Figure 7) the richly fossiliferous Waynesville zone begins with a horizon in which the typical Richmond fossil, Hebertella insculpta, is more or less common. It frequently is associated with Catazyga headi, a form ranging far below the typical Richmond in the province of Quebec, but whose value as a diagnostic fossil depends on the fact that on Manitoulin island no form of Calazyga has been found in strata underlying the Hebertella insculpta horizon. Hebertella insculpta occurs at the base of the richly fossiliferous Waynesville horizon, also 6 miles northwest of Meaford, along the road following the western side of Nottawasaga bay. This locality lies 85 miles southeast of Manitoulin island. No specimens of Cciazyga headi were noticed here; however, 3 miles southeast of Meaford, on Workman brook, Catazyga headi, associated with Strophomeny planumbona, occurs at the base of the richly fossiliferous Waynesville, but without the presence of Hebertella insculpta, and several horizons containing Catazyga occur at still lower levels at this locality.

Neither Hebertella insculpta nor Catazyga headi have been discovered so far at the base of the richly fossiliferous Richmond at the various localities west of Toronto, along the northern shores of Lake Ontario. although a form of Catazyga occurs a considerable distance below the top of the Lorraine-like arenaceous limestones, containing Pholadomorpha pholadiformis, a mile down stream from the railway bridge southeast of Streetsville. Catazyga headi was listed by Spencer, in the Canadian Naturalist, in 1882, from the material found in the old lake beaches at the west end of Lake Ontario, near Hamilton, but the exact horizon from which these drift specimens of Catazyga came is unknown.

Catazyga headi is abundantly represented at the base of the richly fossiliferous Wayn sville in the extreme eastern part of Ontario, east of Ottawa, and also at various localities in the province of Quebec. In the latter province, it is abundant at this horizon along the Nicolet river, 18 miles south of Three Rivers. It occurs also among the Waynesville material on Snake island, in Lake St. John, about 125 miles north of Quebec. However, at these eastern localities, at Ottawa and in the province of Quebec, Catazyga headi ranges far below the typical Richmond, into strata regarded as Lorraine, as may be seen in the Nicolet River section. Hebertella insculpta, a characteristic Richmond fossil, however, is unknown between Ottawa, Three Rivers, and Lake St. John although the fossil which is commonly associated with it in the Lake Huron areas, Catazyga headi, occurs throughout this area and as far east as Anticosti island, about 370 miles farther eastward than Lake St. John.

Associated with the *Hebertella insculpta* and *Catazyga headi* at the base of the richly fossilferous Waynesville, on Manitoulin island, are the following species:

Streptelasma rusticum.	Straphomena humani
Columnaria almediata	Strophomena nuronensis.
Bastana t 177 1	Rannesquina alternata, very flat
rolarea papillata.	Plectambonites sericeus.
Calapoecia huronensis.	Rhynchotrema perlamellorum
Rhombolrypa quadrata.	Zveospira modesta
Iebertella occidentalis.	Pterinen demissa
Platystrophia clarksvillensis.	Cuclomente bilin

These associated fossils, however, are not confined to the *Hebertella insculpta* and *Catazyga headi* horizon, but range upward for variable distances into the overlying part of the Waynesville, some extending their range even for considerable distances into those Richmond beds which overlie the Waynesville member.

The lower or Waynesville part of the Richmond, on Manitoulin island, is by far the richest of the Richmond deposits in fossil remains, and many species, especially among the brachiopoda, appear to be confined to this lower part.

Between Gore Bay, Kagawong, and Little Current, a conspicuous coral reef, from 1 to 3 feet thick, containing *Columnaria alveolata* and *Calapoecia huronensis*, frequently is found between 35 and 45 feet above the base of the *Hebertella insculpta* horizon. For this coral reef the name Gore Bay reef has been proposed. This reef serves locally as a convenient horizon marker.

It has been found that, while most of the fossils which begin their range at or near the Hebertella insculpta horizon reach the Gore Bay Columnaria reef, many of these species do not extend their range beyond this horizon. Among the latter may be mentioned: Protarea papillata, Constellaria polystomella. Rhombotrypa quadrata, Crania scabiosa, Rafinesquina alternata with very flat form, Plectambonites sericeus, Strophomena huronensis, Str. nutans, Str. neglecta, Str. planumbona, Str. sulcata, Platystrophia clarksvillensis, Zygospira kentuckiensis, Helicotoma brocki, Spyroceras hammelli, and various gasteropods and pelecypods not identified. A scrutiny of this list suggests the presence here of an upper Waynesville fauna. Such forms as Hebertella insculpta, and Catazyga headi make their first appearance in Ohio, Indiana, and Kentucky, at the base of the upper or Blanchester division of the Waynesville. Strophomena nutans, Strophomena neglecta, and Zygospira kentuckiensis are first seen a short distance above the base of Blanchester division.

Among the various species, on Manitoulin island, which begin their range in that part of the Richmond section which underlies the Gore Bay Columnaria reef, but continue also above the latter, may be mentioned: Stromatocerium huronense, Girvanella richmondensis, Tetradium huronense, Streptelasma rusticum, Columnaria alveolata, Calapoecia huronensis, Hebertella occidentalis, Rhynchotrema perlamellosum, Zygospira modesta, and various gasteropoda and pelecypoda not identified. Apparently these are all forms which managed to continue existence in muddy waters. They are such forms as frequently are found in argillaceous and arenaceous deposits. In Ohio, Indiana, and Kentucky, they frequently are found in muddy and sandy strata in which all other species have become rare.

Columnaria alveolata and Calapoecia huronensis have a considerable vertical range, but the horizon at which they occur in sufficient abundance to form the conspicuous Gore Bay reef evidently is an important palæontological horizon, since it marks the disappearance of a considerable part of the underlying Richmond fauna. Moreover, it appears to be above this horizon that Beatricea undulata, Columnaria calycina, and various thickwalled gasteropoda, such as Liospira helena, a large Bellerophon, and a large Bucania or Salpingostoma come in. All of these species from above the coral reef apparently are such forms as could live in rough, muddy waters.

In general, the fauna in the strata immediately above the Gore Bay *Columnaria* reef appears to be a meagre one. At least, very few species have been listed from this zone except such forms as *liebertella occidentalis*, *Rhynchotrema perlamellosum*, and *Zygospira*, which appear to be able to survive under very adverse conditions.

At one locality, on an east and west road 3 miles sout. Little Current, Strophomena vetusta and Ceraurinus marginatus occur just above this Gore Bay reef. In Ohio, Strophomena vetusta is represented in the Blanchester division of the Waynesville by an early form, but the range of the more typical specimens begins in the Liberty and extends into the Whitewater. Ceraurinus margina us is unknown outside of Manitoulin, but the closely related species Ceraurinus meekanus, occurs in the Whitewater of Indiana and Ohio. At Manitowaning, at the Clay cliff north of Wekwemikongsing, and on Rabbit and Club islands, east of Manitoulin island, a species of Beatricea, usually referable to undulata, occurs in strata which appear to belong above the Gore Bay reef horizon. In Indiana and Kentucky Bertricea is especially common in the Saluda division of the Richmond, and in the immediately underlying beds which carry a Whitewater fauna. In Indiana, Columnaria alveolata and Calapoecia huronensis also are more abundant at the base of the Saluda than at any other horizon.

While the exact correlation of these strata on Manitoulin island, above the Gore Bay reef, with any of the divisions of the Richmond in Ohio, Indiana, and Kentucky, must remain more or less in doubt for the present, until more information can be secured, it seems quite evident that their horizon is distinctly above that of the Waynesville of Ohio. Provisionally they may be referred to the Whitewater, possibly to that part of the Whitewater which in southern Indiana is quite arenaceous, and, excepting at a few horizons, is quite unfossiliferous. For this part of the Whitewater, the term *Saluda* was proposed some years ago, and while the reference of the strata immediately above the Gore Bay reef, on Manitoulin island, to the Saluda may be rather lithological than palæontological, this reference accords most nearly with our present state of knowledge on the subject.

It may be stated that a day's examination of the coral zone and overlying strata west of the bridge north of Streetsville junction convinced Dr. Ulrich that the general facies of the fauna suggested Whitewater affinities. The coral reef at Streetsville appears to correspond stratigraphically to the Gore Bay coral reef on Manitoulin island.

Another conspicuous zone, between Gore Bay, Kagawong, Honora, and Little Current, on Manitoulin island, is a Stromatocerium huronense reef which usually is found between 25 and 30 feet above the Columnaria reef, but which occurs farther eastward at greater intervals. It probably would be more accurate to say that this Stromatocerium forms reefs at various horizons, but that these various horizons occur sufficiently near each other within the same vertical zone to make their reference to the same general reef possible. Since this Stromatocerium reef is well exposed at various localities in the vicinity of Mudge bay, at the head of which the village Kagawong is situated, the name Mudge Bay reef will be suitable for it. At this Mudge Bay reef horizon, Tetradium often is common, sometimes in fact more common than the Stromatocerium. It is the interval between the Gore Bay and Mudge Bay reefs which usually presents such a meagre fauna, as already stated, although

locally, especially near the eastern end of the island, the lower parts of this interval appear to be richly fossiliferous.

Immediately above the Mudge Bay Stromatocerium reef, at Kagawong and Gore Bay, a rich pelecypod, gasteropod, and ostracod fauna, but not consisting of many species, comes in. Among the pelecypods, Ortonella hainesi suggests the Whitewater age of the strata involved. Near Weisburg, in Indiana, Ortonella hainesi occurs in the Whitewater strata immediately underlying the Saluda, the latter being probably only a local arenaceous phase of the Whitewater. Among the ostracods, Leperditia caecigena and Primitia lativia also suggest the Saluda age of the Maritoulin strata here considered, but in Ohio and Indiana they appear to range from the Saluda to the top of the Richmond. If the Saluda in southern Indiana be regarded as merely a local arenaceous phase of the Whitewater as typically exposed in the more northern parts of that state, the reference of certain fossils in the Manitoulin Island section to the Saluda, and of other fossils in the same strat-, to the Whitewater will be seen to be in substantial agreement.

Among other fossils occurring above the Mudge Bay Stromatoceriu: n reef are Cv^{-r} inta ponderosa, Ctenodonta iphigenia, a large Archine __, and various species of Lophospira. Among those species which continue their range upward, from below the Mudge Bay reef, are Girvanella richmondensis, Tetradium huronence, Hebertella occidentalis, Zygospira modesta, Byssonychia radiata, and Pterinea demissa. All of these are forms which are capable of continuing their existence in muddy waters, judging from the frequency with which they are found in dolomite, fine-grained sandstones, and indurated clays.

The total thickness of this upper part of the Richmond, from the Mudge Bay *Stromatocerium* reef to the base of the Manitoulin dolomite, varies apparently from 45 to 60 feet, at most localities on Manitoulin island.

Although the Gore Bay and Mudge Bay reefs can be traced from west of Gore Bay to the vicinity of Little Current, their exact equivalents farther westward at Manitowaning, and thence eastward to Wekwemikong and Clay cliff, cannot be determined so readily. Perhaps this is due to the fact that at these eastern localities coral reefs occur at more than two horizons so that it is difficult at present to decide which of these eastern reefs are to be correlated with those farther west. Possibly none of the eastern reefs coincide exactly with the latter.

For instance, at Manitowaning, Hebertella insculpta is exposed within 6 feet of the lake level. Occasional specimens of Columnaria occur even at this low level, and continue thence upward. The first specimen of Tetradium was noted 21 feet above the level of the lake, and at 26 feet Calapoecia huronensis is common, associated with some Columnaria and Tetradium. Between 49 and 71 feet, Beatricea undulata comes in at various horizons, associated with Cyrtodonta ponderosa, Liospira helena, and other forms which in the vicinity of Kagawong and Gore Bay are found above the Mudge Bay Stromatocerium reef. Corals are not common until the level of 74 feet above the lake is reached, where Columnaria is common, and is associated with smaller numbers of Calapoecia and Tetradium. At 100 feet above the lake is the top of a massive Stromatocerium reef, for which the name Manitowaning reef has been proposed. The question now arises: Which of these reefs corresponds to the Gore Bay reef? Judging from the fossils in the zones above and below, this is the Calapoecia horizon, 26 feet above the level of the lake. If Beatricea suggests the Saluda horizon, its occurrence above the Calapoecia horizon in the eastern part of Manitoulin island would be in agreement with that fact.

Which of the Manitowaning coral horizons represents the Mudge Bay Stromatocerium horizon? Possibly the Columnaria horizon, 74 feet above the level of the lake. If the overlying beds were better exposed it might be possible to verify this correlation since certain characteristic fossils usually occur in the beds abov the Mudge Bay reef. Because the Manitowaning Stromatocerium reef, 100 feet above the lake, consists of an abundance of Stromatocerium and is about the same distance above the Hebertella insculpta layer, it does not follow that the Manitowaning reef is identical with the Mudge Bay Stromatocerium reef. It is quite certain that different massive growths, including under this term Stromatocerium, Tetradium, Calapoecia, and Columnaria, predominated at different localities along the same reef zone, so

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that *Tetradium* at one locality may be replaced by *Stromatocerium* at another.

At Clay cliff, 3 miles north of Wekwemikongsing, the top of the Hebertella insculpta zone is 114 feet above the lake. The thickness of this zone probably is several feet. Thirty feet above this horizon, Stromatocerium is very abundant. This has been called the Cape Smith Stromatocerium reef. Stratigraphically it appears to correspond with the Calapoecia reef at Manitowaning, and with the Gore Bay reef farther westward. This conclusion, however, may be an erroneous one, since southwest of Wekwemikong there is a massive Stromatocerium reef overlying 9 feet of strata in the lower half of which Beatricea undulata, Calapoecia huronensis, Columnaria alveolata, Columnaria calvcina. an abundance of Tetradium huronense, Cyrtodonta ponderosa, Cienodonta iphigenia, Liospira helena, and other fossils occurring above the Mudge Bay Stromatocerium reef in the Kagawong and Gore Bay areas, are found.

It evidently is not safe to insist on close correlation between widely distant sections until the faunas have been worked up better. Even at this early stage of investigation, however, it may be asserted that, whenever present, the first conspicuous coral reef, found above the *Hebertella insculpta* horizon, marks the top of the Waynesville phase of the Richmond, on 'Anitoulin island, and that the immediately overlying strata inaugurate the Saluda or Whitewater part of the Richmond.

From this first conspicuous coral reef upward, as far as the base of the Manitoulin dolomite, all of the section is to be correlated with the Saluda or Whitewater member of the Richmond. At numerous localities on Manitoulin, where the strata between the Mudge Bay *Stromatocerium* reef and the base of the Manitoulin dolomite are well exposed, minute ostracods, including *Leperditia caegigena* and *Primitia lativia*, are common. These characteristic species are especially common in the upper Saluda of southern Indiana and at some localities on Manitoulin island have been found within 2 feet beneath the base of the Manitoulin dolomite, which here forms the lowest member of the Silurian section.

NORTHWEST OF KAGAWONG.

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(Locality No. 34, Figure 7.)

About 3¹/₂ miles northwest of Kagawong, along the road to Maple point, the base of the Manitoulin (Silurian) dolomite is exposed along the road. Nearby, a small wet weather stream plunges over a falls east of the road, and the Richmond strata are well exposed. The locality is probably near the southeastern corner of lot 6 in concession XV, and here the following section was measured:

Thickness

	feet
Manitoulin dolomite (Silurian) with Orthis flabellites	0
Interval, at top of Richmond, poorly exposed	4
Solid limestone with Tetradium and Stromatocerium common	61
Solid limestone	101
Poorly exposed.	23
Limestone	1
Long gradient along the road, with no exposures	32
Solid rock	11
Conspicuous Gore Bay coral reef, with Columnaria and Calaboecia	3
Solid limestone, at top of Waynesville member of Richmond.	19
Limestone	4
Rubbly argillaceous limestone, but presenting too steep a face to	-
expose the fossils well	19
Strata with Protarea. Hebertella insculpta, and Strophomena	21
Strata with Protorea papillata	11
Base of Richmond section at the falls.	

This section presents the total thickness of the Richmond as at present identified on this part of Manitoulin island. The base is characterized by *Hebertella insculpta*. From this level to the *Columnaria* (Gore Bay) reef, the strata are referred to the upper part of the Waynesville section of Ohio and Indiana. This gives a thickness of 46 feet. The overlying part of the Richmond has a total thickness of 81 feet. It is poorly exposed and contains few fossils excepting at the *Tetradium* reef, near the top. It is referred to the Whitewater including under this term also the Saluda. A short distance south of the last locality, a road leads off eastward toward the western short of Mudge bay. Here the following Richmond section is exposed:

106

Thickness

Manitoulin dolomite (Silurian) with Orthis flabellites, Rhipidomella hybrida, and Dalmanella elevantula.

Softer argillaceous limestone at the top of Richmond	8
Tetradium reef, not measured separately from the underlying stone.	
Massive harder limestone	'n
Not exposed	6
Limestone with bryozoans.	3
Not exposed	41
Stromatocerium (Mudge Bay) reef.	1
Limestone in part, section poorly exposed	21
Not exposed	41
Columnaria (Gore Bay) reef, with Calapoecia, Rhynchotrema perlamel-	= 3
losum and Platystrophia clarksvillensis	3
Interval at top of Waynesville member of Richmond, with argillaceous	
limestone at the top and softer layers below	7
Limestone with Strophomena, Platystrophia clarksvillensis, and Strepte-	
lasma rusticum.	51
Softer argillaceous rock with Streptelasma rusticum. Straphomena	R

Here 30 feet of rock underlies the Gore Bay Columnaries reef, but the Heberlella insculpta horizon, belonging immediately beneath the lowest Richmond seen in the preceding section, is not exposed. The overlying part of the Richmond has a total thickness of 90 feet. The Tetradium reef at the top corresponds with that in the preceding section, but the Stromalocerium (Mudge Bay) reef, 33 feet above the Columnaria reef, is not exposed here.

Somewhere near the southeastern corner of lot 6 in concession XII, the *Stromalocerium* (Mudge Bay) reef is seen 58 feet below the Manitoulin dolomite. The reef here has a thickness of 5 feet. The *Tetradium* reef is not exposed.

NORTHWEST OF KAGAWONG.

(Localily No. 36, Figure 7.)

A mile and a half northwest of Kagawong, where the road to Maple point ascends the hill, the following Richmond section is exposed.

Manitoulin dolomite (Silurian)	
Strata at top of Richmond not exposed	60
Solid limestone with Stromatocerium, forming reef (Mudge Bay reef)	3
Interval measured along a very long and low gradient	8
Greenish clay and rock similar to that along the road from Kagawong to	
Providence bay. Fossils rare. Zygospira modesta	9
Thin greenish argillaceous shale. Fossils few	4
Columnaria common, associated with Calapsecia, Streptelasma, and	
forming the Gore Bay reef. Also Hebertella occidentalis, Platy-	
strophia clarksvillensis, and Rhynchotrema perlamellosum	3
Interval at top of Waynesville member of Richmond	51
Solid limestone with Columnaria, Strophomena, and Hebertella occi-	-
dentalis	4
Clay and argillaceous limestone, poorly exposed	10
Harder bluish limestone with Streptelasma and Strophomena	6
Soft argillaceous limestone rubble with S. ptelasma, Strophomena,	
Platystrophia clarkspillensis, and Rhynchotrema perlamellosum	2

Here also the base of the known Richmond of Manitoulin island, with *Hebertella insculpta*, is not exposed: 33 feet of the Waynesville division of the Richmond is exposed beneath the Gore Bay *Columnaria* reef, and 87 feet of Richmond rock overlie the Waynesville level. The Mudge Bay *Stromatocerium* reef appears to be only 21 feet above the *Columnaria* reef, but this may be due to the difficulty of getting accurate measurements with a Locke level along a long and very low gradient.

SOUTHWEST OF KAGAWONG.

(Locality No. 37, Figures 7 and 8.)

A mile and a half southwest of Kagawong, along the road to Gore Bay, the following section was measured:

	feet.
Limestone, soft at the base, forming upper part of Manitoulin dolo-	
mite (Silurian) exposure.	51
Richly fossiliferous limestone	21
Thinner bedded limestone at base of Manitoulin dolomite	131
Upper layers of the Richmond, containing Rhytimya kagawongensis,	
Leperditia caecigena, Bythocypris cylindrica, and Primitia lativia.	
The thickness of these layers is	3
The thickness of these layers is	3

107

Thickness

Thickness

Not exposed Thin horizon with bryozoans and a large Cyrtodonta Strata not exposed Whitish limestone with Hebertella occidentalis, Cyrtodonta ponderosa, Ctenodonta iphigenia, Ortonella hainesi, a large Archinacella, and various species of Lophospira, Cyrtoceras (Cyrtorhisoceras?) haga- womennis.		
Thin horizon with bryozoans and a large Cyrtodonta Strata not exposed Whitish limestone with Hebertella occidentalis, Cyrtodonta ponderosa, Ctenodonta iphigenia, Ortonella hainesi, a large Archinacella, and various species of Lophospira, Cyrtoceras (Cyrtorhisoceras?) haga- womennis.	46	
Strata not exposed Whitish limestone with Hebertella occidentalis, Cyrtodonta ponderosa, Ctenodonta iphigenia, Ortonella hainesi, a large Archinacella, and various species of Lophospira, Cyrtoceras (Cyrtorhisoceras?) haga- womensis.		
Whitish limestone with Hebertella occidentalis, Cyrtodonta ponderosa, Ctenodonta iphigenia, Ortonella hainesi, a large Archinacella, and various species of Lophospira, Cyrtoceras (Cyrtorhisoceras?) haga- wongensis.	6	
wongensis.		
	4	
Solid limestone with Stromatocerium probably representing the Mudge		
Bay Stromatocerium reef of the sections northwest of Kagawong	4	

This places the Mudge Bay Stromatocerium reef 59 feet below the base of the Manitoulin dolomite. The richly fossiliferous zone above this Stromatocerium reef, and the ostracod horizons just beneath the base of the Manitoulin dolomite are noteworthy.

SOUTH OF KAGAWONG.

(Locality No. 38, Figure 7.)

Half a mile south of Kagawong, the road to Providence turns abruptly eastward, toward West or Honora bay. Here the following section is exposed:

n	nickness
	feet.
Massive limestone with interbedded shaly material containing Heber-	
tella occidentalis and Ctenodonta iphigenia	8
Not exposed	9
Spirorbis cf. cincinnatiensis, Rhytimya kagawongensis, Lyrodesma sp.,	
Leperditia caecigena, Primitia lativia	51
Cyrtodonta and Lophospira	51
Shaly limestone and clay	4
White limestone with Cyrtodonta ponderosa, Modiolopsis, Ischyrodonta,	
Ortonella hainesi, Lophospira, Archinacella, Orthoceras, Heberte !! ?	
occidentalis, and bryozoans	9
Mudge Bay Stromatocerium reef	4

Here 41 feet of strata, belonging to the Whitewater division of the Richmond, are known above the Mudge Bay Stromatocerium reef. The level for the base of the Manitoulin dolomite belongs at least 18 feet above the top of the section. The level

108

Thickness

for the Gore Bay Columnaria reef should be somewhere near the level of the bridge at the mill south of Kagawong, but it is not exposed. It is evident that the ostracods occur here at a very much lower horizon than along the road to Gore Bay, southwest of Kagawong. In fact, they occur at several horizons in different parts of Manitoulin island, indicating a considerable total vertical range. In this connexion, the light green clay and rock fragments, with ostraco . Leperditia caecigena and Primitia lativia, near lot 23, along the road from Kagawong to West Bay, concession XV, need further examination. Similar light green clay was seen northwest of Kagawong, below the Mudge Bay Stromatocerium reef, but the ostracods elsewhere on Manitoulin island occur usually above this reef.

KAGAWONG FALLS.

(Locality No. 39, Figures 7 and 8.)

The following section is exposed below the falls at the mill south of Kagawong. It belongs to the Waynesville division of the Richmond.

Top of bluff.	feet.
Interval. The top of Waynesville member of Richmond is somewhere within this interval	
This horizon with Carthanne	34
This noticon with Strophomena	••
Interval	31
Thin horizon with one Calasyga, also several Strophomena sulcata	
Interval	2
Thin horizon with a small specimen of Calapoecia, and Bucania cf. capax	-
Interval	۰.,
Thin horizon with Strachkaman sulesta	- T
Internal	••
	1
Thin horizon with Strophomena sulcata and Hormotoma	••
Hebertella insculpta, Catazyga headi common at the base, rare above,	
also Protarea	3
Thin horizon with Vanuzemia several	•
Interval	
Thin horizon with limesters with Clash and	3
Webertelle in with infectione with Strophomena.	••
revertend inscrupta in lower hall. Also Streptelasma. Base of Way-	
nesville member	5
Clay and a few fine-grained samuy limestone layers	101

Here the vertical distribution of *Hebertella insculpta* through an interval of 11¹/₂ feet should be noted. The total thickness of the known Waynesville is about 20 feet, but there is no doubt that a part of the overlying strata, stratigraphically, also belongs to the Waynesville.

The loose blocks along the creek at the base of the section contain Columnaria alveolata, Plectambonites sericeus, Rafinesquina alternata, a very flat form, Hebertella occidentalis, Rhynchotrema perlamellosum, Zygospira modesta, Zygospira kentuckiensis, and Pterinea demissa, in addition to the species already mentioned from this locality.

SOUTH END OF KAGAWONG.

(Locality No. 40, Figure 7.)

Another exposure of Waynesville rock occurs directly south of the main part of the village, where the road from Kagawong to Gore Bay ascends the hill. Here the following section is exposed:

Thickr.eas

	feet.
Argillaceous limestone near top of Waynesville member of Richmond;	
with Columnaria rare, also with Zygospira modesta	5
A large nodose branching Ptilodictya, accompanying numerous	_
fiederleua occidentalis	51
Streplelasma rusticum and Strophomena common	51
Strophomena rare	51
Streptelasma, Plectambonites, Strophomena planumouna, Sr. huronen-	-
sis, Str. nutans, Str. sulcata, Platystrophia clarksvillensis, Zy-	
gospira kentuckiensis, and Plerinea demissa.	51
Strophomena few	51
Rubbly argillaceous rock with Streptelasma dispandum, and Str. rusti-	
cum, Plectambonites, Strophomena neglecta, Str. sulcata, Cyrto-	
donta, Helicotoma brocki, rare	51
Rubble rock without identifiable fossils.	•1

Here there are evidently 38½ feet of rock belonging to the Waynesville division of the Richmond. The total thickness of this division is probably about 10 feet greater. The basal beds, with Hebertella insculpta and Catazyga headi, were not noticed.

NORTHEAST OF GORE BAY.

(Locality No. 41, Figure 7.)

Northeast of Gor Bay, along the road following the top of the bluff, in concession XIV, the following fossils occur above the Stromatocerium reef: Girvanella richmondensis, Streptelasma rusticum, Hebertella occidentalis, Cyrtodonta ponderosa, Cienodonta iphigenia, and Byssonychia radiata. It is evident that the Cyrtodonta horizon above the Mudge Bay Stromatocerium reef is well represented in the area extending froi. Kagawong to the west of Gore bay. Judging from the fossils, beds equivalent to the Cyrtodonta horizon occur also at Clay cliff, on the eastern sides of Cape Smith, on the eastern side of Manitoulin island.

Southeast of the village of Gore Bay, along the road ascending the hill northeastward, toward East Bluff, *Primitia lativia* occurs immediately above the Mudge Bay *Stromatocerium* reef. All of these horizons belong in the Whitewater division of the Waynesville.

SOUTH END OF GORE BAY.

(Locality No. 43, Figure 7.)

At the southern end of Gore Bay, is the fairground. Southwest of the fairground, the base of the Manitoulin dolomite is exposed along the brow of the hill. Between these two localities, the following section was estimated, but as there is considerable dip, and the exposures are not continuous, there is opportunity for considerable error.

Thickness	
8	

Manitoulin dolomite (Silurian).	ICCCI
Upper Richmond strata not exposed	25
middle	12
Not exposed well	25
Mudge Bay Stromatocerium reef, with a few specimens of Tetradium, in	
front of the fairground	3

Same?

The few specimens of *Stromatocerium* about 30 feet above 's Mudge Bay *Stromatocerium* reef, may represent the upper *1 'radium* reef, 4 feet below the Manitoulin dolomite, northwest Kagawong. All of the Richmond exposures at this locality belong to the Whitewater member of the Richmond.

WEST SIDE OF GORE BAY.

(Locality No. 44, Figure 7.)

The Gore Bay Columnaria reef is well exposed along the brow of the hill west of Gore Bay, but it was impossible to secure a fairly reliable estimate of the interval between the Gore Bay Columnaria reef and the Mudge Bay Stromatocerium reef. It is assumed to equal fully 30 feet. Five feet above this Columnaria reef, Streptelasma dispandum, which is a large mutation of Streptelasma rusticum with strongly divergent sides, is seen. and half a foot farther up, Columnaria is associated with Calapoecia, Streptelasma dispandum, Protarea richmondensis, also the variety papillata, and Rhynchotrema capax. Columnaria occurs at various horizons as far as 11 feet above the Columnaria reef, and Rhynchotrema capax is found at this locality 14 feet above the reef. The Columnaria reef is the base of those Richmond strata which overlie the Waynesville member of the Richmond and which are referred to the Whitewater member. Four and a half feet below the Columnaria reef, in the Waynesville member. Strophomena is common and the following fossils are seen between this level and the exposures 11 feet below the reef: Streptelasma rusticum, Protarea richmondensis, Strophomena of the planumbona type, Hebertella occidentalis, Platystrophia clarksvillensis, Rhynchotrema perlamellosum, Zygospira modesta, and Isotelus.

NORTHEAST OF GORE BAY.

(Locality No. 13, Figure 7.)

The base of the known Waynesville section, of Manitoulin island, is not exposed at the last described locality, directly west of Gore Bay, but at the exposures near Gorrel point, about 2 miles northeast of Gore Bay, Hebertella insculpta is found in loose slabs, associated with Plectambonites, Strophomena planumbona, Strophomena huronensis, Platystrophia clarksvillensis, Rhynchotrema perlamellosum, Streptelasma, and Columnaria. These slabs, although loose, evidently came from the base of the Waynesville of Manitoulin island, Hebertella insculpta being confined to that horizon in this area.

NORTHWEST OF GORE BAY.

(Locality No. 46, Figure 7.)

Nearly 2 miles northwest of Gore Bay, along the road between concessions XII and XIII, the following succession of strata is seen. The intervals, measured along the road, are practically worthless, since the measurements were made along long and low gradients where the dip apparently was considerable.

· · · · · · · · · · · · · · · · · · ·	Thickness	Total
	feet.	thickness.
Top of hill.		
Uppermost horizons of the Whitewater member of the Ric mond not exposed.	h-	
Tetradium rare, Cyrtodonta ponderosa, Ortonella haine. Ctenodonta cf. cingulata, Bucania cf. capax, Belleroph.	si, on	
cf. mohri, Lophospira	3	
Interval measured along a very long gradient	12	
Thin horizon with Rhynchotrema capax		
Interval measured along a very low gradient	. 10	
Calapoecia common, Columnaria common, Streptelasma an	nd	
Rhynchoirema cabax	3	
Columnoria, Heberlella occidentalis, and Rhynchotrema cap	ax	
at tot of Waynesville member of Richmond	71	
Interval	. 2	
Thin horizon with Columnaria.	3	
Interval	. 3	
Argillaceous limestone with Columnaria and Rhynchotrem	a. 41	

This section exposes the Gore Bay Columnaria reef very well. Its thickness is estimated at 3 feet. The richly fossiliferous strata at the top of the section are regarded as equivalent

to the richly fossiliferous strata, containing Cyrtodonta ponderosa and Ortonella hainesi, a short distance above the Mudge Bay Stromatocerium reef, in the sections near Kagawong. The measured interval of only 22½ feet between the top of the Columnaria reef and the base of the overlying richly fossiliferous horizon evidently is too small. The Mudge Bay Stromatocerium reef is not exposed here, but a quarter of a mile westward there is a conspicuous Tetradium reef at a lower elevation above lake level, but probably corresponding stratigraphically to the same horizon as the Mudge Bay Stromatocerium reef in the Kagawong sections and at the fairgrounds at the south end of Gore Bay. A Stromatocerium reef is exposed also on Barrie island, between lots 5 and 6, in the southern part of concession V. East of the Barrie Island bridge a variety of Byssonychia richmondensis was found.

SOUTH OF HONORA.

(Locality No. 47, Figures 7 and 8.)

On the eastern side of Honora or West bay, about a mile south of Honora village, on the road to West Bay, the following section is exposed:

	1 nickness
Manitoulin dolomite (Silusian) (feet.
Top of Richmond not exposed	. 16
Massive limestone with a few engineers of Sta	. 20
Bryozoans common	. 2
Thin, whitish limestone	- 1
Not exposed, long low gradient	• 5 1
Mudge Bay Stromatocerium reef with a fare Tetradium	. 18
The second second with a new retraatum	. 4

In this section, the Mudge Bay Stromatocerium reef is well exposed and forms a conspicuous reef. The upper horizon, at which a few specimens of Stromatocerium occur, may correspond to the Tetradium reef, or the Manitowaning reef, as exposed northwest of Kagawong. All of the Richmond strata at this locality belong to the Whitewater member.

ROAD WEST OF INDIAN VILLAGE SOUTHWEST OF LITTLE CURRENT.

(Locality No. 48, Figure 7.)

Three miles southwest of Little Current, the road to Honora and West Bay passes a straggling Indian village. Half a mile west of the village the road turns south between lots 20 and 21, and continuing along this road for half a mile southward, to the point where it ascends a steep hill, the following section is exposed:

Thickness

1	eet.
Manitoulin dolomite (Silurian).	
Interval, at top of the Whitewater member of the Richmond	. 8
Fine-grained, whitish limestone with Cyrtodonta species and Byssony	-
chia radiata	. 51
Bryozoans abundant, the same species as those found southeast o	f
Honora, in the preceding section	. 2
Limestone. In this 20 ft. limestone section Hebertella occidentalis and	đ
Byssonychia radiata are common, and one large Pterinea demissa	
was found	20
Interval along a hilly part of the road, difficult to measure with a Lock	e
level	. 17]
Mudge Bay Stromatocerium reef, with a few specimens of Tztradium.	. 6
Interval	. 321
Massive limestone with Columnaria and Calapoecia represented by a fe	w
specimens at the top. The top of this limestone probably corres	-
ponds to the Gore Bay Columnaria reef, here very poorly repre	-
sented. A Rhynchotrema perlamellosum also was found at abou	t
t' level in the limestone	. 8 1
Expose at top of Waynesville member of Richmond	14
Solid n save limestone weathering to rotten soft limestone, with	a
Streptelasma	. 5
Argillaceous limestone	. 12
Argillaceous limestone and rubble	. 31
Fairly solid sandy limestone 'yer	. 1

In this section the Waynesville fauna has been traced downward only 27 feet below the Gore Bay *Columnaria* horizon, to the lowest horizon containing *Streptelasma*. It is evident, however, ' part of the underlying argillaceous limestone

section must belong to the Waynesville bed, but all of this part of the section is nearly unfossiliferous. In face, one of the most interesting features of the Waynesville section, on Manitoulin island and along Georgian bay, is the frequency with which corresponding parts of the section at localities only very short distances from each other, differ widely in the richness and abundance of their fossil content. For instance, at Kagawong, the Waynesville section along the road in the southern part of the village differs wheely in fossil content from that only a few hundred feet farther southward, just below the Kagawong falls. In the same manner, almost the entire Waynesville section, at the locality southwest of the Indian village here under discussion, is comparatively unfossiliferous, although farther eastward, south of Little Current, the corresponding section contains numerous fossils.

CROSSROAD COUTHWEST OF LITTLE CURRENT.

(Locality No. 49, Figures 7 and 8.)

About 3 miles south of Little Current, an east and west road passes between concessions IV and V. The base of the Manitoulin dolomite is exposed somewhere near lot 10, and the following section is seen along a gradient extending at least over a mile eastward from locality 49, along the east and west road:

Th	ickness
Manitoulin dolomite (Silurian)	feet.
Thin limestones at top of the Whitewater member of the Richmond with Leperdilia caecigena, Rhylimya kagawongensis, and the un- known black plant-like remains found also southeast of Mani-	
towaning	2
Massive limestone with bryozoans.	14
Massive limestone with Byssonychia radiata at the top	5
Interval.	275
Mudge Bay Stromalocerium reef, containing also some Tetradium	9
Shaly layers and thin-bedded limestone	61
Solid argillaceous limestone with Lophospira tropidophora and bryo-	
zoans	2
Not exposed	25]

Argillaceous rubble limestone and al. D. H.	feet.
Horizon with Prolarea, Streptelasma, Columnaria, Strophomena like vetusta, Rhynchotrema capax, Zygospira modesta, Ceraurinus marginatus	3
Horizon with Stromatocerium apparently present formerly but little	1
Apparently the Gore Bay Columnaria reef, at any rate this coral is common here, associated with Rhynchotrema caper common, and	1}
Rhynchotrema capax large and common, at top of Waynesville member of Richmond, associated with Protarea, Hebertella occidentalis,	53
Thin horizon with one specimen of Columnaria alveolata in argillaceous limestone	121
At this level there is a long flat area, where the road from Little Current to the middle of Bass lake crosses the road along which this section was measured. This is the road between lots 5 and 6. Near the crossing of this north and south road, one specimen of <i>Stromatocerium</i> and one of <i>Streptelasma</i> were found.	••
Interval. Thin horizon, top of argillaceous limestone with Streptelasma, Stro- phomena sulcata, Hebertella occidentalis.	17 1
Interval consisting, at the top, of fossiliferous limestone definitely referred to the Waynesville and, beneath, of jorraine-like strata Thin horizon with <i>Pholadomorpha pholadiformis</i> in situ. (For a description of strata underlying this section are pare	95

87 of this report).

9

In this section the basal part of the known Waynesville section, with *Heberlella insculpla* and *Catazyga headi*, is not exposed, although over 30 feet of rock may be definitely referred to the Waynesville bed. The basal part of the bed appears to be practically unfossiliferous, a condition observed at numerous other localities on Manitoulin island and along the southern shores of Georgian bay. The Gore Bay *Columnaria* reef apparently may be detected. The Mudge Bay *Stromalocerium* reef is very well represented, although the interval of this *Stromalocerium* reef above the Gore Bay *Columnaria* reef may not have been correctly determined, owing to the very long and

117

Thickness

low gradient. There is no trace of the upper, or Manitowaning *Tetradium* reef, so well exposed at some localities northwest of Kagawong. The most interesting feature, however, is the horizon with *Leperditia caecigena* and *Rhytimya kagawongensis*, at the top of the Richmond section, just beneath the Manitoulin dolomite. This horizon corresponds to that just beneath the Manitoulin dolomite, 1½ miles southwest of Kagawong, along the road to Gore Bay. This horizon belongs above the upper, *Tetradium* or *Manitowaning* reef. The horizon with *Leperditia caecigena*, *Primitia lativia*, and *Rhytimya kagawongensis*, immediately south of Kagawong, however, belongs between the middle or Mudge Bay *Stromatocerium* reef and the upper, or Manitowaning reef. The fossils mentioned evidently have a considerable vertical range.

BASS LAKE ROAD SOUTH FROM LITTLE CURRENT.

(Locality No. 11, Figures 7 and 8.)

Along the road from Little Current southward to the middle of Bass lake, Richmond strata are exposed where the road ascends McLean hill, about 2 miles southwest of town. The exposures are between lots 5 and 6, in concessions VI and VII.

1	hie	KI	1es	53

Limestone in place near top of Waynesville member of Richmond, but fossils few. Columnaria and Calapoecia occur loose, but are belianed to have been in situ at or just above the base of this level,	
Deneved to have been in situate of just and the	15
at the Gore Bay reer norman recombling sustants in outline, near top	
One specinien ci Strophomena resembling matches in contrast, the of section.	11
strepletasma, crown coopera modesta, some specimens approaching	
kentuckiensis. Rhyncholrema perlamellosum, all in situ. Near the	
middle and top Strophomena sulcata occurs	21
Rhynchcirema capax occurs on large loose slabs of rock at this level	15
Interval	13
Beneath this interval occur slabs of limestone, loose, with	
Strophomena huronensis rather common and with occasional specimens of Cyclonema bilix. The horizon with Hebertella	
insculpta and Catazyga headi probably was just benearn	

Thickness	
feet.	

this level. This may be inferred from the slabs which contain these fossils and which are fourd loose at various lower intervals, evidently dropped from their original level. Interval..... 6 Beneath this interval occur loose slabs with Rafinesquina alternata, Hebertella insculpta, Cyclonema bilix, Bellerophon, and Cornuli! ... Interval..... At the base of this interval occur loose slabs with Strophomena huronensis..... Internal..... At the base of this interval occurs a loose slab with Hebertella insculpta, Strophomena planumbona, Strophomena huronensis..... Interval..... 41 At the base of this interval was found a loose slab, with Rhynchotrema perlamellosum, and Strophomena huronensis Interval..... 111 At the base of this interval Catazyga headi was found loose. In the overlying 22 feet of this section, the following fossils also were found loose: Streptelasma, Calapoecia, Hebertella occidentalis, Platystrophia clarksvillensis, and Cyclonema bilix. Specimens of Trematis, occurring in a sandy, Lorraine-like rock, also occur loose at the base of this section. Interval..... 4 At the base of this interval Hebertella insculpta was found in ioose rock. Interval, composed chiefly of Lorraine-like sandy rock 14 Shallow spring along the road, where it ascends the hill in a southwesterly direction.

(For description of underlying strata see page 90 of this report).

This section is interesting chiefly in showing that the basal parts of the known Waynesville section of Manitoulin island are present here, as inferred from the presence of *Hebertella insculpta* and *Catazyga headi*. Moreover, *Strophomena huronensis*, belonging immediately above, also occurs. It may be remembered from the previously described section, that these fossils were not found a mile farther southward, where the lower parts of the Waynesville section are practically unfossiliferous.

The Gore Bay *Columnaria* reef probably was present in this vicinity, although it can not be definitely located at present. This is inferred from the presence of numerous specimens of

119

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Columnaria alveolata with some of Calapoecia farther southwestward, in the fields along the road between concessions VI and VII, near lot 6. They are not infrequent on the southern side of the road, in the open field, after plowing.

NORTHWEST OF MANITOWANING.

(Locality No. 50, Figures 7 and 8.)

A short distance northwest of Manitowaning, in lot 42, there is a steep gully descending the steep escarpment near the shore, formed by a small stream which may be traced back from the shore to the road leading from Manitowaning to Sheguiandah. It strikes this road a short distance west of its junction with the Providence Bay road. In the angle between the two roads is the conspicuous Manitoulin dolomite promontory known locally as "The Rock." East of the rock, a short distance west of the Providence Bay road, a conspicuous Stromatocerium reef, the Manitowaning reef, is exposed. It is scarcely necessary to state that elsewhere this reef may be characterized, not by the presence of Stromatocerium, but by the great numbers of Tetradium. In fact, different parts of a reef may be characterized by different species. This change of dominant species at different points along the same reef, was true of Palæozoic life as much as of that of the present seas.

The following section extends from "The Rock" eastward to the *Stromatocerium* reef, immediately west of the South Bay road, and then continues farther northward across the western edge of the village where there is an area of no exposures, and descends the stream already mentioned, passing through the steep gully to the margin of the lake:

Thickness

Manitoulin dolomite (Silurian), base not exposed. Interval at top of Whitewater member of the <i>Richmond</i> not exposed	56
Stromatocerium (Manitowaning) reef	4
Interval not exposed	20
Clay	1
Limestone	1
Solid limestone, no fossils seen,	- 1
Thin harizon with Clenadorta	feet.
---	------------
Columnaria common. Tetradium and Calabaria ala	••
sibly the equivalent to the Mudge Bay coral reaf hairs	
Solid limestone	*
Streptelasma, Calapoecia, Hebertella occidentalis, large coarse Bellero- phon. Liospira helena	23
Solid limestone with Beatricea undulata, Streptelasma, Tetradium, Rhymchotema berlandlow	*
Chiefly clay, forming a flat, with the overlying strata giving steeper	63
Flat field surface with no experiment and 11	74
Solid li nestone forming top of bluff at gully, with Beatricea undulata	5
Practically account	3
Zuensbien bentuchieneie Contactute to t	63
Poorly exposed limestone	3
Thin horizon with Besteries loose	2
Nodose branching Philodichya similar to that four 1 and for	••
Also Zypospira kentuchiencie	
Limestone with Byssonychia radiata	- <u>+</u>
Soft argillaceous rubbly limestone	31
Blue argillaceous rubbly limestone with Modiol don and numerous	1
specimens of Zygospira kentuckiensis	
Rubble limestone with Streptelasma, Zyeospira kenturbiensis Carto	
donta ponderosa, Orthoceras	21
Solid limestone with Calupoecia	- 1
Solid limestone with Streptelasma, Tetradium, Calapoecia common.	3
Zygospira kentuckiensis, Byssonychia. Regarded as equivalent	
to the Gore Bay reef horizon	2
ponderosa at top of Waynesville member of Richmond	1
Interval	21
Pterinea demissa and Modiolodon in solid limestone	1
Blue rubble limestone with Tetradium	1
Covered.	7
Columnaria, Rhombolrypa quadrata, Hebertella occidentalis, Platy-	
Strophia larksvillensis, Byssonychia radiata in rubble limestone.	1
Phomboling and rubble limestone with Streptelasma and Rhombolrypa	11
Interval	3
Columnaria Straphologue 77. 1. 19	3
Thin horizon with Arthraria biclavata or dumbbell impressions fully 4	3
niches in length	

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Thickness

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	icet.	
Streptelasma, Columnaria, Rhombotrypa guadrata, Hebertella insculpta,		
Platystrophia clarksvillensis.	1	
insculpta	6	
Lake level.		

SOUTHEAST OF MANITOWANING.

(Locality No. 51, Figures 7 and 8.)

Two miles directly southeast of Manitowaning, across the bay, where the road to Wekwemikongsing ascends the hill, the following section is exposed, presenting some features which are covered up in the Manitowaning section by the soil.

1	Thickne
	feet
Manitoulin dolomite (Silurian).	
Strata at top of Whitewater member of the Richmond, not exposed Argillaceous limestone with Byssonychia radiata, Rhylimya kagawongen sis, Leperditia caecigena, Primitia lativia, Bythocypris cylindric	22 1- 1a
and unknown plant-like black remains	. 5
Interval	. 71
At the base of this inte, val there is a flat plain.	
Inserval	. 12
Beneath this interval occurs the top of massive rock cosse by road.	d
Interval	. 22
At the base of this interval occurs a flat plain, with abandone house on north of road.	:d
Interval	22
At the base of this interval is the gate into Indian reservation	n.
Interval	5
Lake level.	

This section suggests the presence of Rhytimya, Leperditia caecigena, and Frimitia lativia above the Stromatocerium (Manitowaning) reef horizon, which is typically exposed east of the "Rock," at Manitowaning. The top of the massive rock crossed by the road, on the Indian reservation, in the preceding section, probably corresponds to the top of the bluff at the gully north of the lighthouse in the Manitowaning section.

122

Thickness

It will be noticed that there is no definite equivalent to the Cape Smith Stromatocerium reef in the Manitowaning section. This reef belongs beneath the Beatricea zone. The horizon where this reef should occur is somewhere within the massive rock forming the 3 feet of the bluff at the steep gully in the Manitowaning section. This would place it about 45 or 48 feet below the Manitowaning reef. Moreover, there is no equivalent in the Manitowaning section for the Gore Bay Columnaria reef. The nearest approach to such a reef is found between 251 and 28 feet above the base of the section, where Columnaria, Calapoecia, and Tetradium are rather more common than elsewhere in the section. This would give an interval of about 21 feet between the Columnaria horizon and the base of the Beatricea zone at which the Cape Smith reef should come in. The total thickness of the Waynesville bed might be in excess of 26 feet, however, since the vertical range of Hebertella insculpta sometimes is fairly considerable at the base of the Waynesville section, as identified on Manitoulin island.

SOUTHWEST OF WEKWEMIKONG.

(Locality No. 52, Figure 7.)

Two miles southwest of Wekwemikong along the road from Mocasset Landing to Smith bay, the following section is exposed where the road rapidly descends the hill.

Thisley

	1 mcknes
Top of exercise at this loss the	feet.
top of section at this locality.	
Limestone belonging to the Whitewater member of the Richmond.	24
Thin horizon with Beatricea undulata	
Interval	5
Beneath this interval occurs the top of the Stromatocerium re (Cape Smith reef).	eí
Interval Stromatocerium, Girvanella, Beatricea undulata, Tetradium commo and large, Columnaria alveolata and calycina, Calapoecia, Strept lasma rusticum. Crania scabiosa. Zvyostrica benucchienzie Com	. 4 n e-
donta ponderosa, Ischyrodonta, and Ctenodonta iphigenia, Archia acella, Bucania cf. capax, Bellerophon cf. mohri, Liospira helen, and Lobhospira trobidophora	5- 3, 5
Interval at top of Waynesville member of Dickmand	
Zygospira kentuckiensis common through at least	. 4

ekge

This section is of interest chiefly for indicating the horizon of *Beatricea*. It ranges both above and below the *Stromatocerium* reef. Below this reef a short distance there is a *Tetradium* reef, with a considerable number of *Columnaria* and *Calapoecia*. This horizon is again very well exposed at Clay cliff on the eastern side of Cape Smith, but in walls too vertical for favourable study.

NORTHWEST OF WEKWEMIKONG.

(Locality No. 53, Figures 7 and 8.)

Northwest of Wekwemikong, along the road leading up the hill, numerous loose specimens of Richmond fossils are found. The locality is interesting as a collecting ground for some of the Waynesville species, including Hebertella insculpta, Strophomena huronensis, and Protarea. Stromatocerium, Streptelasma rusticum, Tetradium, Columnaria alveolata, a very flat form of Rafinesquina, and Cyrtodonta ponderosa also occur.

CLAY CLIFF.

(Locality No. 54, Figures 7 and 8.)

The best known locality for collecting Richmond fossils undoubtedly is Cape Smith. The exposures are known as Clay cliff, and occur 3 miles north of Wekwemikongsing, halfway to the northern termination of Cape Smith. The locality may be reached most conveniently by a boat capable of entering shallow waters. The walk along the shore is across large boulders. A woodland road permitting the use of wagons extends within a mile of the cliffs, and a good path extends the rest of the way to the southern termination of the much lower clay cliffs extending to the south of the conspicuous ones to which the name usually is confined. The lower, more southern exposures just mentioned belong to the Maysville and Eden sections. The more conspicuous Clay cliff belongs chiefly to the Richmond. At least, only the Richmond strata are well exposed here, the underlying Maysville strata being covered up by talus which has fallen from the Richmond strata. Even the Hebertella insculpta layers are well exposed and, at higher horizons, also the Columnaria reef, and the Stromatocerium reef; but the still higher parts of the Richmond formation are not present here. The locality is not favourable for a study of the vertical distribution of the contained fossils, since most of the fossils are found in the talus. However, it is an excellent collecting ground. The following meagre facts are presented.

A vertical wall of limestone forms the top of the Clay Cliff section. At its base, there is a conspicuous Stromatocerium layer. According to the measurements of Prof. Arthur M. Miller, the interval from the Stromatocerium reef to the top of the bluff or cliff is 31 feet. A very large branching bryozoan is common about 16 feet above the Stromatocerium reef. The highest layers containing Hebertella insculpta occur 29 feet below the Stromatocerium horizon. In the talus there is an abundance of forms which are known from immediately below the Stromatocerium reef southwest of Wekwemikong. These forms include the large thick walled species of Cyrtodonta ponderosa, Ctenodonta iphigenia, Bucania, and Bellerophon, also Liospira helena and the like. Most species found in the talus cannot be referred definitely to any horizons, except in a very general way. The following is a list of the fossils found here:

Streptelasma rusticum (canadensis). Tetradium huronensis. Columnaria alveolata. Columnaria calycina. Calapoecia huronensis (cribriformis). Protarea richmondensis (also var. papillata). Stromatocerium huronensis. Cornulites. Spirorbis cf. cincinnatiensis. Batostoma. Constellaria polystomella. Rhombotrypa quadrata. Crania scabiosa. Dalmanella small, not jugosa. Hebertella insculpta. Hebertella sinuata.

Hebertella occidentalis. Strophomena planumbona. Strophomena huronensis. Rafinesquina alternata, very flat form. Platystrophia clarksvillensis. Zygospira kentuckiensis. Cyrtodonta ponderosa. Modiolopsis. Ortonella hainesi. Rhytimya kagawongensis. Ctenodonta iphigenia. Clenodonta cf. madisonensis. Opisthoptera fissicosta. Byssonychia praecursa var. Pterinea demissa. Archinacetta.

Vallatotheca manitoulini. Cyrtolites ornatus. Oxydiscus. Bucania cf. capax. Bellerophon cf. mohri. Clathrospira subconica. Liospira helena. Lophospira near bowdeni. Cyclonema bilix. Orthoceras piso. Endoceras. Spyroceras hammelli. Cyrtoceras (Cyrtorhisoceras?) Iysander. Cyrtoceras (Cyrtorhisoceras?) postumius. Discoceras? Billingsites. Oncoceras. Leperditia caecigena. Bythocypris cylindrica.

To the Richmond faunas mentioned on the preceding pages may be added the following: Licrophycus hudsonicus described from Manitowaning bay. Cyclocystoides huronensis described from the Beatricea undulata horizon on Rabbit island. Vanuxemia bayfieldi described from the upper Richmond on Bayfield sound. Cyrtoceras ligarius described from the Richmond on Drummond island. Billingsites newberryi, although described from Anticosti island, is cited also from the Ordovician (Richmond) exposures of Cape Rich.

(For the underlying Lorraine-like strata see page 82).

GENERAL REMARKS ON THE RICHMOND OF MANITOULIN ISLAND.

The Richmond strata of Manitoulin island probably were deposited near a shore-line. Sandy clays, with very few fossils, are present at many horizons. In fact, they predominate at some localities, and the rapid manner in which the strata change from richly fossiliferous to practically unfossiliferous zones along the same stratigraphical levels, suggests shore conditions.

This does not imply the immediate presence of the shore or very shallow waters. Wave and ripple-marks were not noticed at the localities so far examined, and there are no coarse sandstones or conglomerates. Judging from the prevailing finegrained sandy and argillaceous strata, the waters probably often were muddy. Certain types of life, such as the bryozoans and crinoids, were poorly represented, excepting locally and for very limited horizons. Estuarine or delta deposits may have prevailed towards the north and the northeast. When these

deposits, by some change of currents, were swept farther south or southwest, the conditions for marine life here probably proved less favourable.

BETWEEN GEORGIAN BAY AND LAKE ONTARIO.

At the localities northwest of Meaford, only the Waynesville member of the Richmond was identified among the more fossiliferous strata underlying the red Queenston clay shales. The Saluda and Whitewater members appear here to be represented by the lower half, if not by all of the Queenston red clay shales. This is true also at all of the iocalities southeast of Meaford, along the southern shores of Georgian bay, so far investigated. No trace of the Gore Bay or Cape Smith coral reefs overlying the strata identified as Waynesville, was noted, and of the overlying faunas present on Manitoulin island, only the ostracod fauna, to be described later, is well represented at certain horizons in the Meaford area. The same statement might be made regarding the Richmond exposures along the northern shores of Lake Ontario, near Oakville. Here the Queenston red clay shales also rest directly on fossiliferous strata all of which appear to belong to the Waynesville division of the Richmond.

The following are more detailed statements regarding certain Richmond localities in the area indicated above.

WORKMAN BROOK, SOUTHEAST OF MEAFORD.

Along the lower part of Workman brook, about 3 miles southeast of Meaford (Figure 6), there are almost continuous exposures of strata resembling the Lorraine (see page 78). At the higher horizons, as indicated by the following notes, fossil exposures belonging to the Waynesville member of the Richmond are found. Catazyga headi associated with Cyclonema bilix and a large Hebertella occurred 349 feet above the lake, according to Locke level measurements, which, of course, are more or less inaccurate. Opisthoptera fissicosta is found farther up. At 325 feet, Catazyga occurs associated with Strophomena planumbona, at the base of those richly fossiliferous strata which are correlated definitely with the Waynes alle member of the Richmond. This locality is between lots 8 and 9 on concession III (locality 7).

Richmond strata belonging to the Waynesville member, occur inland from the cliffs of Eden strata along the lake shore east of the mouth of Wo.kman brook. These cliffs have an estimated height of 148 feet. The railway level occurs about 15 feet above the top of the cliffs. Southeastward, a second narrow, steep gully ascends the hill front. The rocks exposed in the lower part of this gully have a Lorraine-like aspect. Farther up, in the same gully (locality 10) strata referred definitely to the Waynesville member of the Richmond are exposed, about 150 feet above the railway, or 313 feet above the lake. Here Cyclonema bilix, Hebertella occidentalis, Platystrophia clarksvillensis, and Strophomena huronensis are found. At one of the lower horizons, in this Waynesville part of the section, Catazyga headi is common in the same slabs with Strophomena huronensis. Opisthoptera fissicosta occurs farther up. Near the top of the gully, the base of the Queenston shale is well exposed. (The underlying Lorraine-like strata, half a mile southeast of Boucher point, are described on page 81 of this report.)

SOUTH OF MOUNTAIN LAKE, NORTHWEST OF MEAFORD.

The Waynesville member of the Richmond and the overlying Queenston red clay shales, which also belong to the Richmond, are displayed at a locality 8 miles northwest of Meaford. The locality (No. 26) extends half a mile south of the eastern end of Mountain lake. It may be reached most readily by taking the road from Meaford to Owen Sound for a distance of 3 miles and turning off northward for a distance of 7 miles to a school at the crossroads. This crossroad is located between concessions VIII and IX and between lots 36 and 37. South of the crossroads, the land rises. The Queenston red clay section begins at the top of the hill, extends north to the crossroad, then east along the latter for a distance of almost a mile, where the road turns first southward, and then eastward down a short and steep ravine connecting with the direct road from Meaford to Cape Rich on the eastern margin of lot 36 in concession VII (Figure 6). The immediately underlying richly fossiliferous Waynesville part of the Richmond section is exposed (at locality 15) along the stream following the southern side of the road in the ravine. Only the richly fossiliferous part of the Richmond, below the Queenston red shales, is here described. (The Queenston part of the Richmond is described on page 164 in this report.) Thickness

	ieet.
Greenish shales and sandstones occurring immediately below red clay shales and forming the base of the Queenston section of the Rich-	
mond	1
Byssonychia radiata occurs in a limestone layer, at the top of richly fos- siliferous beds referred to Waynesville.	·
Shalv rock with a few thin-bedded limestone layers with Hebertella occi-	
ntalis and bryozoans	51
val including green shales interbedded with fine-grained sand-	-
stones and some limestone	15
Highest level at which Strophomena huronensis was seen	
The underlying beds grade gradually downward into strata resembling the Lorraine and contain Hebertella accidentatic Returnship	
clarbemillensis Rafinesquing alternata Strachamong human mi	
Bussonuchia radiata Osthadarma an Clandanta of simulat	
Curlemente biline this histories at an	
Cyconema ours, thickness about	10

CAPE RICH ROAD, NORTH OF MEAFORD.

The character of the richly fossiliferous part of the Richmond, beneath the Queenston division of the Richmond, is shown best by the exposure on the steep eastern face of the hill, directly west of the Disciples church, on the land of John A. Cox, about 6 miles from Meaford, along the road leading along the western shore of Nottawasaga bay northward to Cape Rich on lot 32, concession VII (Figures 6 and 8). Here, the following section (at locality 28) is exposed in descending order:

Thickness feet.

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Thickness

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14				

Richly fossiliferous strata correlated definitely with the Waynesville	
member of the Richmond section, containing the following fossils:	
Streptelasma rusticum, Tetradium huronense, Columnaria alveolata,	
Calapoecia huronensis, Stromatocerium huronense, Cornulites sp.,	
Rhombotrypa quadrata, Rafinesquina alternata flat, Hebertella occi-	
dentalis, Hebertella insculpta, Platystrophia clarksvillensis, Stro-	
phomena huronensis, Zygospira modesta, Byssonychia radiata,	
Pterinea demissa, Opisthoptera fissicosta, Bellerophon sp., Lophos-	
pira cf. beatrice, Clathrospira subconica, Lophospira tropidophora,	
Cyclonema bilix. Orthoceras sp., Calymene sp.	14
Hebertella insculpta horizon, at base of the richly fossiliferous part of the	
Waynesville section, not measured separately	

Interval, occupied by Lorraine-like strata at the top...... 190 Rock full of *Plectambonites sericeus*, along the road in the form of numerous residual blocks of limestone.

This fossiliferous Richmond horizon is regarded as being equivalent approximately to the Waynesville member of the Richmond as exposed in Ohio, Indiana, and Kentucky.

OAKVILLE.

Oakville (Figure 6) is located on the lake shore about 20 miles southwest of the Union station at Toronto. A short distance north of Oakville station a pike runs parallel to the railway, and a short distance northeast of the station a small stream crosses both this pike and the railway. Between the pike and the railway the following species were found about 5 feet below the level of the railway:

Columnaria alveolata, one specimen.Strophomena planumbona.Hebertella occidentalis.Modiolopsis concentrica.Platystrophia clarksvillensis.Calymene sp.

Immediately north of the pike, along the same stream, a single specimen of *Tetradium huronense* was found in situ directly beneath the base of the reddish Queenston shale, which at this level contains sandy rock layers. Farther northward the stream heads in the hills whose slopes freely expose the lower parts of the Queenston, the total thickness of the Queenston equalling

many times the thickness here exposed. From these lower parts of the Queenston section Ulrich described Drepanella richardsoni-canadensis, Oakville being one type locality.

Proceeding from the railway station three-quarters of a mile northeastward, the railway is crossed by a branch of the same stream, a short distance before reaching a road crossing the railway at right angles. South of the railway this branch exposed the following species:

Columnaria alveolata, one specimen. Hebertella occidentalis. Platystrophia clarksvillensis. Rafinesquina alternata. Pterinea demissa.

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Opisthoptera fissicosta. Modiolopsis concentrica. Lophospira bowdeni. Cyclonema bilix.

Following this branch down stream, both branches join east of the road just described as crossing the railway at right angles. From the point of junction to the lake shore the distance is fully a mile and the total drop from the fossil exposures south of the railway to the lake is 70 feet. Within this interval no diagnostic fossil except *Modiolopsis concentrica* was observed. This species occurred at various intervals down as far as the lake level, but is known to have a much greater vertical range below the base of the Queenston, as may be seen from the Weston section.

The occur. of Columnaria alveolata and Tetradium huronense, although accresented only by isolated specimens, suggests the presence here of an horizon approximately equivalent to the Coral zone at the base of the Whitewater division of the Richmond at Streetsville. Comparisons with exposures as far away as Manitoulin island indicate that these corals could occur also at lower horizons than the Coral zone of the Streetsville section. The underlying Lorraine-like strata, containing Modiolopsis concentrica, probably correspond to those strata in the Streetsville section which extend from the base of the Coral zone down to the Strophomena sulcata horizon. In view of the frequency of Strophomena sulcata in several of the lavers in the lower part of the Streetsville section, their presence in the Oakville area or a short distance east of the Oakville area may be looked for.

STREETSVILLE.

Streetsville (Figure 6) is located about 17 miles west of Toronto. Here the following section is exposed on the north side of Credit river. The top of the section begins above the bridge opposite the mill north of the middle of the village. Stratigraphically, the section is located only a short distance below the Queenston red clay shales, which represent the upper part of the Richmond.

11	ckness
Tom of familiference and of all third and a second	feet.
visionally to the Whilewater member.	
Argillaceous rock, interbedded with shaly clay, containing a few	
specimens of Hebertella occidentalis and Byssonychia radiata	15
Limestone underlain by shaly clay	21
Tetradium, Columnaria calycina and alveolata, Stromatocerium, Heber- tella occidentalis Platystraphia clarberillencie Buseneylie addition	•
Orthoceras. Horizon with large speciments of Standardia,	
huronense, lob of Coral zone	
Interval	23
Bridge level at Mill north of middle of million	3
Columnaria calveina Platvetrophia clashmillensia and Tabat.	
dentalis	
Tetradium huronense, Stromatocerium huronense common, and Colum-	2
naria calycina	3
Clay section, Stromatocerium large and common	11
Limestone with Columnaria calycina and Tetradium.	
Columnaria calycina and Tetradium in limestone at base of the Coral	
Projecting solid limestone laws forming at 1	1
member	
Chiefly clay with fam family another to	3
here to the Warmerville merchand D' I	
Limestone with Distanteable statutions	3
Zunestone with Flatystrophia clarksvillensis, Hebertella occidentalis,	
cloneme bilin	
Close and amillaneous lines	2
stathing darkerillensing in Platy-	
strophic currsvuensis and Byssonychia	3

The basal bryozoan layer of the preceding section is an important stratigraphical horizon. It may represent a glimpse of the Waynesville bryozoan fauna. The overlying coral zone, about 13 feet thick, apparently begins the Whitewater phase of

the Richmond, as exposed in the Streetsville area. Both horizons are well exposed also about a mile farther up the Credit river at the bridge northeast of the railway station at Credit Junction. Here occasional specimens of Calapoecia huronensis or cribriformis are found. Very small specimens of Streptelasma rusticum, one-fourth inch long. occur, but are rare. Constellaria polystomella, Rhombotrypa quadrata, Lophospira bowdeni, Lophospira tropidophora, Clathrospira subconica, and Trochonema sp., are found. To Dr. E. O. Ulrich, the general appearance of the fauna at this locality, including species not listed here, suggested Whitewater affinities.

About one-eighth of a mile south of the bridge at the mill north of the middle of Streetsville, the bryozoan layer mentioned in the preceding section attains a thickness of 5 feet and is strongly cross-bedded, with the bedding planes inclined toward the north. Along the top of this series of inclined layers there is a continuous horizontal sheet of limestone of the same coarseness of grain and containing the same fossils. This continuous sheet is about 4 inches thick, and the entire structure evidently is that of a cross-bedded rock, as already stated, and is not connected in any way with an unconformity.

In this bryozoan layer, locally cross-bedded, the following fossils have been found:

Hebertella occidentalis. Platystrophia clarksvillensis. Zygospira modesta. Pterinea demissa. Opisthoptera fissicosta.

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Byssonychia sp. of radiata group. Modiolopsis concentrica. Lophospira bowdeni. Cyclonema bilix.

In the immediately underlying clay and argillaceous limestone layers, having a total thickness of 3 feet, *Platystrophia clarksvillensis* and *Byssonychia* sp. occur. Here is the top of those layers of rock having a very Lorraine-like appearance. Strata of similar lithological appearance form all of the underlying part of the section a Streetsville described here. Their fossil content, however, indicates their Richmond affinities.

The interval from the 3-foot section of strata described in the preceding paragraph down to the exposures beneath the railway bridge, almost half a mile southward, is estimated at 19.5 feet. This interval is occupied chiefly by clay shales, with which are interbedded argillaceous limestone layers varying from 2 to 4 inches in thickness, and containing, especially at the upper horizons, the following species:

Hebertella occidentalis. Platystrophia clarksvillensis. Pterinea demissa. Byssonychia grandis. Byssonychia of radiata type.

Opisthoptera fissicosta. Modiolopsis concentrica. Pholadomorpha pholadiformis. Ctenodonta of cingulata group.

From the level of the river beneath the railway bridge to the level beneath the first road bridge southward, the interval is about 5 feet; and from the latter level down to the base of the first bluff on the east side of the river, the interval is estimated at 16 feet. At the base of this bluff the rocks have the contorted pillow structure, and contain the following species:

Platystrophia clarksvillensis. Rafinesquina alternata, cc. Byssonychia of radiata group.

Modiolopsis, sp. Lophospira bowdeni. Orthoceras s. Isotelus sp.

From this level down to the base of the strongly pillowstructured argillaceous rock layers exposed on the western side of the river, farther down stream, is an interval of 6.5feet, followed by an interval of 8.5 feet down to the base of the second bluff on the eastern side of the river, south of the road bridge. At the latter locality the following species were found:

> Hebertella occidentalis. Platystrophia clarksvillensis. Byssonychia of radiata group. Lophospira bowdeni. Orthoceras sp.

From the latter locality down to the first high bluff exposure on the western side of the river the interval is estimated at 12 feet. At this locality the river valley approaches close to the pike following the western side of the valley, and the bluff lies northeast of the home of William Crozier. Here the following species were found: 2.5 ich to per

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Hebertella occidentalis. Strophomena sulcata, cc. at base of bluff. Lophospira bowdens. Pterinea demissa. Byssonychia of radiata group. Modiolopsis concentrica. Pholadomorpha pholadiformis.

Whitella of obliguata group. Lopinospira tropidophora. Cyclonema sp. Orthoceras sp.

In addition to the specimens here listed some of the rock slabs showed impressions of some species of Strophomena suggesting planumbona.

About 10 feet below the base of this Strophomena sulcata horizon occurs a bluff on the east side of the river, farther down stream. At this locality most of the fossils were found in loose slabs at the foot of the bluff, but within the path of the river at times of high water, and hence there is no certainty that the slabs were not carried down from some higher level by the river. Here the slabs contained both the Strophomena sulcata and Strophomena planumbona, the latter with the characteristic strongly defined thickening of the shell along the border of the interior of the pedicel valve. Since no trace of Strophomena planumbona was found at any locality farther up stream there is at least a probability of this species occurring associated with the Strophomena sulcata at this and the immediately overlying horizon. A species of Catazyga is present, but whether headi or erratica could not be determined, since only pedicel valves were noticed and the pedicel valves of these two species are not readily distinguished unless well preserved. Large flat specimens of Rafinesquina alternata were common. Modiolopsis concentrica and Opisthoptera fissicosta occur. The Modiolopsis could occur here in situ since it is known at the previously described horizon, only 10 feet higher, but the Opisthoptera fissicosta may have been carried down stream from some point above the railway bridge.

Strophomena sulcata is known on Manitoulin island only from the lower part of the Richmond group. It has not been identified heretofore from any part of the area between Georgian bay and Lake Ontario. East of Ottawa, in the Vars area, in the Nicolet River section, and on Snake island in Lake St. John, Strophomena sulcata also is known only from the lower part of

the Richm nd. For the present, therefore, the exposures between the base of the coral zone and the base of the *Strophomena sulcata* zone are regarded as of Richmond age. According to crude Locke level measurements this interval is equal to 82 feet, but, taking into account the southward dip of the rocks, possibly an estimate of 50 feet would be sufficient.

Down stream from the exposure last mentioned there is a steep bluff on the western side of the river, southeast of the home of William Crozier. The base of this bluff lies about 14 feet below the previously described part of the section. No diagnostic fossils were found here.

CONCLUDING REMARKS.

The observations made () far in the area between Lake Ontario and Georgian bay suggest that at present no sharply defined limits can be assigned to the lower part of those Richmond strate which are included in the Queenston red clay shale. In the Meaford area and at Oakville, it is possible that the basal part of Queenston section includes strata which, although unfossiliferous at the localities mentioned, nevertheless correspond to strata which elsewhere are fossiliferous and which there include a Waynesville fauna. From this point of view, the Coral zone and overlying fossiliferous rocks at Streetsville may not represent a distinct set of strata inserted between the overlying Queenston and underlying Waynesville members of the Richmond, but may merely represent those lower horizons of the Queenston section which elsewhere usually are barren of fossils. In other words, during the deposition of those strata on Manitoulin island which are here regarded as equival: 1 to the Whitewater member of the Richmond, the estuarin or osits between Georgian bay and Lake Ontario were comparatively barren of life, but at Streetsville there is evidence on a local incursion of a typical Manitoulin Island fauna, such as is there regarded as Whitewater. The incursion appears to have been from the southwest, during the earlier part of the Whitewater period of deposition. The fauna soon became extinct, probably owing to a southward extension of the estuarine deposits represented by the Queenston red clay.

In the same manner, a careful search for the basal limits of those richly fossiliferous strata, here definitely referred to the Waynesville member of the Richmond, has failed to find any definite line of demarcation between the Richmond and Lorraine. On the contrary, in all parts of Ontario and Quebec, excepting perhaps locally at Streetsville, the richly fossiliferous, more calcareous strata, definitely referred to the Waynesville niember of the Richmond, grade more or less gradually into those more argillaceous and more Lorraine-like strata beneath, which contain the Pholadomorpha fauna. Since on Manitoulin island the lowest of these richly fossiliferous strata definitely referable to the Waynesville, contain Hebertella insculpta and Catazyga headi, confined to a comparatively narrow zone, they were sought also at Meaford. In the vicinity of Meaford, however, there are several Catazyga zones, but Hebertella insculpta still served for purposes of correlation at the locality 6 miles north of town, on the Cape Rich road. It was observed, however, both here and at various other localities in Ontario, that the strata there identified as Waynesville gradually merged lithologically into the more Lorraine-like strata of the Pholadomorpha zone beneath, so that in the absence of good fossils the division between the Richmond and Lorraine became more or less arbitrary.

The question, therefore, arises whether it may not be necessary eventually to include the *Pholadomorpha* zone of Manitoulin island and of the area between Georgian bay and Lake Ontario, in the Richmond. Certainly it is a striking fact that three such typical Richmond lamellibranchs as *Pholadomorpha pholadiformis*, *Opisthoptera fissicosta*, and *Byssonychia grandis* should occur associated in the same upper Lorraine-like layers at Streetsville, and here the occurrence of *Strophomena sulcata* at still lower horizons certainly warrants the reference of the upper part of the Lorraine-like strata to the Richmond. While the evidence afforded by the bryozoans in the *Pholadomorpha* zone on Manitoulin island and near Meaford suggests Maysville affinities, it must be admitted that only a few species of bryozoans have been discovered in this zone so far, and that if a much larger number of species were at hand the conclusions

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reached might be different. This does not mean that the evidence presented by the bryozoans is of little value. On the contrary, they form the most satisfactory diagnostic fossils in strata belonging to the Cincinnatian series. The real trouble is that, so far. a sufficient number of species, whose evidence is unequivocal, his not been found.

F. STERN ONTARIO AND QUEBEC.

VARS.

East of Octava, in the vicinity of Vars (Figure 5), the Queen to red by shale is appear to rest directly upon strata which reas be cortable with the Waynesville phase of the Richmon A 20 before resembling kentuckiensis, occurs in the high t toss. Here is strata immediately under the Queenston shales. If the zero ones are present anywhere in eastern Ontario, they are not exposed. At a lower horizon Strophomena fluctuosa is associated with Catazyga headi, Pholadomorpha pholadiformis, Modiolopsis concentrica, Pterinea demissa, Byssonychia radiata, and numerous other fossils.

This, the most interesting fossil locality in the area east of Ottawa, is found west of Vars. The *Strophomena fluctuosa* locality may be reached by going from Vars half a mile directly west along the railway, to the first road crossing, and then turning southward for a quarter of a mile to the point where the road crosses a small brook. The exposures lie westward along the brook. Fine-grained limestones are abundant in places, and the breaking of a considerable quantity of rock probably would result in the finding of a considerable fauna. The following species were observed:

Cornulites sp. Pholidops subtruncata. Crania sp. Lingula sp. Rafinesquina alternata, 30 mm long. Plectambonites sericeus. Strophomena fluctuosa. Catazyga headi. Zygospira modesta. Zygospira cl. kentuckiensis. Clidophorus planulatus. Byssonychia radiata. Modiolopsis cl. concentrica. Modiolodon poststriatus. Whitella goniumbonata. Pholadomorpha pholadiformis. Rhytimya sp. Pterinea demissa. Lophospira cf. bowdeni.

Orthoceras sp. Calymene callicephala. Isotelus sp. Bythocypris cylindrica.

In the Nicolet River section, the highest level for Catazyga headi is 100 feet below the highest Zygospira kentuckiensis horizon, which occurs just beneath the base of the Queenston red clay shale series, and the lowest specimens of Strophomena planumbona are found 60 feet below the highest Catazyga headi horizon. Pholadomorpha pholadiformis ranges from 70 feet above the highest Catazyga headi horizon to about 130 feet below the lowest Strophomena planumbona horizon. Plectambonites comes in about 40 feet above the highest Catazyga headi horizon, but it is of large size only among the Catazyga layers, and at lower levels. From these data it is assumed, provisionally, that the Strophomena fluctuosa horizon, half a mile west of Vars, belongs somewhere near the base of that part of the Waynesville member of the Richmond section in which Strophomena planumbona is found. Associated with Catazyga headi, in the Nicolet River section, this would be somewhere between 100 and 160 feet below the Zygospira kentuckiensis horizon, which occurs there also just beneath the base of the Queenston shales.

A third of a mile south of the Strophomena fluctuosa locality just described, there is a crossroad. This crossroad is about three-quarters of a mile southwest of Vars, between concessions VII and VIII, and between lots 25 and 26. A short distance west of this crossroad, a farm lane, formerly an open road, leads diagonally southwards toward a distant house. A short distance before reaching this house, fully half a mile from the crossroads, many weathered red limestone blocks are seen along the side of the lane. These evidently are residual blocks which have not been transported far from their original location. They contain the following fossils:

> Hebertella occidentalis. Zygospira kentuckiensis, very common. Byssonychia radiata. Pterinea demissa.

At this locality are seen the first exposures of the Queenston shales on going southward, and the reddish Queenston clays fill the soil from this point for several miles southward, along the road between concessions III and IV.

To any one familiar with the contact between the richly fossiliferous part of the Richmond section and the overlying Queenston red shales, as exposed in the Nicolet River section, the fossiliferous limestone blocks here mentioned would at once indicate that horizon at which Zygospira kentuckiensis is most abundant, namely, immediately below the Queenston shales.

The greater part of the richly fossiliferous Richmond section, which here is correlated with the Waynesville member of the Ohio area, and which should intervene between the *Strophomena fluctuosa* horizon, at the base, and the *Zygospira kentuckiensis* horizon at the top, is not exposed in the vicinity of Vars.

In the Nicolet River section this missing interval includes the Strophomena hecuba and Strophomena sulcata zones.

EDWARDS STATION.

Boulders of the richly fossiliferous Zygospira kentuckiensis beds, associated with Queenston red shale fragments, occur also at a bridge $2\frac{1}{2}$ miles southwest of Edwards station (Figure 5). The locality may be found by going from Edwards station nearly $2\frac{1}{2}$ miles southwest, and then over half a mile southeastward, to a bridge. Evidently, the original line of outcrop must have been farther northward, since the fossiliferous boulders certainly have been moved to their present position by the glaciers.

GENERAL OBSERVATIONS ON THE UPPER RICHMOND OF VARS AND EDWARDS STATION.

The strongly reddish colour of the limestone boulders containing Zygospira kentuckiensis at the localities here described, southwest of Vars and southwest of Edwards station, suggests that these limestones may have been interbedded with red clays. In other words, they may have been located in the basal

parts of the Queenston red clay shales. Such a position would not be anomalous, considering the fact that the Queenston shales themselves are regarded as of upper Richmond age. They probably represent widespread estuarine deposits along the southern margin of the Laurentian highlands. They are known from the western margin of the Saugeen peninsula which separates Georgian bay from the main body of Lake Huron as far eastward as Streetsville. They line the southern shores of Lake Ontario. They occur in eastern Ontario, east of Ottawa, and in the province of Quebec extensive deposits occur northwest of St. Hyacinthe, north of St. Hugues, south of Ste. Monique, and as far east as the Bécancour river, a short distance south of the St. Lawrence. In this entire mass of strata, fossils are found only locally, chiefly toward the base. Possibly the red limestone blocks southwest of Vars and of Edwards station were located within the basal part of the Queenston section. No fossiliferous equivalent of those Manitoulin Island strata, which are correlated with the Whitewater, occurs in eastern Ontario, and in Quebec fossiliferous equivalents are represented only by the Coral zone on Snake island in Lake St. John.

NICOLET RIVER SECTION.

Fossiliferous Richmond strata are exposed in the already partly described section along the Nicolet river in the province of Quebec (Figures 1 and 2, pages 15 and 16).

Here the fossiliferous Richmond beds are overlaid by a considerable thickness of unfossiliferous clay shales, the basal part of which is of a bluish colour while all of the overlying part is of a strongly reddish colour, and on the basis of its lithological appearance is correlated with the Queenston red clay shales of southern Ontario. In the Meaford area, south of Georgian bay, the Queenston red clay shales are regarded, on the basis of included fossils, as of upper Richmond age. In order to indicate the local change in colour of the Queenston section at its base, where it comes in contact with the underlying richly fossiliferous beds, belonging to the Waynesville member of the Richmond, the following notes are added:

feet. Queension red clay shales; only the basal part exposed at Section No. 1; the remainder is exposed along the river banks northward and evidently has a considerable thickness. The gas wells northwest of St. Hyacinthe have penetrated fully 1,000 feet of these red clay shales. Reddish and bluish clay interbedded..... 5 Bluish clay..... 3 Indurated clay rock..... Bluish clay with indurated clay rock at base..... 31 Bluish clay, forming base of Queenston..... 40 No fossils have been found in any part of the Queenston at this locality, but in the vicinity of Meaford, south of Georgian bay, the Queenston contains fossils regarded as of upper Richmond age. Richmond (Waynesville member). Richly fossiliferous strata, described in section 1, following.

It is a familiar fact that the red colour more or less characteristic of the Queenston section is frequently absent in its basal members. Frequently the latter are blue for distances varying from a few feet to 50 feet or more.

In the following notes on the fossiliferous strata in the Nicolet River section which have been correlated with the Waynesville member of the Richmond, three more or less overlapping sections are described as they appear within short distances of each other in the eastern bank of the Nicolet river, $2\frac{1}{2}$ unles southeast of Ste. Monique. Letters have been assigned to several of the more conspicuous horizons by means of which it will be possible to correlate the strata in these sections sufficiently to form some conception of the character of the strata which might be expected in a single continuous section. Where certain fossiliferous zones are too thin to be measured during a preliminary survey, such as the present one, the list of fossils present is inserted at the proper horizon, but no thickness of these very thin fossiliferous horizons is given (Figure 2).

142

Thickness

Section No. 1, at Bluff Southwest of Home of Honore Auger.

	Th	ickness	Total
	Queension red clay shales, basal part only, underlaid by Queenston blue shales.	ICCL.	uncknew
	Richmond strata, referred to the Waynesville member.		
	Top of section	0	0
<u>Y)</u>	Thin limestone at top of fossiliferous Richmond with Zygospira kentuckiensis very common, also a speci- men of Byssonychia.		
	Argillaceous shale		
	Limestone with Zygospira kentuckiensis large, and also Byssonychia	1	•
	Argillaceous shale	4	6
	Thin horizon with Zygospira and Byssonychia		
	Argillaceous shale	2	8
	Thin horizon with Byssonychia common		••
	Argillaceous shale with thin limestone breaking into		
	thin layers	5	13
	Arrilla coous shale with this limentance the st	••	••
	above	7	
	Thin horizon with Zygospira kentuckiensis, Byssonychia, bryozoana	, "	20
	Argillaceous shale. Thin horizon with Byssonychia, gasteropoda, Zygospira kentuckien si	6	26
	Argillaceous shale with thin limestone, several Za-	••	••
	gospiro, and many gouged out cavities several inches		
	long and half an inch deep on the upper surface of		
	the limestone layers, as in the Lorraine south of		
	Clay cliff, in the Cape Smith area of eastern Mani-		
۲N	toulin island	41	301
~)	Pleringe demines lump some limestone, containing		
	2 inches in height: Buttomuchig Blackdowethe		
	pholadiformis. Lophospira hondeni	71	70
	Argillaceous shale	1	30
	Thin horizon with Pterinea demissa.		
	Argillaceous shale	3	42
	Thin horizon with Lophospira bowdeni common, bryo-		
	zoans	••	••
	Argillaceous shale with Whitella, Pholudomorpha pho-		
	saasjormis, Pterinea demissa, Lophospira bowdeni	5	47

	1	nckness	Total
		feet.	thickness
	Argillaceous shale with bryozoans, and with both Plerinea demissa, and Lophospira bowdeni very com-		
	mon	6	53
	Argillaceous shale with several layers of limestone Argillaceous shale with one specimen of Strophomena	1	54
	hecuba, Byssonychia, Pterinea demissa, and Whitella. At this level a species of Bythopora, not meeki, is associated with Hallopora subnodosa. A species of Clathrospira also occurs at and within 15 feet above		
(W)	this horizon Argiliaceous shale with Strophomena hecuba large and very common, Hebertella occidentalis large, Phola-	31	571
	domorpha pholadiformis and Cyrtolites ornatus Thin limestone layers with Plectambonites sericeus of	. 2	59 <u>1</u>
	medium size, Hebertella occidentalis Base of exposures at water level at southern end of cl Holopea sp., and Clathrospira subconica were found	iff.	60

Section No. 2, Along Gully South of Section No. 1 (page 18).

In this section layer (W) corresponds to the top of the Strophomena hecuba horizon in section No. 1; layer (X) is at the top of the zone in which Plerinea demissa is common.

	1	nickness	Total
		feet.	thickness
	Glaciated strata, rather hard rock layers	. 3	
	Argillaceous shale	. 31	
	Thin horizon with Bryozoans common in clumps		••
	Argillaceous shale	. 1	
	Thin horizon with limestone layer with gouged ou markings on top surface	t	
	Argillaceous shale.	21	••
X)	Thin horizon with Plevinea demissa very common Lophospira bowdeni		
	Argillaceous shale with Lophospirs	11	
	Argillaceous shale with Byssonychia, Pterinea demiss	a	
	very common, Lophospira bowdeni	. 21	
	Thin horizon with Whitella very common		••
	Argillaceous shale	. ŧ	
	Argillaceous shale with Byssonychia, Pierinea demisso	i, "	
	Hard limestone layers	·	••
	Argiliaceous shale with Plerinea demissa	. 1	

	1	hickness	Total
		feet.	thickness.
	Thin horizon with Plectambonites sericeus common	•••	••
	Argillaceous shale	11	
(W)	Strophomena hecuba large and common, Pterinea de	•	
	m155G	2	59
	Strophomena hecuba, triangular form not rare	. 1	6U§
	Thin horizon with one specimen of Streplelasma rusti	•	
	cum, several of Pieciamooniles sericeus		
	This begins with Stratheners beside not eniongula	. 4	029
	in form Disctambonitas sericaus Discince demises	r	
	Hard rock layer	•••	••
	Aroillaceous shale	1	63
	Thin horizon with Whitella		00
	Argillaceous shale without fossils.	41	67
	Thin horizon with Plectambonites sericeus common		
	Argillaceous shale	. 1	681
	Argillaceous shale: Plectambonites large and common	n	•
	both at top and bottom of this interval	. 1	69
	Argillaceous shale without fossils	. 31	72
	Argillaceous shale with Byssonychia, Whitella, smal	1	
	Liospira	. 2	74
	A succession of hard limestone layers, the most con	-	
	spicuous in the section, and containing a few trace	5	
	of trilobites	. 3	77
(11)	Argiliaceous shale with practically no tossils	. 59	83
(V)	i nin norizon with Strophomena suicata, one specimen	• • •	
	This besiege with Orthogenes	. 2	03
	Argillaceous shale	••••	851
	Thin horizon with Strackomena sulcata common		009
	Platystrophia clarksvillensis. Strophomena resemb		
	ling Str. precursor but with no vertical folds along th	e	
	hinge line		
	Argillaceous shale	. 1	861
	Thir horizon with Strophomena hecuba large		
	Argillaceous shale	. 31	90
(U)	Thin horizon with Strophomena sulcata common	l ,	
	Strophomena resembling precursor and huronensi.	5,	
	but without vertical wrinkles along the hinge line	4	
	Platystrophia clarksvillensis, Platystrophia cypha	-	
	versaillesensis		
	Argillaceous shale with no fossils	. 3	93
	Arginaceous shale with Platystrophia	. 2	95
	Arginaceous shale with Whitelia	. 19	204

	Thickness	Total
	feet.	thickness.
Thin horizon with Catasyga headi, Platystrophia clarks	-	
villensis, Strophomena, large and triangular, possibl	v	
Str. hecuba, Whitella large		
Argillaceous shale with no fossils	11	98
Thin horizon with Catasyga headi abundant		
Argillaceous shale	14	991
Argillaceous shale, with Calasyea heads abundant a	t	
several levels, and with Byssonychia at the top	21	102
Argillaceous shales	3	105
Base of measured part of gully section.		

146

(T)

That part of the Richmond group of rocks which extends from the highest horizon containing *Catazyga headi* (layer T) to the lowest horizon containing *Strophomena planumbona* (layer S) is exposed along the steep hill-side about 100 yards south of the gully, and is described as section No. 3. This section begins north of the western end of a long farm lane, about halfway down the hill-side.

Section No. 3, Hill-side Section, South of Gully Mouth (page 19).

		hickness	lotal
		feet.	thickness
	Cross-bedded limestone layer		
(T)	Argillaceous shale. Highest horizon at which Catasy headi occurs. Platystrophia versaillesensis an	iq .	
	Strophomena planumbona also occur here	. 2	97 1
	Argillaceous shale with Cornulites flexuosus of Lo	r-	
	raine form figured by Hall, at top	. 4	102
	Thin horizon with Catasyga heads abundant		
	Argillaceous shale	. 1	103
	Heavy limestone		1031
	Argillaceous shale	71	111
	Heavy limestone layer followed by clay shale with	h	
	interbedded thin limestone lavers, not well expose	d 174	1281
	Hard limestone	1	120
	Thin horizon with Catagora heads abundant		147
	Chiefty amillaceous shale	10	120
	Hard limestone interhedded with limesters and ini-	. 10	133
	mand innestone interbedded with innestone containin	g	
	an abundance of Coldryge needs, and also numerou	15	
	speciments of typical forms of Strophomena planun	8-	
	bona, Kafinesquina alternata	. 1	140

	1	Thickness	Total
	Aprillaneous shate	leet.	thickness
	Thin horizon with Catasvea keadi abundant	12	152
	Amillaceous shale		184
S)	Argillaceous shale with Catasyga heads abundant. Several specimens of Strophomena planumbona. Two specimens of Rhynchotrema perlamellosum occur in a loose slab of sandy fine-grained limestone, also containing Catasysa heads at this horizon. It is		134
	probable that this slab is almost at its original lowel	2	180
	Base of strata correlated definitely with Waynesville member of the Richmond.	2	150
	Shaly strata	4	160
	Thin horizon with Catasyga headi abundant		
	Argillaceous shale	0	169
	Harder limestone with Plectambonites sericeus common	1	1601
	Shalv strata	13	1821
	Not exposed	161	100
	Shalv strata with Cymatonata intermediate between	103	177
	recta and tholadis near the middle	14	212
	Poorly exposed	20	213
R)	Shales with Catasyga very abundant, and with occa- sional specimens of Cyrtolites ornatus and Byssony-	20	233
	chia The Lorraine-like strata underlying section No. 3 are described on page 19.	51	2381

The Catazyga headi horizon (R) occurs at the northern edge of a long bluff immediately south of a farm lane coming down the hill-side from the road passing the home of Honore Auger. The locality may be reached as follows. From the home of Auger southeastward to the point where a road comes in from the northeast is a distance of a quarter of a mile. Several hundred yards beyond this point there are two barns on the western side of the road. The lane passes these barns and strikes the hill slope a quarter of a mile distant. The lower Catazyga headi exposure here mentioned is located on the left side of the road, at the edge of the bluff, about 60 feet above the level of the river.

In the first of these three sections the base of the Queenston clay shales rests directly on strata containing numerous specimens of a species of Zygospira resembling kentuckiensis. This

Zygospira, associated with Byssonychia radiata, has a vertical range of 30 feet. The interval between the Strophomena hecuba laver (laver W) and the lowest Zygospira kentuckiensis horizon 30 feet above, is characterized by the abundance and large size of a thick shelled form of Pterinea demissa, and numerous specimens of Lophospira beatrice which is a rather short spired form of Lophospira bowdeni. A form of Whitella, resembling Whitella ohioensis, is common at several levels, and occasional specimens of Pholadomorpha pholadiformis occur. It will be noted that all of the forms mentioned as occurring in this interval between the Strophomena hecuba layer and the Zygospira kentuckiensis horizon are found also at lower levels. The highest level for Strophomena hecuba is 54 feet below the highest level for Zygospira cf. kentuckiensis. Three and a half feet lower, in laver (W), Strophomena hecuba is common, and is associated Streptelasma rusticum is with Pholadomorpha pholadiformis. found just beneath this abundant Strophomena hecuba horizon. The highest horizon for Strophomena sulcata is about 78 feet beneath the top of the Zygospira zone, but it ranges down to 90 feet, associated with Platystrophia clarksvillensis, and a species of Strophomena which resembles the more triangular typical form of hecuba in outline. No very good specimens of this larger Strophomena were collected; the same form occurs also at 97 feet. Immediately below, in layer (T), typical specimens of Strophomena planumbona occur, associated with Catazyga headi. Platystrophia clarksvillensis and versaillesensis range from about 25 to 40 feet below the Strophomena hecuba layer (W). Most of the fossils here mentioned have an extended vertical range, but their vertical range and order of succession in the provinces of Quebec and Ontario are so much alike that they have a measure of diagnostic value. The danger lies not in making use of these fossils after their ranges are known, but in using them for correlation before their local ranges have been determined. Strophomena planumbona occurs not only at the 962-foot level but also at the 141, 154, and 156-foot levels. Between 155 and 157 feet (layer T), it is associated with Catazyga headi and Rhynchotrema perlamellosum. This Rhynchotrema perlamellosum layer is the lowest horizon (layer T) at which forms definitely suggesting the Waynesville phase of the Richmond are known to occur at present. From some one of the Strophomena planumbona zones, in the Waynesville part of the Richmond, Dr. Ulrich determined Homotrypella hospitalis and a Heterotrypa resembling prolifica, two very characteristic Richmond species. Plectambonites sericeus is common as low as 170 feet below the highest Zygospira layer, and Catazyga headi is abundant at the 240-foot level (in layer R) in the descending scale. Below this lower Catazyga headi horizon (layer R), the rock assumes a very Lorraine-like appearance, and in these lower strata Pholadomorpha pholadiformis and the Modiolopsis resembling concentrica are found, associated with Rafinesquina mucronata, Pholidops subtruncata, Clidophorus praevolutus, Clenodonta lorrainensis, Byssonychia radiata, Pterinea demissa, and other forms.

In this Nicolet River section the correlation of the Pholadomorpha zone, beneath the strata definitely referred to the Waynesville, offers difficulties. That part of the Waynesville section which extends from layer Y down to layer W is distinctly calcareous. Between layers W and T the strata have a lithological resemblance to the Lorraine and between T and S this lithological resemblance becomes very marked. Lithologically there is no abrupt change between the strata above layer S and any of the underlying strata here referred to the Pholadomorpha zone. The general impression produced by a study of the Nicolet River and other sections in Quebec and eastern Ontario is that of a Richmond fauna gradually invading a Lorraine sea, with only a few species of Richmond fossils making their appearance in the Pholadomorpha zone, but with their number increasing in layer S, and becoming dominant between layers T and Y. Any attempt at a more exact correlation of the upper Ordovician sections of Quebec and eastern Ontario with those in the Cincinnatian areas of Ohio, Indiana, and Kentucky probably represents more or less of a perversion of the actual facts. Such elements of the fauna as Strophomena hecuba and Strophomena fluctuosa may have entered the province of Quebec from the north or northeast while Strophomena planumbona, Strophomena sulcata, and Rhynchotrema perlamellosa may have entered from southwestern sources. Pholadomorpha pholadi-

formis and its associates in the Streetsville area, Opisthoptera fissicosta and Byssonychia grandis also represent southern or southwestern invasions into a Lorraine sea.

When many species of a fauna enter a new territory rapidly they are likely to displace more or less of the previously existing fauna and the line of demarcation between the recently introduced fauna and the previously existing one is likely to be more or less sharply defined.

In the case of the Richmond fauna in the provinces of Ontario and Quebec, the fauna appears to have entered a territory dominated by Lorraine forms not *en masse* but a few species at a time, so that there is nowhere in these provinces any sharp demarcation between the Richmond and the Lorraine.

RIVIÈRE DES HURONS, 4 MILES NORTHEAST OF CHAMBLY BASIN.

In the collections of the Geological Survey are various specimens which are labelled as coming from the Rivière des Hurons, occasionally with a reference to St. Jean Baptiste (Figure 1). Among these, the following species have been identified:

Strophomena planumbona var. Plerinea (Caritodens) demissa. Pholadomorpha pholadiformis divaricata. Psiloconcha subovalis.

From the same collection, the following species and varieties have been described by the writer as new:

Modiolopsis postplicata. Cymatonota lenior. Psiloconcha sinuata-borealis. Whitella securiformis. Whitella complanata. Whitella goniumbonala. Clidophorus praevolutus. Cuneamya scapha-brevior. Lophospira beatrice.

The horizon appears to have been distinctly above the *Proetus chambliensis* zone, and the lithological appearance of the rock suggests either the *Pholadomorpha* zone in the upper part of the Lorraine, or the lower part of the Waynesville.

The locality from which these fossils were obtained is stated by Ells in his report on the geology of the Montreal sheet, to have been well known. On the map (No. 571) accompanying his report, the fossil locality is indicated as being found a little over a mile downstream from the bridge at the southern edge of the village of St. Jean Baptiste. This bridge lies on the road leading from Mont St. Hilaire village southeastward to the river. However, no exposures occur south of this bridge, either on the river or anywhere near the river, until a point 3 miles downstream is reached. Here the Rivière des Hurons, onl' a very small creek in midsummer, is crossed by a cement br tge, and from this point exposures extend for at least half a mule down the river. The cement bridge is in the northeast edge of the area known as Chambly East, and lies entirely outside of the St. Jean Baptiste area.

No fossils were found anywhere near the bridge; but about a quarter of a mile down stream a fragment of *Eusarcus*, an Eurypterid, recognizable owing to its very characteristic ornamentation consisting of small oblong elevations with lunulate raised margins, was found at the first locality at which the rock appears black and shaly.

No other fossils were found until a point about half a mile below the cement bridge was reached. Here a road leading to a farm house north of the stream, descends through a cut in the bank and rock is exposed in abundance on the south side of the stream, immediately below the crossing point. Here most of the species listed from the Rivière des Hurons in the collections of the Geological Survey were found. These species include:

Hebertella (identalis.
Strophomen flanumbona.
Strophomena hecuba.
Rafinesquina alternata both flat and convex forms. The flat are more common and attain a length of 1½ inches.
Catasyga headi.
Byssonychia "radiata."
Pterinea demissa, with thick shells as in Waynesville part of Nicolet River section.
Pholadomorpha pholadiformis.

Modiolopsis cf. concentrica.

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Whitella securiformis. Whitella complanata. Whitella goniumbonata. Cymatonota cf. recta. Lophospira beatrice.

Although confined to only a small area, the locality may be said to be richly fossiliferous. On the opposite side of the stream, the rock does not rise more than a foot above the water level and fossils are few, although including *Catazyga headi*, *Strophomena planumbona*, and *Byssonychia radiata*. The dip at the richly fossiliferous locality is eastward, so that the *Eusarcus* bearing black shale, farther eastward, probably represents a higher horizon.

The richly fossiliferous horizon probably corresponds approximately to that part of the Waynesville division in the Nicolet River section in which Strophomena hecuba is fairly common. At this horizon the Pterinea demissa frequently preserves the entire thickness of its shell and is not represented merely by the impression of its exterior surface. Here also Lophospira beatrice, a representative of the Lophospira bowdeni group is common. Here Whitella is common and the range of Catazyga headi begins just below.

ST. HILAIRE.

Richmond exposures, referred to the Waynesville member of this group of rocks, occur also east of St. Hilaire village (Figure 1), on the Grand Trunk railway, about 18 miles northeast of Montreal. The station is on the eastern side of the Richelieu river, at the point marked Otterburn park on the Montreal sheet (Map No. 571). At present the Otterburn Park station is farther southward, at the eastern end of the bridge across the river.

From St. Hilaire station a road leads southeastward up the hill and continues for half a mile across a flat plain beyond which it ascends another hill rising toward the foot of the igneous mass of rock forming Mt. St. Hilaire. Near the lower part of the second rise of land an exposure of black shale occurs along

the eastern side of the road and contains the fossils listed as a *Pholadomorpha* zone fauna on page 45.

Three-quarters of a mile southeast of the railway station the road turns abruptly southward and within an eighth of a mile an exposure on the south side of the road is reached. The dip of the rock is southward, away from the mountain. The total thickness of the section is 21 feet, the top terminating at a small culvert. Toward the top of the section only a few specimens of *Byssonychia radiata* were noticed, but between 5 and 10 feet above the base, there is a richly fossiliferous zone containing:

Streptelasma rusticum. Platystrophia clarksvillensis. Strophomena hecuba and planumbona. Plectambonites sericeus. Byssonychia radiata. Pterinea demissa 2 inches in height. Pholadomorpha pholadiformis. Cuneamya brevior.

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Whitella complanata. Cymatonota lenior. Cymatonota cf. recta. Psilonychia subovalis. Clidophorus praevolutus. Clidophorus planulatus. Eotomaria remotistriata, sp. nov.

No specimens of Catazyga were noticed at this locality. The fauna is regarded as corresponding approximately to the Strophomena hecuba zone in the Waynesville member of the Richmond as exposed in the Nicolet River section. The presence of Streptelasma rusticum in association with Strophomena is interesting since Streptelasma is not a common fossil in that part of the Richmond exposed in western Quebec and eastern Ontario.

This Richmond horizon stratigraphically occurs above the so-called Lorraine exposure occurring along the same road but nearer St. Hilaire, but how much above the latter is unknown. It is evident that the general aspect of the fauna here is Lorraine, with only a few Richmond species added. At the Lorraine fossil exposure the shales are black and thin bedded. On approaching the Richmond exposure, the shale becomes interbedded with brownish, more arenaceous rock. Overlying the fossiliferous Richmond beds, farther southeastward, on the road to Mont St. Hilaire village, is a section similar to that at the cement bridge across the Rivière des Hurons 3½ miles southwest of Mont St. Hilaire village, at which no fossils are found.

At the point where the pike three-quarters of a mile southeast of St. Hilaire turns abruptly southward, a less travelled road leads off northeastward along the western margin of the volcanic plug forming Mont St. Hilaire. On the eastern side of this road the hornstone formed by the volcanic mass is well exposed, but no fossils were seen here. Less than a mile from the pike, this road comes to an end in a farmyard, but a wood road continues in the same general direction along the hornstone front of the mountain, and then angles northwestward toward the railway station which is known as St. Hilaire East. Along this road a loose rock fragment, possibly not in situ, contained Catazyga headi and Streptelasma rusticum. This association of Streptelasma rusticum with Catzayga headi was noted also in the exposures along the Nicolet river. The horizon there is above that of the lowest strata containing Strophomena planumbona, and, therefore, the rock fragment east of St. Hilaire East is assigned to the lower part of the Waynesville member of the Richmond as exposed on the Nicolet river.

In one of the hornstone boulders, used for the construction of the wharf at St. Hilaire East, said to have been hauled down from the western side of the mountain, *Catazyga headi* is associated with a large *Pterinea demissa* and a well preserved specimen of *Rhynchotrema perlamellosum*. This association also indicates the lower part of the Nicolet River phase of the Waynesville member. From limestone boulders hauled down from the fields east of St. Hilaire station, west of Mont St. Hilaire, but not from the vicinity of the hornstone contact, the following species were obtained.

Catasyga headi. Strophomena planumbona. Plectambonites sericeus. Rafinesquina alternata. Byssonychia radiata. Pholadomorpha pholadiformis.

These fossils also indicate the lower part of the Nicolet River phase of the Waynesville member. The Zygospira kentuckiensis horizon of the Waynesville bed is unknown so far in the St. Hilaire region, but no thorough exploration of the territory has been attempted as yet.

ST. HUGUES.

The presence of the Waynesville member of the Richmond somewhere north of St. Hugues (Figure 1) is indicated by glacial boulders containing Strophomena planumbona, Strophomena hecuba, and Cyclonema bilix. In one block, Streptelasma rusticum, Catazyga headi, and Platystrophia clarksvillensis are associated. Rafinesquina alternata is associated in another block with Streptelasma rusticum and Catazyga headi. St. Hugues is 37 miles northeast of Montreal, on the St. Hyacinthe and St. Guillaume branch of the Canadian Pacific railway; and 12 miles north of St. Hyacinthe.

The origin of the erratic Richmond blocks in the St. Hugues area is uuknown. However, they could have come from within a short distance northward since the geological map of the area indicates that a syncline crosses the Yamaska river a number of miles below St. Hugues, retaining the Queenston red clay shales within the trough of the syncline. On each side of the central axis of this syncline, fossiliferous Richmond strata should be present.

SNAKE ISLAND, LAKE ST. JOHN.

Lake St. John is about 120 miles northwest of Quebec. Roberval is situated on its southwestern shore, and Trenton limestones extend from this village for several miles northward. toward Blue point. Fissile black shales, usually regarded as Utica, occur near the northern end of the line of outcrops, and also south of Roberval, east of the Ouiatchouan falls. All of these strata dip eastward at rather low angles. Snake island lies 2 miles directly east of Roberval. The island is about a mile long, from north to south, but is only a few hundred yards wide. Outcrops occur only in a small patch along the southeastern shore, near the northern end of a rocky beach, but most of the fossils occur in loose and more or less rounded fragments of rock which cover the beach for a distance of 400 or 500 feet along the shore, and for 50 to 160 feet inland, as far as the most distant points reached by the waves in the roughest weather. A second area covered with fossiliferous rock fragments lines the

shore a short distance north of mid-length on the eastern side of the island.

At the small patch of exposed rock, on the southeast shore, the dip is eastward at about 5 or 10 degrees. The bedded rock does not rise more than 2 feet above lake level, the surface being glaciated. The glacial striæ are approximately north and south in direction. In winter the ice freezes tight to the rock and pulls it loose. The waves break up the ice and throw it upon the shore; here the ice melts later and releases the rock. The rock which is in situ contains: Streptelasma rusticum, Columnaria alveolata, Calapoecia huronensis, Lyopora goldfussi, Tetradium huronense, Stromatocerium huronense, and Streptelasma divaricans.

It is probable that the loose specimens of *Beatricea undulata*, and those of *Ortonella hainesi* which occur in the same rock fragments as *Calapoecia huronensis* originate at about this same horizon.

The horizon containing the above named fossils apparently corresponds to the Gore Bay coral zone of Manitoulin island, and belongs above the Waynesville member of the Richmond. It is correlated provisionally with the Whitewater member.

It is evident, however, that another horizon must be present below water level. The rocks from this source are known only from the fragments tossed up by the waves. These strata contain quite a different fauna and some of the loose rock fragments are distinctly different lithologically from the actual exposures on the island. They are thinner bedded, more compact in texture, and bluer in colour. From the loose fragments coming from these lower horizons the following species were obtained:

Rhombotrypa quadrata.

Strophomena, of the planumbona type, with about the same triangular outline as those identified as *fluctuosa* at Vars, east of Ottawa, but without any evidence of concentric folds.

Strophomena resembling sulcata.

Platystrophia clarksvillensis.

Catasyga headi; the proposed variety borealis evidently has no standing whatever.

Orthodesma canaliculatum.
Modiolopsis cf. concentrica. Pholadomorpha pholadiformis, Ctenodonta cf. albertina. Archinacella, Cyrtoliks ornatus, Oxydiscus, Liospira micula, Helicotoma.

These fossils, notwithstanding the low eastward dip of the few layers of rock seen *in situ*, are regarded as belonging to a lower horizon than the coral zone which forms the actual exposures on the island. They occur lower also at all other localities in the provinces of Ontario and Quebec, so that, no matter what their range may be elsewhere, in these provinces they indicate a lower horizon than the Coral zone. This horizon is correlated with the Waynesville member of the Ohio Richmond.

Other fossils found in the same rock fragments, from beneath the coral zone, but not considered so diagnostic, are:

Crania scabiosa.

Crania with very fine concentric striæ. Crania with very fine radiating striæ. Crania with coarse radiating striæ, not identical with laelia. Trematis millepunctata. Dalmanella of testudinaria group. Hebertella occidentalis. Rafinesquina alternata. Zygospira modesta. Rhynchotrema, a tiny new species scarcely more than 7 mm long. Byssonychia, smaller than subcrecta and with more plications than radiata. Clidophorus. Ctenodonta, nearest albertinc.

Clenodonta with shorter, more rotund outline than albertina, but otherwise not differing from that species, as far as known at present.

Pterinea demissa.

Archinacella, somewhat resembling richmondensis in size and general appearance, but with the apex more overhanging anteriorly and more depressed below the middle convexity of the shell, and without any conspicuous concentric striæ.

Cyrtolites ornatus.

Eotomaria.

Helicotoma, resembling planulatoides with the upper half of the lateral margins of the outer whorl making a much smaller angle with the horizontal, owing to distortion resulting from pressure. Hormotoma? a form without the surface striæ, and, therefore, not identifiable generically.

Lisspira, resembling micula in the closed umbilicus, but without any raised line differentiating the inner reflexed lip or callosity from the remainder of the shell.

Lophospira bowdeni.

Lophospira tropidophora, the type of this species appears to be a Schisolopha, but the Snake Island specimens do not preserve any indication of a long narrow slit along the peripheral angle. Sinuites concellata.

Oxydiscus.

Orthoceras.

Calymene callicephala.

Isotelus.

Loose specimens of *Rhynchotrema*, resembling in the distinctness of their concentric striations *perlamellosum*, occur entirely iree from the rock, but they are somewhat crushed and may belong to the series of *Rhynchotrema increbescens* found in undoubted Trenton limestones several miles north of Roberval, on the western shore of Lake St. John.

This lower Richmond fauna is quite rich, and breaking up the boulders found on the island would no doubt increase the number of species considerably; but sufficient is at hand to indicate the presence of the Waynesville member of the Richmond, or rather that phase of the Waynesville which has been found at various localities in the provinces of Quebec and Ontario as far west as Manitoulin island. The upper coral horizons, with *Stromatocerium* and *Beatricea*, are known not only in the eastern part of Manitoulin but also on Rabbit and Club islands, off the eastern coast. These coral horizons are distinctly higher than the Snake Island horizons furnishing the broken up blocks of Waynesville limestone above mentioned.

It is an interesting fact that at present no outcrops of this coral horizon are known nearer to Snake island than Streetsville, west of Toronto, and Manitoulin island. This coral zone is not present on the Nicolet river, nor in the Vars section, east of Ottawa, nor on the Saugeen peninsula, between Collingwood and Owen Sound. It is unknown at corresponding horizons in New York, but possibly is represented on Frobisher bay. northwest of Labrador, and at other northern areas. The same species of coral have an extensive vertical range on Anticosti island. There probably was free connexion between Anticosti, Lake St. John, and Manitoulin island during the deposition of the coral zones in late Ordovician times.

By far the most widely distributed zone of the fossiliferous Richmond, in the provinces of Quebec and Ontario, is the fossiliferous Waynesville zone below the Gore Bay or lower Saluda coral horizon. The coral zone has been identified at almost every locality on Manitoulin island at which the proper horizon was exposed. Between Georgian bay and Lake Ontario it is absent excepting at one locality, namely, Streetsville, west of Toronto. It appears to be absent also in New York, since no clear evidence of the presence of *Columnaria* in situ in that state has been presented, so far.

The coral zone reached Indiana and Kentucky, and the striking feature of this migration is its presence only on the western side of the Cincinnati geanticline, excepting in central Kentucky, where in an extremely limited area it crossed the geanticline, appearing as far east as Ophelia, 4 miles north of Richmond.

THE ANTICOSTI ELEMENT IN THE RICHMOND FAUNAS.

On comparing the Richmondian faunas east of the Frontenac axis, in the extreme eastern part of Ontario, and throughout the province of Quebec as far northeast as Lake St. John, 120 miles north of Quebec, with those of the Anticosti section, the presence of a few characteristic Anticosti forms may be noted. Among these are the *Strophomena fluctuosa*, from the section east of Vars; the *Strophomena hecuba* from the Nicolet River section and the *Lympora goldfussi* from the Lake St. John section. When the faunas on Anticosti have been fully described and illustrated, the number of characteristic Anticosti species found in the Richmond strata farther westward at the various localities in the province of Quebec and in the eastern part of Ontario, east of the Frontenac axis, no doubt, will be greatly increased. A close comparison of the faunas east of Ottawa, on the Nicolet river, and on Lake St. John, with those from the various divisions of the Richmondian on Anticosti island, as worked up by Professors Schuchert and Twenhofel, does not show as close a resemblance as was at first expected.

Strophomena fluctuosa has such a great range on Anticosti, that at present it has little diagnostic value in identifying parts of the more western exposures with the lesser divisions of the Anticosti section. No close resemblance between the fauna west of Vars, east of Ottawa, and any part of the Anticosti section can be noticed. With the single exception of Strophomena fluctuosa, the resemblances are with Richmond faunas along the northwestern part of Lake Ontario, and around the northern part of Lake Huron, rather than with those of Anticosti. I am rather inclined to believe that the Vars Richmond fauna belongs below the lowest published Richmond fauna on Anticosti.

The vertical range of Strophomena hecuba on Anticosti is more restricted than that of Strophomena fluctuosa, although equalling about 400 feet. Although Rhynchotrema perlamellosum has an almost equally extensive range on Anticosti, it is exceedingly rare in the lower half of the Strophomena hecuba zone. Streptelasma rusticum, on the contrary, is listed only from the lower half of this Strophomena hecuba zone. I am inclined to regard the Nicolet River Richmond exposure as below the base of the Charleton division of the Richmond, but how far below is quite another question. It may be lower than any Richmond fauna so far listed from Anticosti. The general facies of the Richmond fauna on the Nicolet river is western. Notwithstanding the presence of Strophomena hecuba, the general fauna resembles that found at Vars, east of Ottawa, and in the areas between the northwestern part of Lake Ontario and the northern part of Lake Huron. This is suggested also by the presence of Strophomena sulcata, a form not identified so far from Anticosti.

Lyopora goldfussi is listed by Twenhofel from the Charleton formation in Anticosti, It is listed by Lambe also from Clay cliff, on the eastern side of Cape Smith. Streptelasma rusticum is listed only from the lower, or English Head division of the Richmond, on Anticosti. Tetradium is not listed at all from Anticosti. Columnaria halli is not listed below the lower part of the Charleton division. Columnaria alveolata is mentioned first about 200 feet above the base of the Charleton. Calapoecia cribriformis is listed from the lower part of the Charleton, but Calapoecia anticostiensis begins its range in the underlying English Head division. Beatricea begins its range near the middle third of the Charleton.

From the general aspect of the fauna I am inclined to correlate the coral zone of Snake island (see page 156) with the Charleton division, rather than with the English Head division of the Richmond, as exposed on Anticosti. This inclination is somewhat strengthened by the presence of *Ceraurinus marginatus* immediately above the Gore Bay coral zone 3 miles south of Little Current, on Manitoulin island, and the presence, on Anticosti, of the closely related *Ceraurinus icarus* which begins its range near the base of the Charleton division. The underlying part of the Richmond, on Lake St. John, as far as known from the fragments to sed up by the waves, is regarded as belonging very low in the English Head section, if represented on Anticosti at all.

In this connexion, the absence of Dinorthis subquadrata in all of the area between Lake St. John, Lake Ontario, and the northern part of Lake Huron should be noted. Any close comparison of the Richmond faunas of these more western areas with those on Anticosti can not fail to demonstrate great differences. It is difficult to avoid the conclusion that the western areas belonged to basins quite distinct from the Anticosti basin, notwithstanding the fact that various Anticosti species succeeded in entering the more western territory at various The presence of Streptelasma angulatum, in association times. with Dinorthis subquadrata, and the great abundance of Rhynchotrema perlamellosum in the lower part of the Charleton section, suggest the possible connexion of the Anticosti with the Manitoulin basin by way of some northern passage during the deposition of this part of the Richmond. The presence of such a temporary northern channel is suggested also by the distribution of Lyopora goldfussi, as given by L. M. Lambe. Endoceras anticostiensis Billings was cited by its author also from Lake St. John, but it is doubtful whether this species is sufficiently distinct to suggest the presence of an additional Anticosti element in the Lake St. John fauna.

After the publication of the later studies of the Anticosti faunas by Twenhofel a much better basis for comparison will be at hand. The object of the present notes is to emphasize the comparatively small, strictly Anticosti element in the Richmond of localities east of the Frontenac axis, even as far east as the Nicolet river and Lake St. John and to contrast this with their general western aspect. That coral reefs may occur at any horizon, and in themselves have no diagnostic value, we already know. It is only the associated fauna which may be diagnostic.

Queenston Formation.

The very meagre Queenston fauna along the southern shores of Georgian bay, and the single species of ostracod found at Oakville along the northern shore of Lake Ontario represent faunas which entered a sandy delta deposit from the southwest. The ostracod element, at least, appears to be a typical representative of the Saluda of Indiana, and of a part of the Whitewater in Ohio.

WESTERN ONTARIO.

BETWEEN GEORGIAN BAY AND LAKE ONTARIO.

OAKVILLE.

Oakville (Figure 6) is a village near the shore of Lake Ontario, about 20 miles southwest of Toronto, and about 10 miles directly south of Streetsville, the locality at which the Richmond formation is so well exposed.

The reddish and purple Queenston shales are well exposed northeast of the village, on the hillsides. Here the type of Drepanella canadensis was found by Ulrich. A considerable Waynesville fauna occurs here directly beneath the Queenston red clay shales (see page 130).

In the October number of the Journal of the Cincinnati Society of Natural History, published in 1890, Mr. E. O. Ulrich briefly described *Drepanella richardsoni*, var. *canadensis*. Since this description is so brief as to almost escape attention, it is given below.

"A variety of *D. richardsoni*, differing from the typical form of the species mainly in the more regular character of the superficial reticulation of the test, occurs at Oakville, Ontario, in purple shales, referred by the Canadian geologists to the Hudson River group. It might be called var. *canadensis*."

It is not stated upon what basis the Canadian geologists referred these strata to the Hudson River group, or where this reference was published, but, whatever their reasons may have been, their reference was correct, since the term Hudson River group was used by them to include the equivalent of all the Cincinnatian strata, of which the Richmond group forms the upper part.

Ulrich's views regarding the Hudson River age of the Queenston shales unquestionably were based upon the evidence offered by his new variety of *Drepanella*, since typical *Drepanella richardsoni* is abundant at the type locality on Cowans creek, northeast of Clarksville, in the western part of Clinton county, Ohio, in strata belonging to the Whitewater division of the Richmond.

In the Catalogue of Types in the U.S. National Museum, the Canadian specimens are listed as *Drepanella richardsoni* canadensis, Ulrich, Lorraine (Ord.), Oakville, Ontario, Canada. In this catalogue, however, the term Lorraine includes those Cincinnatian strata for which the name Maysville has been proposed recently. Used in this sense, the Lorraine formation underlies the Richmond, in southwestern Ohio. Evidently this single species of ostracod had not at the time of publication of this catalogue been considered sufficient to demonstrate the Richmond age of the purple shales at Oakville.

NORTHWEST OF MEAFORD.

164

The distance from Oakville to Meaford is about 90 miles, in a northwesterly direction. Within this intermediate area no very detailed examination has been made for fossils in the Queenston shales, but the brief examination given to the exposures along the railway, from Cataract to Credit Forks and Inglewood, did not offer encouragement for future long continued search for fossils in the Queenston section. Between Collingwood and Cape Rich, however, the Queenston shale is known to be richly fossiliferous, at certain horizons, and at numerous localities.

The first discovery of this fact was made in the summer of 1911, when in company with E. J. Whittaker, the writer found several rather richly fossiliferous zones at a locality 8 miles not thwest of Meaford at locality 26 (Figure 6). The locality is immediately south of the crossroads, half a mile south of the eastern end of Mountain lake. It may be reached most readily by taking the road from Meaford to Owen Sound for a distance of 3 miles, and turning off northward for a distance of 7 South of the crossroads, the land rises. The section miles. begins at the top of the hill, and extends north to the crossroad, where there is a school house, then east along the other road for a distance of almost a mile, where the road turns first southward, and then curves eastward down a short and steep ravine. The section ends along the stream following the southern side of the ravine, the description being given in descending order.

> Thickness feet.

Top of hill west of lot 36 in concession VIII, half a mile south of Mountain lake.

Queension red clay shales, forming the upper part of the Richmond section; top of Queenston not exposed 57

Road crossing with school at southwest corner of section 37, in concession VIII.

T	icknew
	feet.
Farther east along same road, the same ostracods occur associated with Zygospira. Wave marked layer at base, interval	51
school house A few whitish beds interbedded in the red clay shales contain Zygos-	53
pire, rather rare. Reddish and greenish clay shales with some interbedded reddish sand-	51
Greenish shales and sandstones forming the base of the Queenston	44
Top of richly fossiliferous part of Waynesville member of the Richmond (described as locality 15 on page 129).	y

Starting from the top of the same hill, as in the case of the section just described, west of lot 36 in concession VIII, but going southward instead of northward, the following section is presented.

	IIIC KIICH
Top of hill.	feet.
Interval occupied by red Queenston clay shales	7
Thin stratum of white unfossiliferous material	
Interval	. 28
Same ostracods as on north side of hill, but not as abundant, nor in a thick a section. Moreover, they occur in small greenish fragments	1 5
of rock, not in thin limestone layers. The horizon still belongs	3
in the Queenston and appears to be about 22 feet above the upper	ł
fossiliferous layers occurring on the north side of the hill, and	l .
described in the preceding section	3

Similar fossiliferous horizons are exposed along the same north and south road west of concession VIII, at locality 27, less than 5 miles south of locality 15. Here the base of a massive Silurian limestone, belonging to the lower part of the Manitoulin dolomite section, is exposed along the southeast margin of lot 25 in concession IX. This massive limestone is underlaid by greenish clay, below which is reddish clay, and underneath the latter there is a thin limestone layer rising strongly northward so as to come in contact with the overlying massive limestone. In this inclined limestone layer, typical Leptaena rhomboidalis of the Silurian type, and not Leptaena richmondensis,

165



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occurs. Judging from this single locality, the top of some of the red clay shales, locally, belong to the basal part of the Manitoulin dolomite section, representing material washed along during Silurian times from neighbouring Queenston red clay shales which are of Richmond age, but the redeposited material contains fossils evidently of Silurian age belonging approximately to about the same horizon as the overlying Manitoulin dolomite.

Beginning with the Silurian limestone layer, in which the Leptaena rhomboidalis was found, the following section occurs following the road on the eastern margin of lot 24 in concession IX.

M

Т	hickness
	feet.
Manitoulin dolomite, a single basal layer, with Leptaena rhomboidalis	,
dipping strongly southward	. 1
Interval chiefly covered with rock fragments from the overlying Mani- toulin dolomite, but occupied evidently by the top of the Queen	-
ston red clay shale of the Richmond	44
East and west road between sections 25 and 24.	
Red clay, chiefly covered with rubble from the Manitoulin dolomite farther up	e 23
Red clay	. 5
Poorly exposed	. 113
Thin limestones interbedded with greenish clay, both containing Bys sonychia radiata, Byssonychia of richmondensis group, Pterine demissa small, Eurychylina striatomarginata, Bythocypris cylindrica	- 1 1,
Leperditia caecigena, Primitia lativia, and numerous fragments o	£
bryozoa	. 2
Ostracods numerous, in thin limestone layers	. 5
Thin limestones and greenish clay containing Byssonychia radiata and	d
Leperditia caecigena	. 2
Poorly exposed	. 9
Thin limestone layers in greenish clay, with Drepanella canadensi common at the top, Byssonychia radiata and numerous fragment of bryozoans near the middle, the ostracods being common also in	s s n
the lower part	. 16
Red clay shales belonging to the lower half of the Queenston section	•
If the preceding sections be correlated, by as	sumin

that the greenish horizons at which the ostracods and other fossils are fairly abundant are practically the same, then the following general section of Queenston strata in the Meaford area (Figure 8) results, in descending order.

3	Thickne
Manitoulin dolomite (Silurian).	feet.
Upper part of Queenston red clay shales	85
Os vacods and other fossils, in thin limestone layers Interbedded with	n
	. 35
Lower part of Queenston red clay shales	45
Greenish shales and very fine-grained arenaceous layers, unfossiliferou	5
and resembling the strata usually identified as Lorraine	. 10
Similar strata with fossils few	20
Top of the more richly fossiliferous Richmond horizons in which Strophomena huronensis is common, and which are definitely corre- lated with the Waynesville member of the Richmond	1

In some sections the reddish colour sets in only a short distance above the richly fossiliferous Richmond horizon, so that the total thickness of the Queenston section in this part of Ontario, including the greenish clay shales at the base, may equal 195 feet. More accurate measurements may be made at other localities.

At the section 6 miles north of Meaford, west of the Disciples church on the road to Cape Rich, at locality 28, the Queenston red clay shales are underlaid almost immediately by greenish clays and interbedded limestones which are quite richly fossiliferous, and the base of this fossiliferous section, here referred to the Waynesville, is distinctly defined by a thin horizon containing *Hebertella insculpta*. At locality 15 along the road entering the gully a mile farther northward, neither the top nor the bottom of the so-called Waynesville zone was distinctly defined. *Hebertella insculpta* was absent. None of the horizons could be said to be richly fossiliferous, and all fossils were scarce between 9 and 30 feet beneath the level of the red Queenston shales.

In the same manner, neither the top nor the bottom of the so-called Waynesville zone is clearly defined in the gullies between 2 and 3 miles southeast of Meaford. *Hebertella insculpta* is absent. *Catasyga* occurs at the 167, 203, 325, and 349-foot levels above the lake (Locke level readings). The first specimen of *Strophomena planumbona* is seen at the 325-foot level, and the red clay makes its appearance at different distances above the fossiliferous beds. The general impression produced by the

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various sections is that of an invading Waynesville fauna which established itself only locally and for a very short time, and which was followed by a period during which chiefly red clays were deposited.

CORRELATION OF QUEENSTON STRATA WITH UPPER RICHMOND STRATA ON MANITOULIN ISLAND.

The fossiliferous horizon with the Queenston red clay shale section containing Drepanella canadensis, Eurychilina striatomarginata, Leperditia caecigena, and Primitia lativia, appears to correspond to the Saluda division of the Richmond, as recognized in southeastern Indiana. At least, Eurychilina striatomarginata, Leperditia caecigena, and Primitia lativia are known to occur in the Saluda of Indiana, this being the type horizon for the first two species and the third species is abundant there. Moreover, the nearest relative of Drepanella richardsoni-canadensis, as already stated, occurs in the Whitewater beds of Clinton county, Ohio, and it is very probable that the Saluda merely represents a southward more arenaceous zone in the lower part of the Whitewater bed, or an arenaceous phase of the greater nart of this bed.

At the time when the Saluda bed was first described, in Indiana, it was regarded as lying above the Whitewater, since there is a thin Whitewater fauna telow the typical Saluda in southern Indiana. If, therefore, a Whitewater fauna exist anywhere in Ontario, it would not be in opposition to the known order of succession in Cincinnatian areas to find this Whitewater fauna, or at least a part of it, below the ostracod horizon in the Oueenston shale.

A number of facts favour such an interpretation. For instance, on Manitoulin island there are no red clay shales corresponding to those belonging to the Queenston section. However, there are ostracod horizons which apparently may be correlated with those found in the Queenston beds along the southern shores of Georgian bay. These ostracod horizons occur in the upper part of the Richmond sections, not only above the horizons here referred to the Waynesville division, but also above horizons which might be correlated with the Whitewater, or, at least, with the lower part of the Whitewater.

One of these localities is 1¹/₂ miles southwest of Kagawong, on the road to Gore Bay. Here Leperditia caecigena, and Primitia lativia occur within a distance of 3 feet beneath the base of the Manitoulin dolomite. Fifty-two feet lower, there is a 4-foot section in which Ortonella hainesi, a familiar species in the Whitewater beds of Ohio and Indiana, is abundant, immediately over



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Figure 8. Diagram illustrating the supposed equivalence of the Queenston formation of Meaford with the Upper Richmond (Whitewater and Saluda) formations on Manitoulin island.

a massive Stromatocerium reef. Immediately south of Kagawong, the same ostracod species occur 19 feet above a massive Stromatocerium reef. On the road from Kagawong to West Bay, about 2 miles southeast of Kagawong, ostracods are common in a greenish fragmentary rock in the road ditch above the Stromatocerium horizon.

Along the east and west road passing about 3 miles south of Little Current, Leperditia caecigena occurs immediately below the Manitoulin dolomite. Forty-six feet lower, there is a massive Stromatocerium reef 9 feet thick, and 37 feet lower, occur Strophomena vetusta and a species of Ceraurinus which resembles Ceraurinus meekanus but which has been described recently by Barton as Ceraurinus marginatus. Columnaria is abundant immediately below this horizon, and the strata here identified as Waynesville occur still lower. Strophomena vetusta is common in the Liberty and Whitewater divisions of the Richmond in Ohio, Indiana, and Kentucky; and Ceraurinus mee unus is a Whitewater form in Indiana.

Southeast of Manitowaning, across the bay, Leperditia caecigena and Primitia lativia occur 22 feet below the base of the Manitoulin dolomite; they range through a thickness of 5 feet, and the horizon is estimated as belonging about 28 feet abc e the conspicuous Stromatocerium reef southwest of the village of Manitowaning.

From these data it appears that there is a series of ostracod horizons on Manitoulin island above the *Stromatocerium* zone which might be correlated with those in the Queenston sections south of Georgian bay. These ostracod horizons overlie beds in which Whitewater fossils occur, and the ostracods themselves suggest Saluda or Whitewater affinities. For this reason it seems possible to correlate the ostracod horizons on Manitoulin island with strata belonging above the base of the Whitewater, in Indiana.

If the ostracod horizons on Manitoulin island be regarded as Saluda, which appears to be equivalent to that part of the Whitewater section which belongs a short distance above the base of the Whitewater, then it may be possible to correlate also the ostracod horizons in the Queenston red clay shales, south of Georgian bay, with the Whitewater. This at present is the correlation favoured by the writer. At every locality (except at Streetsville) so far examined where the Queenston red clay shale was found underlaid by fossiliferous rocks, these proved to be Richmond strata which could becorrelated with the Waynesville member. This is true not only in Ontario, but also in western Quebec, east of Ottawa, and also east of Montreal, along the Nicolet river. At Streetsville, the Queenston red clay shales are underlaid by the Coral zone, but since the latter is overlaid by strata containing fossils suggesting Whitewater affinities, the reference of the overlying Queenston beds to strata at least as high as the Whitewater is strengthened by this fact.

As far as may be determined from the observations so far made, the horizon at which the red colouring of the Queenston shales begins varies from place to place, but it seems always to begin above the base of the Waynesville. There is a possibility, however, that at some future time localities may be found in which the Queenston red clay shales may be regarded as replacing not only a part but actually all of the fossiliferous strata referred to the Waynesville in Ontario and Quebec.

No red shales are found among Ordovician strata on Manitoulin island which are regarded as equivalent to the Queenston shales. Not only is the red colouring absent in these strata on Manitoulin, but the number of fossil horizons and the variety of their fossil content is greatly increased.

If the red colouring and arenaceous grain of the Queenston be regarded as due to weathering of a land surface, the deposits may be estuarine or delta sands and clays. The land area from which they were derived may have been the Pre-Cambrian mass in northern Ontario and in the Adirondacks, but it certainly appears to have lain east of the Manitoulin Island area.

It may be noted that the unfossiliferous Salmon River Falls sandstone, overlying the fossiliferous Lorraine in New York, also has an eastern distribution. If there are any equivalents of the Salmon River sandstone west of the eastern border of Lake Ontario, in southern Ontario, these equivalents have not been recognized definitely, excepting possibly in the vicinity of Weston, northwest of Toronto. At present the Salmon River strata of New York are regarded as of Maysville age, but the presence of *Pholadomorpha* in the immediately underlying beds suggests the possibility of their Richmond age.

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EASTERN ONTARIO AND QUEBEC.

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Queenston strata occur along a farm lane crossing the middle of lot 27 in concession VIII, 1¹/₂ miles southwest of Vars in the area east of Ottawa; here they appear to rest directly upon strata containing Zygospira kentuckiensis which may be correlated with the Waynesville phase of the Richmond (see page 138).

Southward, at a brick house located on the road between concessions III and IV, near the line between lots 23 and 22, a well is said to have passed through 80 feet of red clay, then through about 20 feet of bluish clay, and finally into 20 feet of red clay at the bottom. The elevation of the top of the well is about 295 feet above sea-level. The elevation of the Zygospira kentuckiensis residual blocks at the more southern locality, with the base of the Queenston shales immediately above, is approximately 265 feet. Determining the dip of the strata in the Vars area from these data, the Strophomena fluctuosa horizon, half a mile west of Vars, at the northeastern edge of lot 25, in concession VIII, is at least 75 feet below the base of the Queenston shales, and may be 100 feet below. At the same rate of dip, the Hebertella occidentalis and Catazyga headi horizon along the middle of the eastern edge of lot 23 in concession VIII a quarter of a mile north of the railway west of Vars, may belong from 125 to 175 feet below the Zygospira kentuckiensis horizon. The exposures at the road crossing nearly 2 miles northwest of Vars between lots 20 and 21 and concessions VII and VIII lie north of a fault extending east and west through the Vars area. But it is known that they contain Proctus and in the Nicolet River section this Proetus zone extends from 700 to 1,160 feet below the base of the Queenston beds.

The probabilities are that there is a large section of strata intervening between the exposures of the *Proetus* zone at the crossroads 2 miles northwest of Vars and the strata containing *Triarthrus becki*, at the bridge across Bear brook farther northward, near the middle of the western edge of lot 16 in concession VII. Of this intervening section, so largely exposed along the Nicolet and Bécancour rivers, and elsewhere east of Montreal, no trace has been found so far in this upper Ordovician area east of Ottawa, probably owing to faulting.

Estimating the upper Ordovician section below the Queenston shales along the Nicolet river as considerably over 3,000 feet, and the corresponding part of the upper Ordovician section on Manitoulin island at about 400 feet, it is evident that the upper Ordovician section thins rapidly westward, and it may be assumed that considerable thinning has taken place before reaching Ottawa; but no data are at hand to determine the amount of this thinning. At the well about 2 miles southwest of Vars, on lot 25 of concession IX, north of the road and west of the culvert, Trenton is said to have been struck at a depth of 700 feet, but the rock fragments brought up from this depth and identified as Trenton do not suggest Trenton limestones but fine-grained, argillaceous shale not softened by weathering; therefore, instead of a total thickness of less than 1,000 feet of upper Ordovician strata below the Queenston shale level, a much greater thickness probably is present here.

NICOLET RIVER SECTION.

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Queenston strata occur, as already mentioned, in the Nicolet Piver section. At this locality the basal beds of the Queenston shale, for a thickness of about 50 feet, are not red, but the overlying part which is at least several hundred feet thick and is not included in the measured section, has an almost uniformly red colour. Northwest of St. Hyacinthe, the Queenston is known from well borings to be 1,000 feet thick. At the bluff southwest of the home of Honore Auger, the following section, at the contact of the Queenston and Waynesville, may be seen.

Section No. 1, at Bluff Southwest of Home of Honore Auger.

	Thickness
enston red clay shales, top not exposed, not measured.	feet.
.teddish and bluish clay, interbedded	5
Bluish clay	
Hard clay rock	
Argillaceous shale, lowest layer of hard clay rock.	. 31
Clay shale, chiefly blue, base of Queenston section	40
Fossiliferous strata referred to the Waynesville.	

Here the lower part of the Queenston shales for a thickness of nearly 50 feet is not reddish.

(For the underlying parts of this section see pages 142 and 143.)

GENERAL REMARKS ON QUEENSTON SHALE.

In view of the fact that the lower part of the Queenston shale section on the Saugeen peninsula, between Collingwood and Owen Sound, has been proved to be of Richmond origin, and in view of the probability that practically all of the Queenston shale belongs to this Richmond section, as far as can be judged from its similar lithological features, a few comments on the Queenston shale of the Quebec province may be added.

In the first place the fact that throughout this province the first fossils found below the Queenston shale belong to the Zygospira kentuckiensis zone should be noted; next, the great thickness of the red shale section, its uniform lithological characteristics, and its considerable geographic distribution. Since it is preserved chiefly in broad synclinals, it is probable that it once extended over much of the country where it now is unknown. There is a large patch of Queenston indicated on the Three Rivers and Quebec sheets, from 25 to 40 miles east of Three Rivers. Ancther large patch is mapped south and southeast of Three Rivers, and this patch was examined hastil; both along the Nicolet and Bécancour rivers. Another patch crosses the St. Francis river, 30 miles southwest of Three Rivers. Recently, well borings have determined the presence of fully 1,000 feet of red Queenston strata under the glacial drift area northwest of St. Hyacinthe. Then, after a long interval, come the exposures southwest of Vars east of Ottawa, the outcro, along the northwestern shore of Lake Ontario, thence northwestward to Cataract Junction, and, after another long break, the shale appears in the Saugeen perinsula from Collingwood to Owen Sound and northwestward. On Manitoulin, the stratigraphical equivalent of the Queenston section is present; how-

ever it does not consist of red shale but chiefly of bluish or brownish clay, interbedded with limestone, and contains a considerable number of easily identifiable Upper Richmond fossils.

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As already noted, t Streetsville the Queenston belongs above the rich coral horizon of that locality. Since this coral horizon is regarded as of Whitewater age and is correlated with that coral horizon which, on Manitoulin island, lies at the base of the strata there referred to the Whitewater, it is evident that at Streetsville none of the Queenston is older than the Whitewater. At most other localiti i, for instance at Oakville, and near Meaford, the Queenston issts directly on Waynesville strata, and at these other localities the deposition of red shales may have begun before the close of the Waynesville.

The Queenston shales appear to be merely the estuarine representatives of a part of those marine strata which elsewhere are known under the term Richmond formation.

At Streetsville, the coral zone has a vertical extent of 13 feet. The associated fauna here suggests Whitewater affinities, agreeing in this respect with the faunas beginning with the Gore Bay coral reef, on Manitoulin island. At Streetsville, at least 20 feet of clay shale with some interbedded argillaceous rock overlies the coral zone. The base of the red ccloured clay shales included in the Queenston appears to be at least 10 feet higher, so that the base of the red Queenston shales at Streetsville is at least 43 feet above the base of strata correlated with the Whitewater.

At all of the localities northwest of Meaford, however, there not only is no trace of a Whitewater fauna beneath the red clay Queenston shales, but even the upper part of that part of the Waynesville section which is exposed at so many localities on Manitoulin island, appears to be missing. West of the Disciples church, on the J. A. Dix farm, 6 miles north of Meaford, only 14 feet of fossiliferous strata are found above the lowest horizon containing I^* tella insculpta, which here is regarded as the base of that part is section which can be referred with some confidence to the Waynesville. The upper part of this section passes so gradually into comparatively unfossiliferous clay shales that it is difficult to believe that the lower part of the latter does not represent the upper part of the Waynesville section. Near the base, these clay shales are bluish or greenish, but between 10 and 20 feet above the fossiliferous Waynesville horizons, the red coloured shales begin to alternate with the bluish clay shales, until farther up the red colour prevails almost to the exclusion of the bluish or greenish colours. In other words, the lower part of the red coloured Queenston clay shales at this locality may correspond stratigraphically to the upper part of the Waynesville member of the Richmond.

This is the case apparently also in the vicinity of Oakville, along the northern shore of Lake Ontario.

May it not be possible that farther southward, in New York, where no representatives of the Richmond are known, that the basal part of the Queenston red clay shales may replace even the lowest strata referred to the Richmond in western Ontario?

In this sense of the term the name Queenston does not represent a definite series of strata with a definite base and top. The base, at least, probably changes in horizon more or less from place to place. Nevertheless it is a very convenient lithological term. There appears to be no very good reason, hcwever, why this term should be confined to the red coloured shales, to the exclusion of the lithologically similar unfossiliferous bluish coloured clay shales immediately beneath.

CHAPTER IV.

DISTRIBUTION AND RANGE OF SPECIES.¹

All of the essential data contained in the preceding pages, relating to the geographical distribution and the geological range of the species listed have been tabulated in the following tables. The localities indicated by numbers in the locality column are given in the list at the end of the table. The references of species to the subdivisions of the Lorraine and Richmond which have been defined in the Ohio valley, are in some cases more or less provisional, and represent the author's opinion in the light of his present knowledge of the faunas.

¹ These tables have been complied by Miss A. E. Wilson from the data scattered throughout the preceding pages.

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				Genera and species	species of uncertain appinities. Arthratia		Arthraria Diciavata Muller		Girvanella sp	Girvanella richmondensis Miller			

Geographical Distribution and Geological Range of Species.

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Geographical Distribution and Geological Range of Species.

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Geographical Distribution and Geological Range of Species.

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Geographical Distribution and Geological Range of Species.

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Geographical Distribution and Geological Range of Species.

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187

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189

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Hallopora onealli (James)	Hallopora sigillarioides Nicholson.					fallopora subnodera Ulrich	Iallopora subplana Ulrich	femiphragma sp	femiphragma whitfieldi (James)		leterotrypa cf. inflecta Ulrich	leterotrypa cf. prolifica Ulrich	Iomotrypella hospitalis (Nichol-		eptetrypa vrnata Ulrich	aleschara beani (James)	aleschara cf. beani (James)	erenopora compressa Ulrich	erenopora vera Ulrich				hylloporina sp		tilodictya		hombotrypa sp

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204

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Geographical Distribution and Geological Range of Species.

220

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Geographical Distribution and Geological Range of Species.



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Geographical Distribution and Geological Range of Species.









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			Genera and species.		ARTHROPODA-CRUSTACEA-Continued Ostracoda-Continued. Primitta lativia Ulrich			



LIST OF LOCALITIES.

266

NEW YORK STATE.

- 1. Lorraine, Jefferson county.
- 2. Two miles east of Lorraine, Jefferson county.
- 3. Worthville and neighbourhood, Jefferson county.
- 4. Bennett Bridge, one mile down (west) from Salmon River falls.
- 5. Near base of Salmon River falls.
- 6. General-from Lorraine village eastward to Worthville, Jefferson county.
- 7. Pulaski village to railway bridge, one mile east of the town.
- 8. Lorraine gulf, northwest of Lorraine village, Jefferson county.
- 9. South of Allandale, a short distance west of mouth of Lorraine gulf.
- 10. New York-general.

QUEBEC.

- Nicolet river, east bank, 2¹/₂ miles due south of Ste. Monique station, 14 miles south of Three Rivers.
- 2. Louse at 18.
- Chambly Canton, along west side of Richelieu river, 15 miles southeast of Montreal.
- A quarter of a mile south of Petite Caroline, along the road to Rougemont, 26 miles east of Montreal.
- 5. Snake island, 2 miles east of Roberval, in Lake St. John.
- 6. St. Hilaire, along road southeast of station, also east of village centre, 18 miles northeast of Montreal.
- 7. Petite Caroline station, same as locality 4.
- 8. St. Hugues, 39 miles northeast of Montreal, 13 miles northwest of station, on Yamaska river.
- St. Hyacinthe in bed of Yamaska river, south of railway 1 10 0 a s northeast of Montreal.
- 10. Breault, 2 mile east of station, on west bank of Bécancou verse '28 southeast of Three Rivers.
- 11. St. Augustin along the railway, east of the station, 12 miles south west of Quebec.
- 12. Montmorency falls, along the hill-side southeast of the falls, 6 miles northeast of Quebec.
- 13. Boulders at locality 6, from the hill-side due east of St. Hilaire station, Quebec.
- 14. Loose at 5, Quebec.
- 15. Boulders at locality 8, Quebec.

- Nicolet River section No. 1, east bank, 2½ miles southwest of Ste. Monioue station (see locality 1).
- 17. Nicolet River section No. 2, along gully, south of section N. 1.
- Nicolet River section No. 3, hill-side section, south of gull.', at western end of long farm lane.
- 19. Nicolet River section No. 4.
- 20. Between 3 and 4 miles north of Roberval on west shore of Lake St. John.
- 21. Nicolet River section No. 5.
- 22. Nicolet River talus at section No. 5.
- 23. Nicolet River section No. 6.
- 24. Nicolet River section No. 7.
- 25. Nicolet River section No. 8.
- 26. Rivière des Hurons, 4 miles northeast of Chambly basin.

ONTARIO-EAST.1

- 1. Vars, 15 miles east of Ottawa. The localities lie chiefly along the road crossing the railway one mile west of the station.
- 2. Navan and along the road for 2 miles northeast, 11 miles east of Ottawa.
- 3. Northwest of Hawthorne, along the railway about 3 miles east of Ottawa.
- 4. Southwest of Ramsay Station, about 21 miles, and then southeast half a mile at a small bridge; southeast of Ottawa.
- 5. Loose blocks at locality 1.
- 6. Loose at locality 3.
- 7. Boulders at locality 4.
- 8. Eastern Ontario-general.
- 9. One mile west of Ramsay station, 5 miles southeast of Ottawa.

ONTARIO-WEST.1

- 1. Two miles southeast of Meaford. On the south side of Georgian bay, at mouth of Workman brook.
- 2. Streetsville, along the Credit river, 17 miles west of Toronto.
- 3. Toronto.
- 4. Toronto-Don Valley brick-yard, at northeastern margin of city.
- 5. Toronto-unknown locality.
- 6. Weston about 3 miles northwest of the northwestern boundary of Toronto.
- 7. Workman brook, between 2 and 3 miles southcast of Meaford.
- South of Clay cliff between 2 and 3 miles north of Wekwemikongsing, Manitoulin island. This is the Lorraine exposure, south of locality 54, which is the Cape Smith locality of Billings.
- 9. Burnett hill, 3 miles south of Little Current along eastern road to Sheguiandah, Manitoulin island.

¹ The Frontenac axis (see page 67) is used as the line of division between eastern and western Ontario. It extends in a general north and south direction through the Thousand Island region, east of Lake Ontario.

- Gully south of the Collingwood pike, half a hile east from the mouth of Workman brook, 21 miles east of Meaford.
- 11. McLean hill, 2 miles southwest of Little Current, along western road to Sheguiandah, Manitoulin island.
- 12. Tamarack point, north of Honora on northeast margin of West bay, Manitoulin island.
- 13. Gorrel point, 2 miles northeast of Gore bay, Manitoulin island.
- 14. Fielos, west of Collingwood, and about 12 miles east of Meaford.
- 15. Eight miles northwest of Meaford, west of the lake shore road to Cape Rich, in the eastern part of lot 36, in concession VII.
- 16. Manitoulin island, general.
- 17. Gore Bay reef, a coral reef in Richmond s'rata, typically exposed between Gore bay, Kagawong, and Little Current, Manitoulin island.
- 18. Localities 18 and 49 have been treated as a single locality. See 49.
- 19. Loose at locality 7.
- Rabbit island, 5 miles south of James bay off eastern shore of Manitoulin island.
- 21. Club island, 10 miles south of James bay, off eastern shore of Manitoulin island.
- Stromatocerium reef or Mudge Bay reef, a reef in Richmond strata, typically exposed, between Gore bay, Kagawong, Honora, and Little Current.
- Kagawong and Gore bay, two localities on Manitoulin island, about 10 miles apart.
- 24. Two miles southwest of Wekwemikong, on the road to Manitowaning, on Manitoulin island (see section 52).
- 25. Oakville, about 20 miles southwest of Toronto.
- 26. Localities 15 and 26 have been treated as a single locality. See 15. One mile west of section 15; exposure half mile south of Mountain lake extending along the roads on the western and northern margins of lot 36 in concession VIII.
- West of concession VIII, 4 miles northwest of Meaford and less than 5 miles south of locality 26, south of a church at the crossroads between concessions VIII and IX vd loss 24 and 25.
- Six miles from Meaford, west of the ros. to Cape Rich, west of Nottawasaga bay. John A. Cox farm, lot 32, concession VII.
- 29. Cape Rich, north of Meaford, 9 miles.
- 30. Loose at locality 50.
- 31. Loose blocks at locality 39.
- 32. Loose slabs in the neighbourhood of locality 48.
- 33. East of Barrie Island bridge, Manitoulin island.
- 34. 31 miles northwest of Kagawong, southeast corner of lot 6, con. XV, on road to Maple point.
- 35. Northwest of Kagawong, south of locality 34.
- 36. 11 miles northwest of Kagawong,

- 37. 11 miles southwest of Kagawong, on road to Gore Bay.
- 38. One-half mile south of Kagawong, south of the mill at the falls.
- 39. Below the falls at the mill south of Kagawong.
- 40. Directly south of Kagawong village, where the road to the mill ascends the hill.
- 41. Northeast of Gore Bay, about 2 miles, at concession XIV, along the road on top of the bluff.
- 42. Southeast of Gore Bay, along the road leading toward East bluff.
- 43. South end of Gore Bay village.
- 44. West side of Gore Bay village.
- 45. Along east and west road, 3 miles due south of Little Current.
- 46. Nearly 2 miles northwest of Gore Bay along an east and west road between concessions XII and XIII.
- 47. Eastern side of West bay about a mile south of Honora village, at a steep hill on the road to West Bay village.
- 48. Southwest of Little Current southwest of Indian village, on north and south road.
- Three miles southwest of Little Current on east and west road. This section is about 11 miles in length.
- 50. From "The Rock" southwest of Manitowaning, northward to gully north of lighthouse.
- 51. Two miles southeast of Manitowaning, where the road to James bay ascends the steep hill.
- 52. Two miles southwest of Wekwemikong, along the road to Manitowaning (see section 24).
- 53. Northwest of Wekwemikorg, loose, along the road leading over the hill.
- 54. Three miles northeast of Wekwemikongsing at Clay cliff. This is the Cape Sn.ith locality of Billings.
- 55. Bayfield sound, south and west of Barrie island.
- 56. Drummond island.
- 57. Loose at locality 11.
- 58. Lot 23, concession XIV, road between Kagawong and West Bay.
- 59. Loose at locality 2, Streetsville.

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- 60. One mile up Credit river from Streetsville at bridge north of Credit Junction.
- 61. At mouth of Workman brook, 2 miles southeast of Meaford.
- 62. Road between concessions VI and VII, near lot 6, southwest from Little Current, Manitoulin island.
- 63. Humber river, in northwestern part of Toronto.
- 64. Loose at locality 13.



INDEX.

Α.

	ACE
Allandale, New York	11
Ami, H. M v	, 14
Anticosti fauna	, 160
" island	160
Arnh m formation	7, 96
Auger, Honoro	, 173

B.

Barton, D. C)
Bass Lake road, Manitoulin island	3
Bassler, R. S. Dr	2
Beachville 7	ž
Bear creek 62 17	>
Deat treet	č
Deauport	2
Becancour river	2
Bell, R.	2
Bellevue formation	5
" " Cinclnnati 67	1
" " Clay cliff 84	£.
" " Obio	ż.
" " Vorkman brook 79.8	ŝ.
Bant att Bridge 7 26 25	ź.
Denter Dinge	2
Fillings, E	2
W. R)
Birdseye limestone	i
Blanchester formation)
Blue point	5
Boucher point	i.
Breault	ŝ
Dread D W	1
Drock, N. W	
Burnett hill)

С.

Calciferous formativ	1
Calvaire, lac	57
Cape Rich road, north of Meaford.	129
Cape Smith	124
" Stromatocerium reef	123
Chambly.	64
" basin	42
" Canton	40
* East	151
" member of the Lorraine, Ouebec	30
Charleton formation	161
Chilbouet river	50
Cincinnati	94
Cincinnati geanticline	159
Cincinnatian faunas. Chio.	94
" formation, Ohiovi, 10, 62, 94, 163,	168

Clarkson Ont			PAGE
Clay cliff.		102 104	
Club island	02,	102, 104,	111, 124, 100
Collingwood formation, Little Current	· · · · ·		85
" shales			6, 62
Conrad, I. A.	• • • • •		1, 6
" " Streetsville	••••	••••••••	161
Corryville formation	••••	••••••	131,136
Cowans creek, Ohio	• • • • • •		163
Cox, John A			129
Credit Junction	• • • • •		133
Crozier, Wm	• • • • •	• • • • • • • • •	76, 132
Cynthiana formation, Kentucky.	•••••	•••••	
			· · · · · · TI , JU

D.

David river	 	60
Dix, J. A.	 	175
Don Valley brick-yards	 •••••••••••••	37 70 71 76 77
Dresser, J. A.	 	
Drummond island	 	
Du Chene syncline	 	····· VII

E.

Eaton,	N. Y	
Econon	iy forma	tion, Little Current
"	"	Ohio
Eden fo	rmation	vi 10 04
"	"	Cincinnati.
44	"	Gore Bay
4	æ	Little Current 95 96 99 90 01
44	"	Manitoulin island
66	"	Menford 50
44	"	Montmoreney falls
"	"	Norman 58
"	u	Navan
"	"	Nicolet river
		Unio
		Ontario
"	"	Tamarack point
"	66	Toronto
4	"	Workman brook
Edward	s station	140
Ells, R.	W	190
Emmon	° F	V, 151
English	Head to	
Englian	i lead 10	161

F.

Faber, C.	L	
Fairmount	formatio	D
66	"	Cincinneti
		Cincinnati
**	64	Little Current on
"	4	Ohio 09
		Onio

Fauna New Vork state	PAGE
Forestdale	. 5
Fort Ancient formation, Ohio.	. 80
Fossils, list of	178-265
Frankfort formation	. 2, 11
Frontenzo avia	. 159
riomenac axis	67, 159
G.	
Gas, Quebec	. 60
Gentilly river	. 61
Georgian bay	162, 170
" coral zone	. 27
" northeast of	11 112
" northwest of	11, 112
" reef	117. 123
south end of	. 111
West side of	. 112
Grabau, A. W.	. 85, 92
Greens creek.	. V 66
Grey sandstone of Oswego	. 3
Grimsby	. 68
Grondines	. 61
Н.	
Hall, James.	2. 8. 68
Hamilton, Ohio	. 80
Harvie, R	50, 53
Honora south of	. 65
Hudson river	· 11+ 74
" River series	2.3
" " Breault	. 58
" " Oakville	. 163
Huron lake	69, 74
	98, 100
I.	
Illinois	. vii
Indian Ladder shale	. 4
Indiana Village, Manifoulin Island	. 115
Indianav, vii, 27, 44, 99, 100, 102, 159, 1	02, 168
J.	
Jefferson county, N.Y	. 3
K	
Kagawong	160
" falls	109
" northwest of	05, 106
" south end of	110
" of	108
southwest of	107
Nentucky	00, 159

.

L.

PAGE

1933

Labrado		150
Laba St	Ichn c	139
Lake St	. Jonn s	ection
Lambe,	L. M	
Les Ecu	reuils	
Levis ba	asin	
Liberty	formatio	on
Little C	urrent	27 85 100
"	"	authmat of 01 115 116
T	. 1'	outliwest 01
Locanti	es, list o	M
Logan, S	Sir Wm.	· · · · · · · · · · · · · · · · · · ·
Lorraine	e format	ion
"	u	eastern Ontario. 62
66	"	New Vork state 4 6 23 26 28 68 70 75 78
4		Nicolat river 14
		Nicolet river
		Untario and Quebec, general observations on 93
"	4	Rivière des Hurons 150
44	66	St Hilaire 153
66	a	western Ontario 67 127
		western Ontario
	village	
Low. A.	P	v

М.

McLean	hill													90	0.	118
Manitou	lin dolom	ite														108
"	"	Gore	Bay.													111
65	ű	Kag	wong			••••	•••	•••	•••	•••	•••	••	•••	•••		105
u	"	Littl	e Curr	ent	•••	••••	•••	•••	•••	•••	•••	••	•••	•••		116
"	"	Man	itowar	ung.	•••	•••	•••	• • •	• • •	•••	•••	•••	•••			120
"	"	Maa	ford	mig.	••••	•••	•••	•••	•••	•••	• • •	•••	•••	•••		165
"	island	wica		27	20	56	60	61	:		1	27	154	14		140
66	151ang.	Diahma	. VII, J	, 21,	20,	30,	09,	01	, 04	, 93	, 1,	<i>.</i> ,	150	, 10	л, 1	100
Maniton	maina	Kichmo		natio	n	••••	•••	•••	• • •	•••	•••			144		.97
Wantow "	aning			••••	•••	•••	•••	•••	•••	•••	• • •	. 10	ю,	104	ζ, Ι	103
4	nc	ortnwest	01	• • • • •	• • •	• • • •	•••	• • •	• • •	•••	• • •	••				120
	re	er		• • • •	•••	• • • •	••	• • •	• • •	• • •	• • •]	103,	11	8, 1	120
	SO	utheast	of	• • • • •	• • •	• • •	•••	•••	• • •	• • •	• • •	••		•••.	_ 1	122
Maysvill	e tauna							• • •		• • •	• • •			67	7, 1	137
	formatio	on				• • •		• • •			• •	v	i, 2	8, 9	3, 1	163
	**	Clay of	liff											84	I , 1	124
4	a	Gore	Bay											• •		92
	ű	Little	Curre	nt			••								89.	91
æ	ű	New 1	York												Í	171
65	"	Nicole	t river	•												41
	"	Ohio.												•••	70	73
		Ontar	in		••••	••••	•••	•••	•••	•••	••••	•••	•••	<u>ن</u> ا	70'	04
	"	Toron	to	••••	•••	••••	•••	•••	•••	•••	•••	•••		.,	<i>i</i> 0,	71
Meaford		101011		••••	••••	28	io i	78	01		11		1 26	12	7 1	75
"	northwes	t of	•••••	• • • •	• • • • •	.0, (,,,	10,	,,	74	14		130	, 13	11	64
Medina	red sandet	01	•••••	••••	• • • •	••••	•••	•••	•••	•••	•••	•••	• • •	••	-	104
Michigar	lake		• • • • • •	• • • •	•••	••••	•••	•••	•••	•••	•••	•••	•••	••		
Millor A	TidAC	•••••	• • • • • •	• • • •	• • • •	••••	•••	•••	•••	•••	•••	•••	•••			VII
Mimier, A	a chur M.	•••••	• • • • • •	• • • •	• • • •	•••	• • •	• • •	•••	• • • •	•••	• • •	• • •	.21	, I	23
Minico.		•••••		• • • •	• • • •	•••	• • •	• • •	• • •	• • • •	•••	• • •	• • •	••		10
IVI1581851p	pi valley.			• • • •	• • • •	•••	• • •		• • •	• • • •	• • •		• • •	••		vi

		PAGE
Mohawk limestone		1 2
Montmorency falls		°59
Mount Auburn formation		69
Mount Hope formation		60
Mountain lake	•••••••••	164
" " northwest of Meeland	•••••••	104
Muda Dana (128
Mudge bay reel	12, 106, 107, 108, 112, 114	1, 117
" " " Gore Bay		102

N.

Navan
New York state, list of localities 266
" " " upper Ordovician of
" " strata vi
Niagara sandstone
Nicholson, H. A.
Nickles, John M. v 33 85 86 02
Nicolet river
"River section 14 40 55 57 64 65 66 70 141 150 173
syncline
Nomenclature New York state

0.

Oakville	162
Ohio	168
" River valley	vi
O'Neill, I. I 40	47
Ontario lake	160
Ophelia, Kentucky	1 50
Orton, E	vi
Oswego	12
" county	1 3
Ottawa	08
Otterburn park	152
Oujatchouan falls	155

P.

Parks, W. A	71
Petite Caroline	0 48
" Rivière du Chene.	61
Pierreville	60
" syncline	61
Pulaski formation 2.0.11.1	1 02
* * Nov Vol-	4, 70
	08

Q.

Queenston	formatio	n. eastern Ontaria	172
"	44	Edwards static	140
a	66	general remarks on	174
44	65	Meaford	164
46	65	Montmorency falls	50
66	4	Mountain lake	128

Oueenston	formatio	n. New York	PAGE 13
"	4	Nicolet river 14	17 141 147 172
"	"	Oakville	11, 11, 11, 11, 113
4	"	Ontario lake	100
44	"	Streetsville	121
44	4	Voe	
"	"	western Ontario.	

R.

Dabbia :	alamat	
Rabbit I	stand	
Ramsay	station	
Raymon	a, P. E.	
Red san	dstone of O	swego 3
Richelie	u river	
Richmon	id fauna	
"	" An	ticosti element in
	formation	vi. 28
4	"	Bass Lake road
44	"	between Georgian bay and Lake Huron, con-
		cluding remarks
4	4	Cape Rich. 120
4	"	Clay cliff 124
44	"	correlation of with Oueenston 169
44	"	eastern Ontario
44	"	Ceorgian bay
44	"	Gere hav
"	"	Vore bay
"	"	Little Comment
"	"	Little Current
"	"	Manitoulin Island 126
"	"	Nicolet river
		Uakville
		Ohio 44, 80
"		Ontario
	4	" lake 127
	u	Quebec
"	"	St. John lake
"	"	Streetsville
"	"	Toronto
"	"	Vars
4	66	" and Edwards station general observations 140
64	4	Workman brook
44	Indiana	100 x man 0100 x
Rivière o	les Hurons	13 42 49 1EQ
Roberva	1	
Rome	••••••••••	
Rougem	*********	
Ruodom	D D	48
it acuema	ann, K	

s.

St. Amable	60
" Augustin	57
" Bruno mountain	48
" Catharines	77

C. 1111 .														1	AGE
St. Hilan	re		• • • • •		• • • •				• • • •				1	4, 45,	152
	mou	ntair	1												152
Hugu	les													50.	155
 Hyac 	inthe.													0. 53.	173
Jean	Baptis	te												18	151
" John	lake									/ü. (5. 9	18.	155.	150	162
" Lawr	ence a	nd Cl	hamp	lain	fault								,	,	61
et 4	• va	alley.									•••	•••	••••	•••• v	ii c
Ste. Mor	nique.								••••	•••	•••	•••	••••	· · · · · · · · · · · · · · · · · · ·	142
Salmon r	iver.					••••	••••	••••	•••••	•••	•••	•••	••••		144
* R	iver fa	lls			••••	• • • •	••••	• • • •	• • • •	•••	•••	• • •	··· 7	12 2	< 70
	# 80	ries		••••	••••	• • • •	••••	••••	••••	• • • •	• • •	•••	,	12, 20	, 10
Saluda fo	ormatic	100.1	•••••	••••	••••	••••	••••	• • • •	••••	•••	•••	•••	• • • •	. 1, 0,	1/1
#	#	In	diana	• • • •	• • • •	• • • •	••••	• • • •	••••	•••		·. ·	104	100	101
		M	anito	lin	inlan		• • • •	• • • •	••••	• • • •	. 10	<i>1</i> 2,	104,	102,	108
*	44	M	antor	3	13141	u	••••	• • • •	• • • •	• • • •	• • •	• • • •		• • •	170
Schenest	adu ba	191	calor	1	• • • •	• • • •	• • • •	• • • •	• • • •	• • • •	• • •	• • • •	• • • •		127
Schucher	auy ba	sm.,	•••••	•••	• • • •	• • • •	• • • •	• • • •	• • • •	• • • •	•••	• • • •		•••	5
Schucher	L C			• • • •	• • • • •	• • • •	• • • •		• • • •	• • • •		.v,	47,	49,	160
Section,	Dass L	ake	road.	• • • •	• • • •		• • • •							90,	118
-	Cape I	Kich.		• • •	• • • •	• • • •	• • • •								129
	Gore E	say	• • • • •	• • •	• • • •		• • • •							.111,	113
	Honor	a													114
	Kagaw	ong.		• • •							105	100	5. 107	7. 108.	110
		_	Falls.			• • • •									109
	Little	Curre	ent											115.	116
"	Manito	owan	ing									•••	••••	120	122
<u>#</u>															
-	Meator	rd									••••	••••	••••	164	166
4	Meator	rd ain la	ake.	••••	• • • •	• • • •	••••	••••	••••	••••		• • •	••••	. 164,	166
4	Meator Mount Nicolet	nd ain la trive	ake	••••	• • • •	••••	••••	••••	••••	••••	••••	•••		. 164,	166 129
4	Meator Mount Nicolet	ain la t rive	ake	Ver	•••••	Juff			· · · · ·	 		1	42,	. 164, 143,	166 129 146
46 46 46	Meator Mount Nicolet No. 1,	ain la t rive Nico	ake r olet ri	ver,	at 1	oluff	sout	thwe	st of	ho	me	of	42, Hon	.164, 143, ore	166 129 146
4	Meator Mount Nicolet No. 1,	rd ain la t rive Nicc	ake r olet ri	ver,	at l Au	oluff ger	sout	thwe	st of	ho	me	of	42, Hon	.164, 143, ore 18,	166 129 146 173
4	Meator Mount Nicolet No. 1, ⁴ 2, ⁴ 3	rd ain la t rive Nicc	ake r olet ri	ver,	at I Au	oluff ger . ully	sout	thwe	st of	ho n N	me 0. 1	of	42, Hon	. 164, 143, ore 18,	166 129 146 173 18
4 4 4	Meator Mount Nicolet No. 1, ⁴ 2, ⁴ 3, ⁴ 4	rd ain la t rive Nicc	ake r olet ri "	ver, alo hill	at Au ng g side	oluff ger . ully secti	sout sout	thwe h of south	st of	ho n N gully	me 0. 1	of	42, Hon	.164, 143, ore 18,	166 129 146 173 18 19
4	Meaton Mount Nicolet No. 1, ⁴ 2, ⁴ 3, ⁴ 4,	rd ain la t rive Nico	ake er olet ri «	ver, alo hil	at l Au ng g Iside	oluff ger . ully secti	sout sout	thwe h of sout	st of	ho on N gully	me o. 1	of	42, Hone	. 164, 143, ore 18,	166 129 146 173 18 19 20
4 4 4 4	Meaton Mount Nicolet No. 1, ⁴ 2, ⁴ 3, ⁴ 4, ⁴ 5,	ain la trive Nico	ake er blet ri «	ver, alo hill	at Au ong g Iside	oluff ger. ully secti	sout south	thwe h of i	st of	ho n N gully	me 0. 1	of	42, Hone	. 164, 143, ore 18,	166 129 146 173 18 19 20 23
	Meaton Mount Nicolet No. 1, 2, 3, 4, 5, 6, 6,	rd ain la t rive Nico	ake r olet ri « «	ver, alo hil	at Au ng g Iside	oluff ger . ully secti	sout sout	thwe h of south	st of section	ho on N gully	me 0. 1	of	42, Hon	.164, 143, ore 18,	166 129 146 173 18 19 20 23 30
	Meaton Mount Nicolet No. 1, 2, 3, 4, 5, 4, 5, 6, 7,	rd ain la t rive Nico	ake r blet ri « «	ver, alo hill	at Au ng g Iside	oluff ger . ully secti	sout sout	thwe h of south	section section	ho n N gully	me 0. 1	of	42, Hone	.164, 143, ore 18, 	166 129 146 173 18 19 20 23 30 35
	Meator Mount Nicolet No. 1, 2, 3, 4, 5, 4, 5, 4, 5, 4, 8, 7, 8,	rd ain la rive Nico	ake r blet ri « « «	ver, alo hill	at Au ong g Iside	oluff ger . ully secti	sout sout	thwe h of isout	st of	ho n N gully	me 0. 1	of	42, Hond	.164, 143, ore 18, 	166 129 146 173 18 19 20 23 30 35 38
	Meator Mount Nicolet No. 1, 4 2, 4 3, 4 4, 5, 4 6, 4 7, 4 8, 5 Sheguia	rd ain la rive Nico « « « « «	ake olet ri « « « « «	ver, alo hill	at l Au ong g Iside	oluff ger. ully secti	sout on, s	thwe h of i south	st of	ho n N gully	me	of	42, Hone	. 164, 143, ore 18, 	166 129 146 173 18 19 20 23 30 35 38 87
	Meator Mount Nicolet No. 1, 2, 3, 4, 4, 5, 6, 7, 8, Sheguis Streets	rd ain la rive Nico " " " " andal ville.	ake plet ri « « « « « « »	ver, alo hill	at l Au ong g Iside	oluff ger . ully secti	sout sout	thwe south	section section section	ho n N gully	me o. 1	of	42, Hone	. 164, 143, ore 18, 	166 129 146 173 18 19 20 23 30 35 38 87 132
	Meator Mount Nicolet No. 1, 2, 3, 4, 5, 4, 5, 4, 7, 8, Sheguia Streets Wekwe	rd ain la trive Nico " " " " andal ville. emiko	ake r blet ri « « « « « » » n roac	ver, alo hill	at Au ng g Iside	oluff ger . ully secti	sout sout	thwe south	section of	ho n N gully	me 	of	42, Hone	.164, 143, ore 18, 	166 129 146 173 18 19 20 23 30 35 38 87 132 123
a a a a a a s Sheguiand	Meator Mount Nicolet No. 1, 2, 3, 4, 5, 6, 7, 8, Sheguis Streets Wekwe dah be	rd ain la trive Nico a a andal ville. miko ds	ake rr blet ri " " " " " " " " " "	ver, alo hill	at Au ng g Iside	oluff ger secti	sout on,	thwe h of south	section section	ho n N gully	me o. 1	of	42, Hon	.164, 143, ore 18, 	166 129 146 173 18 19 20 23 30 35 38 87 132 123 94
a a a a a a a a a a a a a a a a a a a	Meaton Mount Nicolet No. 1, 2, 3, 4, 4, 5, 4, 5, 4, 7, 8, Sheguia Streets Wekwe dah be ro:	rd ain la trive Nico " " " andal ville. miko ds	ake rr blet ri " " " " " " " " " " "	ver, alo hill	at Au ng g Iside	oluff ger secti	sout on,	thwe h of south	st of	ho n N gully	me o. 1	of	42, Hond	.164, 143, ore 18, 	166 129 146 173 18 19 20 23 30 35 38 87 132 123 94 85
a a a Sheguiano Smith, Ca	Meaton Mount Nicolet No. 1, 2, 3, 4, 4, 5, 4, 5, 6, 7, 8, Sheguis Streets Wekwe dah be roo ape	rd ain la rive Nico " " " " " " " andal ville. miko ds	ake r olet ri " " " " " " " " " " "	ver, alo hill	at Au ng g Iside	oluff ger. ully secti	sout south	th we	st of	hor hor gully	me o. 1	of	42, Hond	.164, 143, ore 18, 	166 129 146 173 18 19 20 23 30 35 38 87 132 123 94 85 124
a a a s Sheguiand Smith, Ca Snake isla	Meaton Mount Nicolet No. 1, 2, 3, 4, 4, 5, 6, 7, 8, 5 treets Streets Wekwe dah be ro: ape and, La	rd ain la rive Nico " " " " andal ville. miko ds ad	ake r olet ri " " " " " " " " " " " " " "	ver, alo hill	at Au ng g Iside	bluff ger ully secti	sout sout	th we h of a south	section section	ho on N gully	me o. 1	of		.164, 143, ore 18, 	166 129 146 173 18 19 20 23 30 35 38 87 132 123 945 124 85 121
a a a a a a a a a a a a a a a a a a a	Meaton Mount Nicolete No. 1, 2, 3, 4, 2, 4, 5, 4, 5, 4, 5, 4, 5, 4, 5, 4, 8, 5, 5, 1, 8, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1,	rd ain la rive Nico " " " " andal ville. miko ds ad id	ake r olet ri " " " " " " " " " " " " " " "	ver, alo hill	at Au ng g side	bluff ger. ully secti	sout ion, s	thwe h of south	section	ho on N gully	me 0. 1	of .vi	.92, i, 98,	.164, 143, ore 18, 	166 129 146 173 18 19 20 23 30 35 38 87 132 123 94 85 124 161
a a a s Sheguiano Smith, Ca Snake isla Southgate	Meator Mount Nicolee No. 1, 2, 3, 4, 5, 4, 5, 4, 5, 4, 5, 4, 6, 4, 5, 8, 8, 8, 8, 8, 8, 8, 8, 8, 8, 8, 8, 8,	rd ain la trive Nicc " " andal ville. miko ds kke S ttion,	ake r blet ri " " " " " " " " " " " " "	ver, alo hill	at Au ong g Iside	bluff ger. ully secti	south	thwe h of south	st of	hon N gully	me 0. 1	of .vi		. 164, 143, ore 18, 111, , 155,	1666 1299 1466 173 18 199 200 233 300 355 358 887 132 123 94 855 124 161 853
a a a a s s s s s s s s s s s s s s s s	Meaton Mount Nicoleie No. 1, 2, 3, 4, 2, 4, 4, 5, 4, 4, 5, 4, 4, 5, 6, 7, 8, 8, 8, 8, 8, 8, 8, 8, 8, 8, 8, 8, 8,	rd ain li trive Nico a andal ville. miko ds ad tion,	ake r blet ri " " " " " " " " " " " " "	ver, alo hill	at Au ng g Iside	bluff ger . ully secti	sout ion, :	thwe south	st of	hon N gully	me o. 1	of 		.164, 143, ore 18, 	166 129 146 173 18 19 20 23 30 35 38 87 132 123 94 85 124 161 85 33
a a a a a s Sheguiand a Sheguiand a Smith, Ca Snake isla Southgate a Species, d Specer, d	Mealon Mount Nicolete No. 1, 2, 3, 4, 4, 5, 4, 4, 5, 4, 4, 5, 4, 4, 5, 6, 7, 8, 5 treets Wekwe dah be rot ape and, La forma listribu L. We	rd ain li t rive Nicc " " andal ville. mikco ds ad kke S ttion, tion	ake r blet ri " " " " " " " " " " " " " " " " " " "	ver, alo hill	at l Au ng g side	bluff ger . ully secti	sout ion, s	thwe south	st of	hon N gully	me o. 1	of 	.42, Hond		173 18 19 20 23 30 35 38 87 132 123 94 85 124 161 85 33 177
a a a a Sheguiano Smith, Ca Snake isla Southgate a Species, d Species, d Species, d	Meaton Mount Nicolete No. 1, 2, 3, 4, 4, 5, 4, 7, 4, 8, 5 Streets Streets Streets ape and, La e forma distribu J. W le.	rd ain li t rive Nico a andal ville. miko ds ad kke S	ake r et ri a a a a a b t. Join b t. Join c and r	ver, alo hill	at Au ng g side urren e of.	bluff ger . ully secti	sout sout	thwe h of a south	st of section	hon N gully	me o. 1		.42, Hond	. 164, 164, 18, 	166 129 146 173 18 19 20 23 30 35 38 87 132 123 94 85 124 161 85 33 177 98
" " " " " " " " " " " " " " " " " " "	Mealou Mount Nicoleie No. 1, 2, 3, 4, 2, 4, 3, 4, 4, 5, 4, 4, 5, 4, 6, 7, 8, 5 heguia Streets Wekwe dah be ro: ape and, La e forma listribu J. W	rd ain lik Nicc """ andal ville. mike ds ad kke S ttion, ttion	ake rr e e e e e e e e e e e e e e e	ver, alo hill	at Au ng g side urren e of.	pluff ger. ully secti	sout sout sout sout sout sout sout sout	thwe south	st of section of p	, 13	me o. 1 7	.vi		. 164, 143, ore 18, 	1666 129 146 173 18 19 20 23 30 35 38 87 122 123 94 85 124 161 85 33 177 98 175
a a a s Sheguiand a Sheguiand a Sheguiand a Smith, Ca Snake isla Southgate a Spencer, Streetsvill Synclines,	Meaton Mount Nicolete No. 1, 2, 3, 4, 4, 5, 4, 5, 4, 5, 4, 5, 6, 7, 8, 8, 8, 8, 8, 8, 8, 8, 8, 8, 8, 8, 8,	rd ain la rive Nicc """"""""""""""""""""""""""""""""""	ake r blet ri " " " " " " " " " " " " "	ver, alo hill	at Au org g Iside	bluff ger. ully secti	sout sout sout sout	thwe h of south	section section of p , 131	ho on N gully	me o. 1 /	.vi		. 164, . 143, ore 18, 	1666 129 146 173 18 19 20 23 35 38 87 132 123 94 85 124 161 85 33 177 98 175 , 61
a a a a sheguiano Sheguiano a Sheguiano a Sheguiano a Sheguiano a Spencer, j Streetsvill Synclines,	Meaton Mount Nicolete No. 1, 2, 3, 4, 2, 4, 4, 4, 5, 4, 4, 4, 5, 4, 4, 4, 5, 6, 7, 8, 8, 8, 8, 8, 8, 8, 8, 8, 8, 8, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1,	rd ain li t rive Nicco """""""""""""""""""""""""""""""""""	ake olet ri " " " " " " " " " " " " "	ver, alo hill	at Au ng g Iside	bluff ger. ully secti	sout sout , 97,	thwe h of a south	set of section of p , 131	, 13	me 0. 1 7		42, Hond	164, 143, ore 18, 18, 	1666 129 146 173 18 19 20 23 30 35 38 87 132 123 94 5 33 85 124 161 85 33 177 98 5 175 961

Table of formations,	Canada	•••••	13
	Maysville, Unio		- 73

Table of fo	ormatio	ns. New York	, 3, 13
4	"	Quebec	59
Tamarack	point		56, 91
Toronto			3, 94
Trenton fa	Ills		1
* fc	ormation	n	1
46	"	Breault	57
66	46	Mimico	76
46	46	Montmorency falls	58
K	K	St. Hyacinthe	56
46	4	St. John lake	155
Twenhofel	W. H.		0, 162

U.

Ulrich, E.	0 v ,	vi, viii, 10, 28, 33, 37, 40, 46, 68, 71, 8J, 81, 84, 85, 86, 89, 91, 92, 101, 131, 133, 140, 163
Utica form	nation	92, 101, 131, 133, 149, 105
	"	Montmorency falls
a de la companya de l	K	New York 5
4		St. John lake
"	"	Toronto

v.

w.

Warren cour	nty, Ohio)	27
Waynesville	formatio	on	170
"	"	Bass Lake road	119
	ĸ	Clay cliff	82
46	65	Kagawong	110
"	46	" falls.	109
#		Little Current	117
4	46	Meaford 127, 167,	175
		Mountain lake	128
"	44	Nicolet river 14 20 21 26 142	140
	44	Obio	101
		Rivière des Hurone 150	152
"		St Hilding 157	152
	"	St. Human	155
		St. Inter Jahr	157
"	"	St. John lake	120
317 1 1		vars	100
weisburg, 1	ndialia.	••••••••••••••••••••••	102
Wekwemiko	ng		102
Wekwemiko	ng, north	hwest of	124
	south	hwest of	123
Wekwemiko	ngsing		100
Weston			, 74
Whitall's qu	arry		3

niteaves, J. F	***************************************	
nitewater format	ion	
	Georgian hav	
4 A	Kagawong	
	Masfand	
	Mealord	
	Ohio	62
	Streetsville 122 12	
hittaker E I		1, .
leon A F		
nson, A. E.		
orkman brook	70 07 04	

Y.

Yamaska river	40	\$0	\$7	
	417.	50.	57	



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	1014-bu I Austen Banaralt
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	A Desser
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