

GM 01998

REPORT ON THE LORRAINE AND RICHMOND OF THE ST. LAWRENCE LOWLANDS

Documents complémentaires

Additional Files



Licence



License

Cette première page a été ajoutée
au document et ne fait pas partie du
rapport tel que soumis par les auteurs.

Énergie et Ressources
naturelles

Québec 

REPORT ON THE LORRAINE AND RICHMOND

OF THE ST. LAWRENCE LOWLANDS

NICOLET SEIGN.

*et
DE GUIRE SEIGN.*

By

DR. BILAL RIAZ HUSAIN

Ministère des Richesses Naturelles, Québec

SERVICE DES GITES MINÉRAUX

No GM- 1998

PUBLIC

April 1957

TABLE OF CONTENTS

INTRODUCTION pages 3-7

 Introductory remarks page 3

 Field work page 3

 Previous history page 3

 Classification page 4

 Acknowledgements page 6

STRATIGRAPHY pages 8-15

 South west branch of the Nicolet river page 8

 Nicolet river main branch page 11

 St. Francis River page 14

PALAEONTOLOGY pages 16-58

 Vermes page 16

 Trilobites page 17

 Corals page 21

 Cephalopods page 23

 Gastropods page 25

 Brachiopods page 28

 Pelecypods page 34

 Bryozoans page 45

DISTRIBUTION OF SPECIES pages 59-63

CONCLUSIONS pages 64-68

BIBLIOGRAPHY page 69

INTRODUCTION

Introductory Remarks

The main purpose of this paper is to revise the stratigraphy of the Upper Ordovician rocks in the St. Lawrence Lowlands. Various faunal zones of Foerste (1921) were found by the present writer to be inconsistent with the more detailed geological mapping done by the Imperial Oil geologists in 1954, 1955. Also during the course of a preliminary survey in 1955, the present writer collected large number of bryozoans and established bryozoan faunal zones. Hence, the necessity of revising Foerste's work and to establish more horizon markers with the help of bryozoans led to this project.

During the summer of 1956, the present writer studied the various sections exposed in the rivers, such as the Nicolet River, Nicolet River, S. W. Branch, St. Francis River, and the Becancour River, Gentilly River, etc. and fossils were systematically. In all these sections numerous faults, both major and minor, have disrupted the continuity and since the lithology is constant, the only means of establishing the ages were the fossils.

Field Work

The following areas were studied:

1. St. Francis River
2. Nicolet River
3. Nicolet River, S. W. Branch
4. Becancour River
5. Gentilly ridge
6. Gentilly River

Besides these sections in the above areas covered, samples from the Imperial Lowlands #1, South shore #1 and #2 wells were examined. Please see attached map showing the regions studied.

Previous History

Before 1916 various small reports on the palaeontology of the Upper Ordovician rocks of Quebec are available in the geological literature. Foerste (1916) incorporated all the information and attempted a correlation of these rocks in Quebec with those of New York, and Ontario, subsequently Foerste (1921) published a memoir on the palaeontology of the Upper Ordovician rocks of Quebec and Ontario. This paper formed the basis of all future geological work. A summary report by Clark (1942) on the Upper Ordovician is included in Geology of Quebec by Denis & Dresser.

4

It was not until 1944 that Dr. Clark of the Quebec Department of Mines started geological mapping of the areas south of St. Lawrence River. These reports are still unpublished.

The present work was started in 1955 when a preliminary survey was made by McAlary and in 1956 Wicherts, and Lesperance and the present writer. With the help of Mr. S. Dean, the writer examined the Upper Ordovician sections in detail, and this report incorporates all the information collected during the two years in the St. Francis River, Nicolet River and Nicolet River south west branch areas.

Classification

The term Upper Ordovician includes all rocks above the Trenton, namely, the Queenston, Richmond, Lorraine, Leclerville and Utica groups in descending order of succession. (See table of formations).

Queenston group

This group includes the red and purple red shales, clays and siltstones. These rocks are unfossiliferous in Quebec but in Ontario at Oakville, Medford and Streetsville, the beds include numerous ostracods which are closely related to Drepanella richardsoni, a Richmond species. Also the red beds overlies the green shales and siltstones which are characterised by Waynesville fossils. Foerste (1924, p.5) believes that the Queenston group should be regarded as a lithologic unit rather than stratigraphic.

In this report the writer feels that since no fossils were found in the Queenston beds and as they (the Red beds) form a distinct unit, quite separate from the fossiliferous Richmond, it would be unwise to group them together. Hence, they have been considered as entirely different groups.

Richmond group

The upper Richmond beds in this part of St. Lawrence Lowlands is noted for its rich fauna. Lithologically, the red beds of Queenston age are underlain by the green shales and siltstones. Below these green beds, a marine limestone facies is developed in all the sections known to the writer which contain abundant Zygospira kentuckiensis, Strophomena planumbona, Streptelasma profundum. The fauna of the Richmond group has elements similar to those found in the Medina of New York but Foerste (1924, p.3) decided after a detailed study to retain the Richmond within the Ordovician. This system has since been established and is still followed by the Geological Survey of Canada and the Quebec Department of Mines.

A noteworthy feature of the Richmond group may be mentioned here; it contains a recurrent fauna. The various species of the Richmond are closely allied and even identical to the ones found in the Trenton and Black groups found in other parts of Quebec. Such species as

Dalmanella rogata, Sowerbyella sericea, Rhynchonella increbescens, Rafinesquina alternata, Helicotoma sp., Vallatotheca sp., Spyroceras sp., Leperdita sp., all have closely allied species in the Trenton and Black River groups.

Lorraine group

Lithologically, the group is consistently uniform without any distinct lithologic breaks. Faunally however, it can be divided into a number of zones and subzones which the writer found fairly easy to correlate. Foerste (1916) divided the Lorraine section along the Nicolet River into the following zones:

- | | |
|---------------------------|---------------------------------------|
| <u>Pholadomorpha</u> Zone | <u>Leptaena</u> Zone |
| <u>Proetus</u> Zone | <u>Cryptolithus</u> (Trinucleus) Zone |

Foerste (1921, p.22) admits that these zones had not been examined for their stratigraphic value and represent the state of knowledge of faunal zones at the time they were established by Foerste. During the past few years, Dr. T. H. Clark unpublished reports of the Quebec Department of Mines, has hinted that the Pholadomorpha zone should be included within the Richmond on account of distinct faunal affinities. This subject is discussed in detail later. Also, geologists on the staff have established two new zones, i.e. Leptaena Cryptolithus zone and Leclerville shales zone below the Cryptolithus zone.

The present writer from his study of the bryozoan fauna has established a number of bryozoan zones in the Lorraine group. They are:

- | | |
|---|--|
| <u>Fenestella</u> subzone |) within the <u>Leptaena</u> zone of Foerste |
| <u>Glauconomella</u> subzone) | |
| <u>Stigmatella stearnii</u> subzone in the upper part of <u>Proetus</u> zone of Foerste | |

Besides the subzones established above the following species were found useful in establishing the age of the various horizons.

Richmond

- Eridotrypa clarki, sp. nov.
- Diplotrypa (?) westoni Ulrich

Lorraine

PHOLADOMORPHA ZONE

- Prasopora donensis Parks and Dyer
- Dekayia lambtonensis (Parks and Dyer)
- Stigmatella halysa Armstrong

PROETUS ZONE

Stigmatella stearnii, sp. nov.

LEPTAENA ZONE

Stigmatella ? vulgaris Parks and Dyer
Hallopora subplana var. deanii, n. var.
H. dalei var. subalta Parks and Dyer
Chiloporella flabellata (Ulrich)
Diplotrypa petropolitana (Nicholson)
Prasopora nicolettinensis, sp. nov.
Eridotrypa moniquensis, sp. nov.

LEPTAENA-CRYPTOLITHUS ZONE

Stigmatella catenulata var. (a) Parks and Dyer

The upper part of Leclerville shales is characterised by the presence of Lingula sp.

From the present study it was noted that Foerste's Proetus zone extends into the Pholadomorpha zone on the one hand and into Leptaena zone on the other. Consequently Proetus position as a stratigraphic marker horizon is negligible unless it is found in association with other fossils.

Leclerville Shales

The shales and siltstones of this group underlie the Cryptolithus zone of the Lorraine group. They are practically barren except for rare specimen of Lingula sp. Sactoceras westonense.

Utica group

The shales and siltstones are typically black in colour and are characterized according to Clark (1952) by Triarthrus becki and Leptobolus insignis.

Acknowledgements

The writer is indebted to the Dr. I. Jones and Dr. T. H. Clark of the Quebec Department of Mines for allowing him free access to the maps and reports on the various map areas mapped by the department.

The writer wishes to acknowledge the help and criticisms from Messrs. J. D. McAlary, P. Lesperance and E. Wicherts, and P. P. Simard.

7

To Mr. S. Dean acknowledgement of his help during the field season of 1956, and to Mr. R. Handfield during the summer of 1956 is made here.

To Miss R. Gaudet, who typed this manuscript, acknowledgement is made here.

STRATIGRAPHY

SOUTHWEST BRANCH OF THE NICOLET RIVER

This branch of the river is found in the Yamaska map sheet, and the outcrops start approximately 2 miles west of La Visitation, near a sawmill. These outcrops are continuous for half a mile upstream up to the big bend where they are covered up by drift. The outcrops reappear about 1 mile upstream from the mill and are continuous from thereon to the 2nd sawmill and dam upstream and a half mile beyond. The location of these outcrops is shown on map No.....

The section includes an almost complete sequence of the Richmond and Lorraine groups in the east limb of an anticlinal structure along the river. The west limb of the anticline is repeatedly faulted and consequently it cannot be measured.

This section as a whole lies, along strike, between those found along the St. Francis River in the southwest and the Nicolet River in the northeast.

Structure

Folds

The Upper Ordovician rocks are folded to form a broad anticline, the axis being approximately 1500 feet downstream from the 2nd sawmill. Due to repeated thrust or gravity faults the complete sequence is not represented in the north eastern limb.

Minor folds and contortions are associated with the faults.

Faults

At least four major faults are recognized, and from a regional study, are believed to be dipping southeast. The displacement along these faults from 260 to 650 feet. The minor faults have, however, a displacement of the order of 50 to 100 feet.

Stratigraphy

Lorraine Group

The rocks of this group are found continuously from the axis of the anticline to the big bend downstrain and upstream up to where a stream enters the river on the right bank 3 1/2 miles east of St. Perpetue.

Leclerville shales member

The shales and siltstones belonging to this group are found upstream from the major fault (M.F.4). No fossils were found except for rare specimens of Lingula sp.

Breault member

The lowest beds of this member, few thick beds of coarse-grained limestones associated with the sandstones and shales, are found in the block between the faults M.F.4. These limestones contain abundant Cryptolithus, and Dekayella sp. and rare Sactoceras westonense, Lingula hyacinthensis.

The upper part of the Breault member is exposed in the axis of the anticline. The shales, siltstones and sandstones contain abundant Cryptolithus sp. and Sactoceras sp.

Cryptolithus - Leptaena zone

This zone, as we know, is characterized by the presence of Cryptolithus bellulus, Leptaena rhomboidalis, and L. moniquensis. These beds are found on both the limbs of the anticline. The thickness of this zone, along this river is, however, only 150 feet as compared 300 feet along the main branch of the Nicolet River.

Leptaena zone

This zone has numerous bryozoan which are confined to it, and two of the species, Fenestella and Glauconomella are so prolific that they form subzones. Besides these two Hallopora subplana var. deanii, H. dalei var. subalta, Eridotrypa moniquensis, Prasopora nicolettinensis and Chiloporella flabellata form good index fossils.

Fenestella and Glauconomella subzones

These two zones are always found close together, separated by a hundred feet of section. Along the north-western limb these two zones are exposed near the two islands, 2 1/2 miles upstream from La Visitation. On the south-eastern limb due to faulting and overturning, the zones are repeated twice upstream from the dam.

Proetus zone

About three hundred feet from the south-eastern tip of the islands mentioned above, the Proetus zone is exposed as a result of the major fault M.F.2. Proetus chamblensis was found in the outcrops along the left bank, associated with small specimens of Lingula sp. and Stigmatella stearnii. The same Lingula species was found in the outcrops along the right bank close to the islands. Most of the Proetus section is, however covered up by drift.

Pholadomorpha zone

This zone along the southwest branch of the Nicolet River is difficult to separate from the rocks of the Richmond group. Throughout these rocks which exposed from the first sawmill up to the great bend, elements of Richmondian fauna such as Strophomena planumbona, Rafinesquina alternata, Zygospira modesta, Streptelasma rusticum, Holtedahlna sulcata, Pterina demissa are found.

Clark, Quebec Department of Mines (unpublished report) on 'Yamaska map area', (p.28) has divided Richmond group into two zones as follows: "It is suggested that it (lower Richmond) starts a few hundred feet upstream from the beginning of the exposures on the north bank above the dam". The above division is admittedly arbitrary and ambiguous. For the present purpose the boundary is placed in the Richmond section where Streptelasma rusticum is first found.

Queenston

The contact between the red and green beds is clearly seen 500 feet below the 1st dam upstream from La Visitation. Just below the green beds Zygospira kentuckiensis is common. This contact is also in the section exposed a tributary entering the river from the right bank, 600 feet below the first dam.

NICOLET RIVER MAIN BRANCH

This section is approximately 9 miles west of Nicolet, close of the village of St. Monique. It is accessible by car. The outcrops are along the river which from steep banks, forming cliffs up to 80 feet, but the outcrops can be reached easily at a number of places.

This section was used by Foerste (1916) as the type section of the Richmond and Lorraine groups in the St. Lawrence and he (Foerste, 1916) established the various faunal zones.

The section can be divided into two parts, contorted and repeatedly faulted sections west of the point where the 2nd tributary enters the river from the right bank. The section east of this point is more or less continuous, being faulted a few times and the displacements along these faults have been of the order of tens of feet. The detailed description of the lithology has been made by Foerste (1916) and no attempt was made to redescribe the rocks by the present writer.

Structure

Faults

This section has so many faults that it is not possible to discuss them individually. The common type is the south-easterly dipping faults related to the regional structure similar to that found on the southwest branch of the Nicolet River, in interpretation No. 1. Besides this type, a second major fault dipping towards the N.W. is believed to be present. In interpretation No. 2 the faults are all assumed to be dipping in the same direction, viz. due S.E. secondary faults are numerous and help to explain the adjacent beds of different ages.

Folds

The major fold is the anticline whose axis is approximately 3 miles upstream from the intersection of the first tributary and the Nicolet River. This anticline, due to numerous faults and the incompetent nature of the beds, has caused it to be broken up to numerous small anticlines and synclines, and even overfolded.

Stratigraphy

Leclerville shales

These shales like in all other localities are practically devoid of all fossils. It is found upstream on the south-eastern limb of the anticline where it is brought up to the surface through repeated thrust faults. Typically, it is composed of shales but it also contains few beds of sandstones and siltstones in this section. Lingula sp. is found sparingly.

Lorraine Group

Breault member

The lowest part of this member is found exposed close to the axis of the anticline where abundant Cryptolithus bellulus and Byssonychia hyacinthensis and Sactoceras westonense are found in the shales and sandstones.

In the upper part of this member massive bryozoans such as Stigmatella and Dekayella cf. ulrichi are common.

Leptaena - Cryptolithus zone

This zone with Leptaena rhomboidalis, L. moniquensis and Cryptolithus bellulus is found repeated in the north-eastern limb and is also repeated in the south-eastern limb due to overfolding the zone with the same characteristic fossil assemblage. The maximum thickness of 300 feet of this zone is found along this section.

Leptaena zone

Beds belonging to this zone overlie those of the Breault member and is characterized by the lack of Cryptolithus bellulus. These beds are exposed only in the north-western limb and a complete section of this member can be measured here. While its lower boundary is well defined, it merges quite gradually into the Proetus zone of Foerste. The bryozoans fauna forms important basis for dividing the zone into subzones. Fenestella and Glauconomella form two subzones which can be traced in all the rivers studied. (Please see maps). Besides these two, Prasopora, Diplotrypa and Chiloporella flabellata, Hallopora, also occur in the Leptaena zone, though not as characteristically to form subzones of their own.

Proetus zone

This zone of Foerste is by no means distinct. The characteristic species, Proetus chamblensis, extends from the upper part of the Leptaena group of the Lorraine group to the base of the Waynesville member of the Richmond group. From the present study, it is concluded that the abundance of Proetus and the first appearance of Stigmatella stearnii and Modiolopsis mcalarii should be regarded the basis of separation of the Proetus zone from the underlying Leptaena zone. Its upper limit is vague and the only reliable fossil would be the occurrence of Pholadomorpha pholadimorphis, Modiolopes modielaris.

Pholadomorpha zone

The so-called Pholadomorpha zone of Foerste appears to be the most confusing. It contains elements of the overlying Richmond and the underlying lower and middle Lorraine. Pholadomorpha pholadimorphis which occurs at the base of this member, is found associated with

Strophomena planumbona, Rafinesquina alternata, and other characteristic Richmond fossils. Again its faunal boundaries with the overlying Richmond is not distinct. Lithologically, however, the first appearance of Streptelasma rusticum serves as a marker for the upper limit of Pholadomorpha zone. For the sake of convenience and to avoid confusion, it is suggested that this member should be rightly included with the Richmond, since the fauna of Richmond group and that of the Pholadomorpha zone are more closely allied than those of Pholadomorpha zone and the Proetus zone.

The bryozoan fauna contains abundant small Stigmatella sp. Diplotrypa sp. According to Foerste (1916, p.28), "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 these suggested to him affinities with species occurring near the Bellevue horizon, near the middle of the Maysville horizon in Ohio, rather than any known Richmond species". This statement is hard to contradict, but it is still open to doubt in view of the fact that no descriptions of these bryozoans can be found to compare the present writer's findings. The small Stigmatella sp. and Dekayella sp. are both found in the Leptaena zone of Lorraine group, as well as Richmond group and hence should be considered stragglers. It may be added here that Constellaria, a characteristic Richmond species, has been recorded from the Pholadomorpha zone along this river.

Like in the section along the southwest branch of the Nicolet River, all those beds above the Proetus zone and (below the Waynesville member) are incorporated with the Lower Richmond. No new name is suggested for this interval at this time.

Richmond Group

The Lower Richmond group is already discussed above. The Upper Richmond group, referred to as Waynesville member is characterized by the presence of abundant Zygospira kentuckiensis, Lophospira sp. Cymatonota sp.

Queenston Group

The contact between the Richmond and Queenston, like in southwest branch of Nicolet River is a lithological one. The red beds overlie green shales and siltstones of the Richmond about 1500 feet downstream from the barn (see map...).

ST. FRANCIS RIVER

The St. Francis River section is found 7 miles upstream from Pierreville. For the first half mile the outcrops are discontinuous, and then a continuous but repeatedly faulted section is seen on both sides of the river for two and a half miles. Near the place where the St. Francis River widens out small islands are found in the river bed, and here the outcrops cease. They reappear on the right bank but this part of the section was not examined in detail by the writer.

Along the St. Francis River, parts of Richmond and Lorraine are found in the numerous fault blocks.

Structure

Folds

Minor anticlines and anticlines occur throughout the section. One major anticlinal structure can, however, be seen on the right bank, 1/2 mile downstream from where a small stream enters the river. From the right bank due to this structural feature the Leptaena and Leptaena - Cryptolithus zones are repeated upstream. (See map...).

Faults

Faults are numerous along this river. The displacements along these faults are in the order of 100 to 500 feet.

Stratigraphy

Lorraine Group

Leclerville shales

The shales, siltstones and few dolomite beds occur in the section upstream from where the river widens. Few fossils were obtained from these outcrops; and they included Lingula sp. and Triarthrus sp.

Cryptolithus zone

Rocks belonging to this zone are found in two places; once near the junction of the stream and river and the second near the extreme southern end of the section before the river valley widens out.

The fossils included Cryptolithus bellulus, Byssonychia hyacinthensis, Liospira micula and Dekayella ulrichi.

Leptaena - Cryptolithus zone

This zone like in other rivers is characterized by the association of Cryptolithus bellulus and Leptaena moniquensis. One bryozoan species,

Stigmatella catenulata var. (a) was also found in this part of the section.

Leptaena zone

This zone is repeated four times due to repeated faulting and due to overfolding it appears to be overlie the Proetus zone. The Fenestella, Glauconomella zones are also found in this section. Detail fossil list is given under chapter "Distribution of species". The presence of the anticline along this river was confirmed by the presence of these two subzones upstream from the junction of the small stream and the river along the right bank.

Proetus zone

The rocks belonging to this zone are found along the river, corresponding almost opposite to the school along the right bank. The following fossils were found:

- Proetus chambliensis
- Catazyga headi
- Stigmatella (?) stearnii
- Byssonychia praecursor
- Modiolopsis mcalarii
- Pseudolingula rectilateralis

Pholadomorpha zone

The zone is found 1/4 mile downstream from the 'school' marked on the topographic map. The characteristic fossil Pholadomorpha pholadimorphis is found in abundance. Associated with it the following species are found:

- Proetus chambliensis
- Sactoceras westonense
- Ceraurus sp.
- Stigmatella halysa
- Dekayia lambtonensis

Richmond Group

The Lower Richmond group characterized by Zygospira kentuckiensis is found in the second fault block, lying between two blocks of Pholadomorpha zone. The Upper Richmond rocks are found in close proximity to the red beds of the Queenston. These beds possess Streptelasma rusticum, Strophomena planumbona and Vallatotheca sp.

Queenston Group

The beds belonging to this group are characterized by the characteristic red colour and complete lack of fossils. In this river section, the Queenston beds were also effected by a fault, an occurrence not seen along both branches of the Nicolet River.

PALAEONTOLOGYVERMES

Arthraria minor, sp. nov.
pl. fig.

Arthraria rogersensis Foerste, Geol. Surv. Can. Mem. 138, 1924,
p. 79, pl. IV, fig. 5.

Arthraria biclavata var. westonensis Foerste, Ibid.
p. 78, pl. V, fig. 3.

Arthraria biclavata Miller, Jour. Cinn. Soc. Nat. Hist. vol. 21,
1914, pl. 2, fig. 9.

The specimen has a narrow width, and the bulbs are relatively small. A comparison with Arthraria rogersensis is shown below.

	Groove length	Groove width	Diameter of bulbs or disturbed regions
<u>A. rogersensis</u>	16-17 mm.	3 mm.	5.5 mm.
<u>A. minor</u>	20 mm.	1 mm.	3 mm.

Its comparison to A. biclavata and its variety, A. westonensis shows that the sizes of the latter are too large to be considered relevant.

Locality and distribution

One lone specimen was found in the lower Richmond rocks along the St. Francis River.

TRILOBITES

Cryptolithus bellulus (Ulrich)

Trinucleus bellulus Ulrich, Cinn. Soc. Nat. Hist. Jour. 1, 1878,
p. 99, pl. 4, fig. 15.

Cryptolithus bellulus Basoler, Maryland Geol. Surv. Cambrian and
Ordovician, 1919, p. 333, pl. 56,
figs. 5, 6.

Cryptolithus bellulus Foerste, Geol. Surv. Can. Mem. 138, 1924,
p. 237, pl. 45, fig. 17; pl. 43,
figs. 19, 20.

This species is very common in the Breault and forms an important index fossil in the Upper Ordovician of Quebec.

Foerste (1924, p. 138) mentions that the genal spines are rare. However in the Leptaena - Cryptolithus zone along the S. W. branch of the Nicolet River as well as along the Becancour River, samples of Cryptolithus bellulus with genal spines are prolific.

Previously Foerste (1921) had established the Cryptolithus zone. Subsequent work by Mr. J. D. McAlary and the present writer established that Cryptolithus - Leptaena association forms a distinct zone in the stratigraphic column. This zone ranges from 180 feet along the S. W. branch of the Nicolet River to as much as 300 feet along the main branch of the Nicolet River. No new name is suggested for this zone. Since the present writer feels that the "Leptaena - Cryptolithus zone" is fairly descriptive and comprehensive and does not warrant an addition to the stratigraphic terminology.

This species is distinguished by the following features:

- A. The cephalon is relatively flat and smooth.
- B. The pits in the outer row are larger and appear to be arranged radially.
- C. The pits in the inner rows alternate in position.

Locality and distribution

As discussed above the species has a wide geographical position and extends from the Cryptolithus zone into the Cryptolithus - Leptaena zone.

Isotelus gigas DeKay

Isotelus gigas DeKay, Ann. Lyceum Nat. Hist. New York 1, 1924, p. 176,
pl. 12, fig. 1; pl. 13, fig. 1.

Isotelus gigas Foerste, Geol. Surv. Can. Mem. 138, p. 241, pl. 45,
fig. 6.

A lone but fairly complete specimen of this species was found in the sandy shales of the Richmond group along the St. Francis River. This species extends from the Trenton and is believed to be part of a recurrent fauna.

Proetus chambliensis Foerste

Proetus chambliensis Foerste, Sci. Lab. Denison Univ. Bull. 17, 1914,
p. 320, pl. 4, figs. 1, a-h.

Proetus chambliensis Foerste, Geol. Surv. Can. Mem. 138, 1924,
p. 243, pl. 46, fig. 7.

On the basis of its abundance in a certain part of the section, along the Nicolet River, Foerste (1921) established the Proetus zone. This species was, however, found to have a long vertical range since it transgresses into the Leptaena - zone on the one hand and extends upwards up to Upper Richmond on the other. Also, along S.W. branch of the Nicolet River and the Becancour River, the section corresponding to the Proetus zone of the Nicolet River contains only a few specimens of Proetus chambliensis. However, its association with Lingula sp. helps in determining the position in the stratigraphical column.

Proetus chambliensis is abundant along the St. Francis River and the main branch of the Nicolet River. It is found in the rocks immediately overlying the Chambly member (Leptaena zone) along the S. W. branch of the Nicolet River, the Becancour River. The species also occurs in the St. Hilaire and Richmond rocks along the main branch of the Nicolet River, the Gentilly River, and the Gentilly ridge.

Calymene granulosa Foerste

Calymene callicephalo granulosa Foerste, Sci. Lab. Denison Univ. Bull.
14, 1910, p. 294.

Calymene granulosa Bassler, Cambrian and Ordovician Geol. Surv. Maryland,
1919, p. 356, pl. 56, figs. 1, 2.

Calymene granulosa Foerste, Geol. Surv. Can. Mem. 138, 1924,
p. 246, pl. 44, figs. 1a, b.

This species is characteriscal by the distinct granules on the surface of the skeleton. It was previously reported from the Sheguindah formation along the Sheguindah road, 3 miles south of Little Current by Foerste (1924). It is also found in the rocks Eden age in Kentucky, Tennessee and New York. This is the first time it has been recorded from Quebec. The species occurs in the Leptaena zone along the St. Francis River.

Triarthus becki Green

Triarthus beckii Green, Mon. Tril. North Amer. 1832, p. 87, Cast. 34,
pl. 1, fig. 6.

Triarthus becki Bassler, Cambrian and Ordovician, Geol. Surv. Maryland,
1919, p. 342, pl. 56, figs. 7-13.

Triarthus becki Foerste, Geol. Surv. Can. Mem. 138, 1924,
p. 239, pl. 43, fig. 22.

The genus Triarthus is represented in the Upper Ordovician by three species, T. eatoni, T. becki and T. huguesensis. Of these only the last two are found in Quebec.

Triarthus becki is characteriscal by a quadratic glabella, the glabellar furrows are less oblique. The angle of the glabellar furrows with the transverse lines is about 20.

Locality and distribution

Triarthus becki is found commonly in the Utica shales and extends into Montreal. Our specimens were obtained from the Utica group in Beloeil area and from the Leclerville - Cryptolithus rocks along the main branch of the Nicolet River.

Triarthus huguesensis Foerste

Triarthus huguesensis Foerste, Geol. Surv. Can. Mem. 138, 1924,
p. 241, pl. 43, fig. 21.

This species is distinguished from T. becki by the following features:

1. Glabella oblong as compared to a quadrati shape of T. becki.
2. Glabella narrower than one found in T. becki.
3. Angle of glabellar furrows with the transverse lines is 30.
4. Glabella more convex than that seen in T. becki.
5. The cranidial margin is deeply incised.
6. Glabellas in T. huguesensis are comparatively smaller.

Locality and distribution

This species is found in Cryptolithus zone along both branches of the Nicolet River, Becancour River, and the St. Francis River. Rare specimens are also found in the Leclerville shales along the St. Francis River and the main branch of the Nicolet River. It was also found in the Leclerville shales in Beloeil map-area.

Its presence in the Leclerville shales helps to distinguish it from the underlying Utica shales.

CORALS

This phylum is represented by a few genera in the Richmond group. Most of the species are same as or closely allied to those found in the Black River and Trenton groups. Clark (Que. Dept. Mines unpublished Rept. on Yamaska map-area) reported the occurrence of Streptelasma, Columnaria, Calapoecia, Protaria, Beatreaeia; all from the Richmond group.

The present writer however discovered only Streptelasma and Columnaria which are described below.

Streptelasma rusticum (Billings)

Petraia rustica Billings, Can. Nat. Geol. 3, 1858, p. 422.
Streptelasma rusticum Lambe, Contr. Can. Pal. Geol. Surv. Can. 4,
 pt. 2, 1901, p. 110, pl. 7,
 figs. 2, 2a, 3.

The specimens range from 40 mm. to 100 mm. in length and are straight. The number of Septa is about 85; the larger ones in the Richmond group along the main branch of the Nicolet River.

Besides these few species the following coral species were identified by other geologists.

Streptelasma dispandans F.
Beatricea undulata C and F.
Calapoecia huronensis C and F.
Protaria richmondensis C and F.

C= Dr. T. H. Clark, Quebec Dept. of Mines, unpublished reports.
 F= Dr. A. F. Foerste, Geol. Surv. Can. Mem. 138, 1924, pp. 65-77.

Columnaria alveolata Goldfuss

Columnaria alveolata Goldfuss, Petrefaeta Germaniae, vol. 1, 1826,
 p. 72, pl. XXIV, figs. 7 a-c.
Columnaria alveolata Lambe, Geol. Surv. Can. Contrin. Can. Pal. IV,
 pt. II, 1901, p. 98, pl. VI, figs. 1, 1a.
Columnaria alveolata Husain, Imperial Oil Ltd. Rept. on Black River
 and Trenton Groups of St. Lawrence
 Lowlands, 1956, p. 44, pl. 7, fig. 1.

This species besides being reported from the Trenton and Black River groups of Joliette and Montreal, was also found in the reach the centre and are twisted to form an imperfect pseudo columella.

Locality and distribution

The species is common in the Richmond group along the Nicolet River (main and the S. W. branches), St. Francis River and in the quarry along the Gentilly ridge. It is also found on the monastary ridge close to St. Angele de Laval.

CEPHALOPODSZitteloceras hitzi Foerste

Cyntoceras hitzi Foerste, Sci. Lab. Denison Univ. Bull. 16, 1910,
p. 78, pl. 1, figs. 7a, b; pl. 2,
figs. 23, a-c.

Zitteloceras hitzi Foerste, Cinn. Soc. Nat. Hist. Jour. 22, 1917, p. 51.

Zitteloceras hitzi Foerste, Geol. Surv. Can. Mem. 138, 1924,
p. 223, pl. 41, figs. 3a, b.

Though the specimen is our collected is a poorly preserved one, its resemblance to Zitteloceras is beyond any doubt.

Locality and distribution

Found in the Upper Chambly member of the St. Francis River. It is however reported in the Black River and Trenton and also the Richmond of the St. Lawrence Lowlands; it also forms part of a recurrent Black River - Trenton fauna occurring in the Richmond group.

Sactoceras westonense Foerste

Sactoceras westonense Foerste, Geol. Surv. Can. Mem. 138, 1924,
p. 226, pl. 39, fig. 5, pl. 40, fig. 2.

A very common specimen. The distance between camerae varies from 0.5 mm. through 11.0 mm. to 4.0 mm. The closely spaced camerae (0.5 to 1.0 mm.), are found in specimens from the Chambly while the first type found has a long range. For the time being no new name is suggested for the closely packed - camerae specimens.

Locality and distribution

This species is very common throughout the Lorraine and Richmond. Its occurrence in the Leclerville shales helps to distinguish these shales from those belonging to the Utica. The distinction between Utica and Lorraine shales is confirmed if Sactoceras westonense is found in association with Triarthrus huguesensis.

The specimens with closely packed camerae is however, restricted to the Chambly member of the Lorraine group.

Sactoceras manitoulinense Foerste

Sactoceras manitoulinense Foerste, Geol. Surv. Can. Mem. 138, 1924,
p. 224, pl. 39, fig. 4 a-c.

This species was not previously described from Quebec province. It was enacted by Foerste (1924) on the basis of samples collected from the Meaford horizon at Clay cliffs. Our specimen comes from the Richmond section along the St. Francis River.

? Kindleoceras triangulare Foerste

Kindleoceras triangulare Foerste, Geol. Surv. Can. Mem. 138, 1924,
p. 228, pl. 43, figs. 11-14.

Only a small broken fragment 12 mm. long and 10 mm. wide was found. The suture lines were distinctly nummuoidal and were 2 mm. apart.

Due to the imperfect nature of the specimen a positive identification could not be made.

Locality and distribution

The lone specimen was collected from the Richmond rocks in the abandoned quarry on the Gentilly ridge.

Spyroceras cf. parksi Foerste

Spyroceras parksi Foerste, Geol. Surv. Can. Mem. 138, 1924,
p. 223, pl. 39, fig. 2; pl. 40, fig. 4.

The specimen in our collection is 15 mm. long and 5 mm. wide and is part of a larger specimen. It possesses strong primary and secondary striations parallel to the length of the shell. However, the annulations are invisible. This specimen is much smaller than the holotype of Foerste which 110 mm. long, 26 mm. wide at the widest part and 17 mm. wide at the narrowest part. However on the basis of a single specimen, a new crena new variety is unadvisable.

Locality and distribution

The single specimen was found from the lower Richmond along the St. Francis River.

GASTROPODSHormotoma gracilis angustata (Hall)

- Hormotoma gracilis angustata Ulrich and Schofield, Geol. Minn. 3, pt. 2,
1897, p. 1015, pl. 70, figs. 30-36.
- Hormotoma gracilis angustata Foerste, Geol. Surv. Can. Mem. 138, 1924,
p. 214, pl. 34, fig. 20.

This species is recognized by its few notations, 7 to 8, and small apical angle (less than 18). None of the specimens however, reached along the 20 mm. as compared to 35 mm. long specimens from Tamarack Point (Foerste, 1924).

Locality

It was found in abundance in the Pholadomorpha zone along the main branch of the Nicolet River.

Hormotoma cf. gracilis var. nicolettinensis, n. var.

- Hormotoma gracilis angustata Ulrich and Schofield, Geol. Minn. 3, pt. 2,
1897, p. 1015, pl. 70, figs. 30-36.
- Hormotoma gracilis angustata Foerste, Geol. Surv. Can. Mem. 138, 1924,
p. 214, pl. 34, fig. 20.

Small elongate spirals with apical angle 20. Length of shell 4 to 6 mm., possessing three to four whorls. The surface of the shell is marked by a median hump, margined by two linear depressions on either side. The suture lines are very prominently depressed due to the marked conocixity of the whorls.

It is relatively smaller in size (4 to 6 mm.) as compared to those found in the Pholadomorpha zone as well as those from the Tamarack Point. Also the Richmond specimens have 4 to 6 whorls as compared to 8 in Foerste's variety angustata. It is therefore suggested that Richmond specimens from the Nicolet River area should be included under a new variety.

Locality and distribution

This variety nicolettinensis is found in the Richmond group along the Nicolet River (main branch and the south west branch).

Clathrospira subconica (Hall)

Clathrospira subconica Foerste, Geol. Surv. Can. Mem. 138, 1924,
p. 210, pl. 34, fig. 12; pl. 36,
fig. 4a, b.

This species has a long vertical range. The specimens in our collection were found in the Pholadomorpha zone along the main branch of the Nicolet River. Later research revealed that this species extends from the Trenton to Richmond.

Liospira cf. micula (Hall)

Liospira micula Foerste, Geol. Surv. Can. Mem. 138, 1924, p. 208, pl. 34,
fig. 10 a-c, pl. 36, fig. 2a, b.

Lenticular in shape, the spire is low. A comparison shows that the specimens in our collection do not possess thin transverse striae which are found in the type specimens of Hall. Hence the specimens have been tentatively put under L. micula. If more specimens without these striae are found it would then be justifiable to either establishing a new species.

Locality and distribution

The specimens were collected from the Leptaena zone along the St. Francis River and the main branch of the Nicolet River. Foerste (1924) has reported the occurrence of specimens with transverse striae from the Richmond group in Wisconsin Illinois, Minnesota and Iowa, also in the Eden formation Ohio and Indiana.

Cyrtolites ornatus Conrad

Cyrtolites ornatus Ulrich and Schofield, Geol. Minn. 3, pt. 11, 1897,
p. 860, pl. 62, figs. 27-29.

Cyrtolites ornatus Foerste, Geol. Surv. Can. Mem. 138, 1924, p. 203,
pl. 34, fig. 3.

This species is distinctly carinated and has a prominent keel. It was found in the Pholadomorpha zone along the Nicolet River (main branch). Foerste's reports the occurrence of the species from Waynesville member in the above mentioned locality as well as from the Pholadomorpha zone at St. Hilaire and the Cryptolithus zone at St. Hughes.

Lophospira lata carinata Foerste

Lophospira lata carinata Foerste, Geol. Surv. Can. Mem. 138, 1924,
p. 212, pl. 37, fig. 4 a-c.

This species was previously found in the Richmond rocks (Kagawong formation) on the manitoulin islands. In the lowlands it was found in the small abandoned quarry along the Gently ridge, 5 miles west of Gently in the Becancour map-area.

BRACHIOPODS

Pseudo lingula cf. rectilateralis (Emmons)

- Lingula rectilateralis Emmons, Geol. New York, Rept. 2nd Dist. 1842,
p. 339, fig. 6.
- Lingula rectilateralis Parks and Dyer, Ont. Dept. Mines, Ann Rept. vol. XXX,
1921, p. 27, pl. VII, fig. 3.

This species of Lingula usually forms large specimens in the Lorraine of Ontario. The Quebec specimens however are in general smaller. The length and breadth of our largest sample 15 mm. and 8 mm. However broadly oval, shaped valves with almost parallel sides are similar to Emmons specimens.

Locality and distribution

Specimens were previously found in the Lorraine of New York, Ontario and they were obtained in Quebec from the Proetus zones along St. Francis River, and the S. W. branch of the Nicolet River.

Leptaena rhomboidalis (Wilckens)

- Conchita rhomboidalis Wilckens, Nachricht Von Selten Versteinerungen,
1769, p. 77, pt. 8, figs. 43, 44.
- Leptaena rhomboidalis Hall and Clarke, Pal. New York 8, pt. 1892, p. 279,
pl. 8, figs, 17-31, pl. 15a, figs.
40-42, pl. 20, figs. 21-24.
- Leptaena rhomboidalis Parks and Dyer, Ont. Dept. Mines, Ann. Rept. vol. XXX,
1921, p. 33, pl. VII, fig. 12.

The radiating striae in this species are very prominent, 13 to 15 undulations, and when the striae cut these striae they frequently bifurcate. Secondary finer striae are also seen in some samples.

Locality and distribution

Found in the Leptaena zone along the St. Francis River, Nicolet River St. Sophie de Levrard, and in the Leptaena Cryptolithus zone in all the rivers.

Also reported from Lorraine of Ontario (Don Brickyard).

Leptaena moniquensis Foerste

Leptaena moniquensis Foerste, Geol. Surv. Can. Mem. 138, 1921, p. 116,
pl. XIV, figs. 2, 2a, b, c.

This species is found associated with Leptaena rhomboidalis and apparently more preponderant in the beds above the Cryptolithus - Leptaena zone.

It is distinguished from rhomboidalis by (1) a geniculate colge. The angle of slope being 130, and the height below the geniculated edge 6 to 8 mm. (2) The concentric stria or undulations meet the linge line almost at right angles.

Locality and distribution

Found in the Leptaena and Cryptolithus Leptaena zones along the four rivers.

Zygospira kentuckiensis James

Zygospira kentuckiensis Foerste, Geol. Surv. Can. Mem. 1924, p. 127,
pl. X, fig. 20 a-c, pl. XV, figs.
1a, b, 2a, b, 4 a-c.

Zygospira kentuckiensis Husain, I.O.L. Rept. on Black River and Trenton,
1956, p. 40.

The species ranges from 10 to 15 mm. in length. The striae are smaller but stronger than those found in Z. meafordensis.

Locality and distribution

The species is common in Waynesville member of Richmond group along the St. Francis Nicolet River and in the monastary ridge near St. Angele de Laval.

Zygospira meafordensis Foerste

Zygospira meafordensis Foerste, Mem. Geol. Surv. Can. 138, 1924,
p. 129, pl. XV, fig. 3 a-c.

It resembles Z. kentuckiensis but is distinguished by its larger number of radiating plications (26 to 28) on each valve. Shells 13 mm. long, 13 mm. wide and are smaller in size than Z. kentuckiensis.

Locality and distribution

The species in the Leptaena and Proetus zones of the St. Francis River. Also found in the Pholadomorpha zones along the same river.

Rhynchotrema tamarackensis Foerste

Rhynchotrema tamarackensis Foerste, Geol. Surv. Can. Mem. 138, 1924, p. 126, pl. XV, fig. 7a, b.

Specimens 4 to 7 mm. long and the width almost equal to the length. There is a median plication with four successively smaller ones on either side.

Locality and distribution

This species was found in the Leptaena zone along both branches of the Nicolet River, St. Francis River and from St. Sophie de Levrard. Also found in wells, South Shore No. 1 and 2 at 1365', and Gentilly River.

Strophomena cf. planumbona var. chambliensis Foerste

Strophomena planumbona var. chambliensis Foerste, Geol. Surv. Can. Mem. 138, 1924, p. 118, pl. XXX, figs. 4, 5.

This variety is characterized by the convexity of the anterior part of the shell, and the shell tends to be subtriangular in shape. In contrast to Strophomena planumbona the chambliensis is larger in size, and possesses the subtriangular shape.

Locality

The variety is found in the Proetus zone along the main branch of the Nicolet River and the St. Francis River.

Strophomena planumbona (Hall)

Strophomena planumbona Foerste, Geol. Surv. Can. Mem. 138, 1924, p. 117,
pl. XII, fig. 1 a-c.

The specimens are usually 8 to 10 mm. long and 8 mm. wide with a subquadrangular outline, anterior region broadly rounded. Specimens with muscular impressions and crura impressions are often found.

Locality and distribution

The species occurs in the upper part of the Pholadomorpha zone and continues into Richmond. It was also obtained from the Pholadomorpha zone along both the branches of the Nicolet River, and from Richmond group from all the four rivers studied as well as from the quarry in the Gentilly ridge. Also found in the monastary ridge in St. Angele de Laval area.

Platystrophia clarksvillensis Foerste

Platystrophia clarksvillensis Foerste, Geol. Surv. Can. Mem. 138, 1924,
p. 112, pl. X, fig. 12, pl. XL, fig. b.

Specimen fairly large, about 28 mm. long. Specimens with nearly rectangular posters - lateral margins.

Locality and distribution

The best sample was found in the scree from the St. Francis River below outcrops of the Pholadomorpha zone. Also found in the Richmond of the old quarry near Gentilly ridge and main branch of the Nicolet River.

Catazyga headi var. borealis (Billings)

Catazyga headi borealis Foerste, Geol. Surv. Can. Mem. 138, 1924,
p. 129, pl. X, fig. 19.

The variety is more elongated and a smaller beak than the type species. Surface is marked by numerous thin radial striae, about ten in a distance of 4 mm.

Foerste (1924, p. 129) argues that his specimens do not show any distinctive characters to warrant a new variety. The present writer feels that the large number of these oblong Catazyga headi which he found in the field, should be treated separately and included in the variety borealis.

Locality and distribution

The species is common in all the areas and ranges from Leptaena zone to Waynesville member of Richmond group. Saltations of this species are in Proetus zone.

Lingula hyacinthensis Foerste

Lingula hyacinthensis Foerste, Geol. Surv. Can. Mem. 138, 1924, p. 107, p. XI, fig. 4a, b.

Shell less elongate than L. cobourgensis concentric striae very fine. Length of sample 15 mm.

Locality and distribution

The species was first recorded by Foerste from the Cryptolithus zone. Subsequently Clark found the sample from Cryptolithus zone along the Nicolet River (main branch) and the Becancour River. The present writer discovered one sample in the cores from Mr. Von Somnitz well near St. Gregoire at 1500' depth. Also found in the Cryptolithus zone of St. Francis River section.

Lingula sp.

The valves 17 mm. long, 10 mm. wide at the middle. Shell elongate, with sides subparallel. The samples were found pressed between the shale laminae and it is not possible to say whether the convex or flat. Only fine concentric striae were found on the specimens.

The species is found in the Leclerville shales along the St. Francis River and both branches of the Nicolet River. Also found in the lowest part of Breault in the road cut on the South bank. Along the road leading down the cliff into the Becancour River opposite to Breault.

Pholidops cf. cincinnatiensis Hall

Pholidops cincinnatiensis Hall, 24th Rept. New York State, Cab. Nat. Hist.
1872, pl. 7, fig. 10.

Pholidops cincinnatiensis Parks and Dyer, Ont. Dept. Mines, Ann. Rept.
vol. XXX, 1921, p. 31, pl. VII, fig. 6.

Shells small, ovate, about 5.7 mm. long and 4.6 mm. wide, with six to seven sub-imbricating marks of growth. Smaller valve unknown. It is distinguished from P. subtruncata by its larger size. (4 mm. in subtruncata). Also P. subtruncata has apparently truncated posterior edge.

Locality

This species is confined to the Proetus zone along the St. Francis River.

Also found in Don Brickyard near Toronto.

PELECYPODSByssonychia grandis Ulrich

Byssonychia grandis Ulrich, Geol. Surv. Ohio 7, 1893, p. 631, pl. 46,
figs. 6-9.

Byssonychia grandis Foerste, Geol. Surv. Can. Mem. 138, 1924, p. 166, pl.
28, fig. 5, pl. 27, fig. 4.

Specimens strongly convex. The umbonal ridge is not very angular; it is fairly smoothly sloping and the number of plications are 41.

Locality and distribution

The species is found commonly in the Richmond group along the St. Francis River.

Byssonychia richmondensis Ulrich
pl. 1, fig. 1.

Byssonychia richmondensis Ulrich, Geol. Surv. Ohio 7, 1893, p. 632,
pl. 45, figs. 3, 4.

Byssonychia richmondensis Foerste, Geol. Surv. Can. Mem. 138, 1924, p. 167,
pl. 28, fig. 4a, b, pl. 27, fig. 1a, b.

The shells are long and elongated, the size of the shells are 20 to 25 mm. long with a sharp pointed beak. Posterior margin broadly convex. Number of plications fifty.

Locality and distribution

Species is very common in the Richmond of all the regions studied by the present writer; it is particularly abundant in the quarry in the Gentilly ridge.

Byssonychia vera Ulrich
pl. 3, fig. 1 (1)

Byssonychia vera Foerste, Geol. Surv. Can. Mem. 138, 1924, p. 163,
pl. 28, fig. 1a, b.

Comparatively this species is small, and narrow. Evenly convex, the shell has fifty-one radial plications crowded together.

Locality and distribution

The species was found in the Leptaena Proetus zones along the St. Francis River.

Byssonychia praecursor Ulrich

Byssonychia praecursor Foerste, Geol. Surv. Can. Mem. 138, 1924, p. 167, pl. 28, fig. 2a, b.

This species is distinguished from *B. richmondensis* in possessing a less prominent beak, and a moderately convex posterior outline. The number of plications in our specimens is 41. Length of shell is 20 mm.

Locality and distribution

Specimens of this species are found in the Richmond group in the quarry on the Gentilly ridge.

Byssonychia hyacinthensis Foerste

Byssonychia hyacinthensis Foerste, Geol. Surv. Can. Mem. 138, 1924, p. 163, pl. 43, figs. 1, 2.

Shells rather small about 15 to 25 mm. long and about 20 mm. wide produce a broad shell. Number of plications fifty. Beak prominently pointed.

Locality and distribution

Common in the upper part of the Cryptolithus zone in all the river sections. Also found in the same zone in Von. Somnitz well.

Modiolopsis mcalarii sp. nov.
pl. 1, fig. 3, (ii)

Modiolopsis manitoulinensis Foerste, Geol. Surv. Can. Mem. 138, 1924, p. 180, pl. 23, fig. 1a, b, 6a, b.

Shell elongate parallel to hinge line, the ventral margin is straight forming an angle of 13 degrees with the hinge. Umbonal ridge quite distinct, petering out posteriorly.

Concentric lines are not too prominent. The specimens resemble M. manitoulinensis but the dwarfed size of Quebec samples (only 4 mm. in length in contrast to 30 to 44 mm. in length in Clay sample) makes it possibly a new species.

The species is named after in J. D. McAlary of Imperial Oil Limited for his contribution to the geology of the St. Lawrence Lowlands.

Locality

Found abundantly in Pholadomorpha member along St. Francis River; sometimes forming entire beds. Also found in the Proetus zone along the same river.

Whitella complanata Foerste
pl. 1, fig. 2

Whitella complanata Foerste, Bull. Sci. Lab. Denison Univ. 17, 1914,
p. 300, pl. 1, fig. 2.
Ibid. Geol. Surv. Can. Mem. 138, 1924,
p. 153, pl. 29, fig. 2, pl. 21, fig. 3.

Shell oblique, moderately convex; ventral outline rounding rapidly in the posterior part; much broader in the anterior. Umbonal ridge slightly angular.

Locality and distribution

Found in the Leptaena along the St. Francis River. Also found in the Waynesville member at St. Hilaire and along the Huron River at St. Hughes.

Whitella complanata var. moniquensis Foerste

Whitella complanata var. moniquensis Foerste, Geol. Surv. Can. Mem. 138,
1924, p. 153, pl. XXI, figs. 1, 2.

This variety is distinguished from W. complanata by the greater convexity of the valves and greater length of the shell.

Locality and distribution

The specimens in our collection were obtained from the Leptaena zone from St. Francis River. It was also reported from the Pholadomorpha and Leptaena zones along the Nicolet River.

Whitella acutiumbonis Stewart

Whitella acutiumbonis Foerste, Geol. Surv. Can. Mem. 138, 1924,
p. 159, pl. 22, figs. 1a, b.

Generally small, (10 to 13 mm. along umbonal ridge) strongly convex, with an angular umbonal ridge. On the post umbonal part distinct concentric striae are present.

Locality and distribution

The species is found in the Pholadomorpha zone along St. Francis River. Foerste reported it from the Leptaena zone from Dons Brickyard.

Whitella impressata Stewart

Whitella impressata Stewart, 29th Ann. Rept. Ont. Dept. Mines, pt. 6,
1920, p. 19, pl. 2, figs. 2, 3, 6.

This species is characterized by a short hinge line, strong obliquity, elongate umbonal ridge, rapid rounding of posterior margin and distinct arrangement of radiating grooves. From the posterior margin the first groove occurs at 10 mm., and then successively at 13, 14, 16, and 18 mm.

Locality and distribution

The species occurs in the Leptaena zone along the St. Francis River.

Orthodesma postplicatum Foerste

Modiolopsis postplicata Foerste, Boll. Sci. Lab. Denison Univ. 17, 1914,
p. 284, pl. 1, fig. 4.

Orthodesma (?) postplicatum Foerste, Geol. Surv. Can. Mem. 138, 1924,
p. 191, pl. 29, fig. 4.

This species according to Foerste (1924) was described p. 192 from the Pholadomorpha zone or lower part of the Waynesville. The specimens were collected from the Richmond along the St. Francis River.

Cymatonota semistriata Ulrich
pl. 3, fig. 4.

Cymatonota semistriata Ulrich, Geol. Surv. Ohio, 7, 1893, p. 663, p. 55,
figs. 6, 7.

Cymatonota semistriata Foerste, Geol. Surv. Can. Mem. 138, 1924, p. 176,
pl. 25, fig. 3a, b.

Ventral margin curves evenly upward at the anterior end, meeting that part of the hinge line anterior to the beak at an abruptly rounded angle, about one fifth of the length of the shell forward from the beak. Anterior part of the hinge line only moderately below the level of the posterior part.

Locality and distribution

The species is found in the Pholadomorpha zone along the St. Francis River.

Cymatonota pholadis (Conrad)
pl. 1, fig. 3 (i)

Cymatonota pholadis Foerste, Geol. Surv. Can. Mem. 138, 1924, p. 175,
pl. 39, fig. 14, pl. 31, fig. 7.

The species is characterized by numerous short wrinkles along the hinge line. Ratio of height to length is about 1:5.

Locality and distribution

The species ranges from top of Proetus zone to Richmond. It was common in all the areas where the above group of rocks occurred.

Cymatonota sp.

The species resembles closely C. pholadis but the ratio of height to length is 2:9 as compared to 1:5 in C. pholadis.

Locality and distribution

Found in Richmond group along the St. Francis River.

Cymatonota sp. possibly new

Cymatonota semistriata Foerste, Geol. Surv. Can. Mem. 138, 1929, p. 176,
pl. 25, fig. 3a, b.

Only one specimen was found in the cores from Mr. Somnitz well near St. Gregoire. The specimen is about half the size of the C. semistriata but otherwise the specimen matches with the description by Foerste (1924, p. 176).

Locality

The lone specimen was found at 1090 level in Mr. Somnitz well.

Cymatonota ? lenoir Foerste
pl. 3, fig. ii

Cymatonota lenoir Foerste, Geol. Surv. Can. Mem. 138, 1924, p. 176,
p. 29, fig. 9.

Our specimens were only fragmentary and therefore any positive identification would be unwise. However the large size of the fragments puts them under C. lenoir.

Locality and distribution

The species is found in the Leptaena Cryptolithus zone along the St. Francis River.

Cymatonota recta Ulrich

Cymatonota recta Ulrich, Geol. Surv. Ohio 7, 1893, p. 663, pl. 55,
figs. 6, 7.

Cymatonota recta Foerste, Geol. Surv. Can. Mem. 138, 1924, p. 174,
pl. 25, fig. 1.

The species is characterized 3:11 ratio of the height and length. Posterior margin slightly 81 right and the anterior margin is rounded.

Locality and distribution

The species is found in the Proetus zone along the St. Francis River.

Clidophorus sp. possibly new

The length of the shell is 8 mm. and about 5 mm. wide. The clavicular ridge starts 0.5 mm. from the anterior ridge margin of the hinge line and firminates about 1 mm. from the ventral margin. The angle of the hinge line and this ridge is close to 80.

In the posterior portion the shell is marked by a slight elongate depression.

This description does not match with any known species and until such time more specimens are collected, a new name is not advised.

Locality

A single specimen was found in the Pholadomorpha zone along the St. Francis River.

Clidophorus neglectus Hall

Clidophorus neglectus Foerste, Geol. Surv. Can. Mem. 138, 1924, p. 141, pl. 17, fig. 11 a-f.

Subelliptical shells, posterior truncated very obliquely. Height about 1/2 of length. Clavicular ridge vertical.

Locality

The species was found in the Pholadomorpha zone along the St. Francis River.

Modiolopsis cf. borealis Foerste

Modiolopsis borealis Foerste, Geol. Surv. Can. Mem. 138, 1924, p. 178, pl. 24, fig. 4a-f; pl. 34, fig. 5.

Shells oblong, narrowing anteriorly, ventral margin forms an angle of 32 degrees with the cardinal one. A small depression just below the beak produces a concave surface along the ventral margin.

Locality and distribution

Foerste reported the occurrence of this species in the Pholadomorpha zone of Clay cliffs. In Quebec one lone specimen was obtained in the cores supplied from well near St. Gregoire by Mr. Von Somnitz at 1135 feet level.

Pterinea demissa (Conrad)

Pterinea demissa Foerste, Geol. Surv. Can. Mem. 138, 1924, p. 161, pl. 26, fig. 3, pl. 29, fig. 10, pl. 31, fig. 12.

The species is characterized by a small rounded anterior lobe on ear (4 to 6 mm.) and a rather elongate posterior lobe (15 mm.). Shell varies in length from 40 to 60 mm. and width 50 to 60 mm.

Locality and distribution

The species is found in the Pholadomorpha zone and the Waynesville member, in all the river sections. It is abundant in the Richmond in the old quarry on the Gentilly ridge.

Pholadomorpha pholadimorphis (Hall)

Pholadomorpha pholadimorphis Foerste, Geol. Surv. Can. Mem. 138, 1924, p. 197, pl. 30, fig. 16.

Long oblong shells, ventral margin diverging from hinge line at 13 to 15 degrees. Posterior margin truncated obliquely and anterior margin rounded. Umbonal ridge not distinct. Prominent plications seen on the surface, which are vertical below the umbonal ridge, and directed diagonally backward and upward above the umbonal ridge.

The present writer found specimens with prominent plications as well as with faint plications, and such differences may depend upon the processes of preservation. Thus the writer agrees with the observations made by Foerste (1924, p. 197) and suggests that P. divaricator should be included as a synonym of P. pholadimorphis.

Locality and distribution

The species is common in the Pholadomorpha zone of the Lorraine group and the Waynesville member of the Richmond group in all areas.

Pholadomorpha chamblensis Foerste

Pholadomorpha chamblensis Foerste, Geol. Surv. Can. Mem. 138, 1924, p. 198, pl. 29, fig. 8.

The shell resembles P. pholadimorphis but it differs in the following:

1. The ventral margin diverges at less than 10 degrees.
2. Anterior margin more rounded and broader producing a more symmetrical shell than P. pholadimorphis.
3. Umbonal ridge distinct.

Locality and distribution

The species is found in the Proetus zone along the St. Francis and Nicolet Rivers.

Otenodonta albertina Ulrich

Otenodonta albertina Foerste, Geol. Surv. Can. Mem. 138, 1924, p. 134, pl. 17, fig. 5a, b, pl. 16, fig. 7a, b, c.

Triangularly ovate; the posterior end rises above the horizontal. The posterior margin makes angle of 125 with the hinge line while the anterior margin forms an angle of 82. Posterior end small, while anterior part is broad. No ornamentation.

Locality and distribution

This species was recorded from the Waynesville member of the Richmond group in Ohio. In Quebec, it is found in the Leptaena zone along the Nicolet River, main branch and the St. Francis River. Also found in the Chambly rocks near St. Sophie de Levrard.

A broken fragment with strong resemblance to the species was found in the Von Somnitz well at 1090 feet.

One specimen was recorded from the Pholadomorpha zone along the St. Francis River. The size of this specimen was unusually small (4 mm. long, 3 mm. high). It may be a different species.

Vallatotherca sp.

The specimens are about 30 mm. long, from the apex to the ventral margin, and 15 to 20 mm. wide. The beak is pointed. Valve convex. However it differs from V. manitoulinensis (Foerste 1924, p. 123) in completely lacking the ornamentation seen in latter species.

Locality and distribution

The specimens are common in the Richmond in the Gently ridge.

Lyrodesma sp.

A single specimen was found in the cores supplied by Mr. Von Somnitz from his well near St. Gregoire. This specimen at 1135 feet level was similar in shape and size to L. poststriatum but the ornamentation was quite distinct. In the post umbonal area, the prominent lines are radial in a fashion with a tendency to be directed upward as they come in contact with the ventral margin. The rest of the shell had concentric striae near the ventral margin of the valve. The upper part does not any ornamentation.

Since only one specimen was found, it is not possible to give it a new varietal or specific name.

This species resembles in the type of ornamentation with L. major (Ulrich) from which it differs in being smaller and L. major lacks the concentric striae which the specimen from Quebec possesses.

Locality

The specimen was obtained from the core at 1135 level. It was found associated with Modiolopsis borealis, and Clidophorus praevalotus age approximately Proetus to Pholadomorpha zones.

Lyrodesma cf. poststriatum (Emmons)

Lyrodesma poststriatum Foerste, Geol. Surv. Can. Mem. 138, 1924, p. 169, pl. 25, fig. 10a, b, pl. 43, fig. 9.

Shell roughly triangularly ovate, the umbonal ridge is straight and angular for 2/3 of its length and then becomes more and more rounded

and tends to be directed anteriorly. The post-umbonal area is marked by concentric striae intersected by five radial plications. Rest of the shell defined concentric lines only.

Locality and distribution

The species was recorded from the Cryptolithus zone along the Yamaska River by Foerste (1924, p. 170). The present writer found one specimen from the Cryptolithus zone along St. Francis River.

BRYOZOA

This phylum is represented in the Upper Ordovician by a relatively few genera in comparison to the abundant Brachiopods and Pelecypods. However most of them have comparatively short stratigraphic extent and serve as good index markers. Also since the bryozoans can be identified positively even if only small fragments are found, their usefulness in chip samples from cores deserves a detailed description of the species.

The individual samples were sectioned in the field by the writer with the able assistance of Mr. R. S. Dean. It may be mentioned that the bryozoan fauna from the Upper Ordovician strata were studied and identified by Bassler for Foerste (1924). No descriptions of these species are, however, available. It was therefore necessary to describe the species in detail in the present report.

The following species were identified:

<u>Stigmatella halysa</u> Armstrong	Ph.
<u>S. stearnii</u> sp. nov.	Pr.
<u>S. ? vulgaris</u> Parks and Dyer	Lept.
<u>S. catenulata</u> var. (a) Parks and Dyer	Lept.-Crypt.
<u>Hallopora subplana</u> var. <u>deanii</u> n. var.	Lept.
<u>H. dalei</u> var. <u>subalta</u> Parks and Dyer	Lept.
<u>Bythopora striata</u> Ulrich	Lept.-Crypt. to Ph.
<u>B. delicatula</u> Nicholson	Crypt. to Lept.
<u>Chiloporella habellata</u> (Ulrich)	Lept.
<u>Diplotrypa</u> cf. <u>petropolitanus</u> (Nicholson)	Lept.
<u>D. ? westoni</u> Ulrich	R.
<u>Prasopora nicolettinensis</u> sp. n.	Lept.
<u>P. donensis</u> Parks and Dyer	Ph.
<u>Fenestella</u> sp.	Lept.
<u>Dekayia lambtonensis</u> (Parks and Dyer)	Ph.
<u>Dekayella ulrichi</u> (Ulrich)	Crypt., Lept., R.
<u>Eridotrypa moniquensis</u> sp. nov.	Lept.
<u>Eridotrypa clarki</u> sp. nov.	R.

Glauconomella sp.
pl. 3, fig. 2.

The species is found in the Leptaena zone, 100 feet below the Fenestella beds. As a result it also forms a good marker in the field.

The genus is characterized by the unusual arrangement of the branches which come off the main branch at 30 to 40 degrees alternately. Specimens in field range from 6 to 10 mm. in length and 1 to 2 mm. wide.

The unique arrangement of the branches in Quebec specimens put them under Glauconomella but no positive specific identification can be made at this point due to lack of thin sections.

Locality and distribution

It is always found about 100 feet below the top of Fenestella beds in the Leptaena zone or about 110 to 125 feet above base of the Leptaena zone. The species was found in the Leptaena zone along the Nicolet River, (both branches,) St. Francis River and along the monastary ridge near St. Angele de Laval.

Fenestella sp.

pl. 1, fig. 6; pl. 2, figs. 3, 4,
pl. 3, fig. 3.

Zoarium flabellate or funnel shaped, celluliferous on one side while the other side is marked by 3 to 4 parallel ridges which are sometimes carinate. Branches 1 mm. wide, generally straight but at times flexuous, joined at irregular intervals by dissepiments.

Zooecia are uniform in size, about 3 in 1 mm; rectangular in shape.

Locality and distribution

The species is abundant in a part of the Leptaena zone, (230 feet from the base of Leptaena zone), and has form an index fossil for the St. Lawrence Lowlands. It was first found in Leptaena zone along the Nicolet River, main branch. Subsequently it was noted in the same part of the section along the S. W. branch of the Nicolet River, St. Francis River, monastary ridge in St. Angele de Laval, and the road-cut, 3 1/2 miles north of St. Wenceslas. It was also found in South Shore #1 and #2 wells.

Stigmatella catenulata var. (a) Parks and Dyer

Stigmatella catenulata Parks and Dyer, Ont. Dept. Mines Ann. Rept. XXX, 1921, p. 12, pl. III, figs. 1-3, pl. IV, figs. 1-3.

Zoarium massive to thin incrustations, usually circular in shape ranging in diameter from 5 to 20 mm.

Transverse section

Zooecia pentagonal in shape, about 8 in 2 mm. In some specimens from the same horizon the zooecia are larger and there are only 5 in 2 mm. The zooecia are arranged in linear series. Mesopores common and are triangular in shape. Acanthopores are few in number.

Vertical section

Diaphragms common, about 10 to 12 in 1 mm. in the mesopores and about 4 in 1 mm. in the autopores. These diaphragms in the autopores are often curved upwards and downwards intersecting the adjoining diaphragms. Some of the mesopores have the beaded structure and are often blind in the sense that they never reach the surface.

Locality and distribution

The species is common in the Leptaena-Cryptolithus zone along the St. Francis and the Becancour rivers.

Stigmatella (?) vulgaris Parks and Dyer

Stigmatella (?) vulgaris Parks and Dyer, Ont. Dept. Mines, Ann. Rept. 30, pt. VII, 1921, pl. 1, figs. 13, 14, pl. VI, fig. 12.

Large fronds, 6 to 10 mm. and about 12 mm. long.

Tangential section

Zooecia imperfectly polygonal in shape. They vary in number from 1 in 1 mm. to 3 in 1 mm. The larger zooecia form imperfect maculae.

Walls integrate, the contacts between zooecial walls are seen in many of the zooecia. No acanthopores are seen.

Vertical section

Walls thick and thin at irregular intervals. Often the walls of the tubes are crenulated. No cystiphrags. Diaphragms are absent in the immature and axial region of the frond. There are 3 to 4 in 1 mm. and about 2 tube diameter apart.

Locality and distribution

Lorraine of Don Brickyard. In Quebec the species was found in the Leptaena zone along the Nicolet River.

Stigmatella stearnii, sp. nov.
pl. 7, figs. 1, 2.

Large massive fronds, 20 to 30 mm. long, and about 10 mm. wide. Surface very spinose and rough due to the presence of acanthopores.

Transverse section

Zooecia irregular in shape, about 1 mm. The zooecial apertures are inflected due to the presence of acanthopores. Mesopores common, and in contrast do not have inflected walls.

Vertical section

The walls are crenulated and thin the immature region. In the mature the walls are straight, thicker with three diaphragms in 1 mm.

This species resembles S. crenulata Ulrich and Bassler (Smithsonian Misc. Coll. XLVII 1904, p. 34) in general but differs in (a) S. crenulata has 9 zooecia in 2 mm. as compared to 6 in S. stearnii.

(b) No diaphragms are found in S. crenulata whereas there are three to four in Quebec species.

The species is named in honour of Dr. C. W. Stearn of McGill University Montreal.

Locality and distribution

The species is confined to the Proetus zone along the main branch of the Nicolet River.

Stigmatella halysa Armstrong
pl. 4, figs. 3, 4.

Stigmatella halysa Armstrong, Jour. Pal. vol. 19, No. 2, 1915, p. 153, text figures 5 and 12.

Stigmatella catenulata var. (b) Parks and Dyer, Ont. Dept. Mines, Ann. Rept. XXX, 1922, pt. VII, p. 12, pl. 3, fig. 3, pl. 4, fig. 3.

Zoarium frondescent, ranging in diameter from 10 mm to 15 mm.

Transverse section

Zooecia variable in size; the smaller ones are 10 to 11 in 2 mm. and the larger ones are 8 in the same distance. The acanthopores common, generally found in the vicinity of the zooecial junctions.

Vertical section

The zooecial tubes show thickening and thinning at irregular intervals. Very few diaphragms are found in the mature region while they are completely absent in the immature and the axial regions. The mesopores are beaded producing the characteristic chainlike mesopores.

Locality and distribution

The species is common in the Pholadomorpha zone along the Nicolet River, main branch.

Eridotrypa moniquensis, sp. nov.
pl. 4, figs. 5, 6.

Small fronds, about 8 mm. long and 1 mm. thick. The specimens are Y shaped.

Transverse section

The zooecia are sunken and are round in shape. Longitudinally measured there are 5 in 2 mm. Diameter of individual zooecium varies from 0.05 to 0.1 mm. The inter zooecial ridges are prominent in this species which near the periphery of the zooecia coalesce to form peripheral ridges. In some of the specimens there is one interzooecial ridge which lies between the interzooecial ridges mentioned above and seems to extend from one peripheral ridge to another. (See diagram below).

Vertical section

Walls uniform in thickness, thickening in the mature regions only. This thickening is also characterized by its unusual form—producing form not dissimilar to a brush. No diaphragms or cystiphragms were seen.

Locality and distribution

The species is common in the Leptaena zone along the St. Francis River. The unusual specimen with the additional interzooecial ridge was obtained from the Richmond along the Gentilly ridge and is possibly a variety.

Eridotrypa clarki, sp. nov.
pl. 4, figs. 1, 1a, 2.

Small fronds, 10 mm. long, 1 mm. wide, increasing to 2 mm. near junction points.

Tangential section

Zooecia oblong, elongated parallel to the length of the zoarium; 0.5 mm. long, and 0.2 to 0.5 mm. Interzooecial ridges are very prominent and they nearly coalesce in the interzooecial areas. The orifices of the apertures are surrounded by a circular raised peristome.

Vertical section

Tubes thick walled; the walls become thicker at irregular intervals and not at the same level are the walls of the tubes of the same thickness. The latter feature could however be due to the differential growth of the axial and the peripheral regions. The walls in the mature region are distinctly thicker than in the immature region.

No cystiphragms or diaphragms are present.

Brown bodies are present in the yellowish brown sacs.

On E. exigua Ulrich (1893, p. 266) with which it bears resemblance, it differs by large size. (E. exigua is 0.5 mm.) No mention of interzooecial ridges was mentioned. Six zooecia in 3 mm. are found in the present sp. whereas there are 8 in the same distance in E. exigua.

51

Locality and distribution

Found in the Richmond of St. Francis and the main branch of the Nicolet River.

Hallopora subplana var. deanii, n. var.
pl. 5, fig. 1, pl. 6, figs. 5, 6.

Hallopora subplana Ulrich, Cinn. Soc. Nat. Hist. Jour. 5, 1882, p. 253
pl. 11, fig. 7, 7b.

Massive fronds, over 20 mm. long and 15 mm. wide in diameter.

Transverse section

The varied sized zooecia are distributed irregularly in the zoarium but there is a distinct tendency for the smaller ones to form clusters. The larger zooecia are two in 1 mm., whereas in the same distance there are four to five small ones. There are no distinct interzooecial ridges but the peripheral ridges are strong and give the autopores a sunken appearance; the peripheral ridges are absent around the mesopores and the smaller autopores. Walls amalgamate and no acanthopores are present.

Vertical section

Diaphragms are common, about two in 1 mm. in the immature region increasing to 4 in 1/2 mm. in the mature region. The mature region is very distinct with its thick walls and the closely packed diaphragms. In the mesopores there are 8 to 10 diaphragms in 1 mm. Some of the diaphragms in the autopores are curved downwards.

Brown bodies are prominent in the mature region; rarely found in the immature section.

This variety differs from H. subplana in the following features:

1. The size of the zooecia in var. deanii is smaller than that found in H. subplana (three in 1 mm. in H. subplana).
2. No diaphragms are found in the immature regions of H. subplana whereas in the variety deanii, diaphragms are common in the mature and the immature regions.

Parks and Dyer (1921, p. 19) described their specimens from the Lorraine of Don Brickyard and their figures match with those of

the variety deanli and it is therefore suggested that the Quebec and the Ontario specimens should be incorporated under the new variety.

Locality and distribution

The species is common in the Leptaena zone in the south limb of the major anticline along the St. Francis River. It is also found in the same zone along the Nicolet River (both branches) and in the Lorraine of Don's Brickyard.

Hallopora dalei var. subalta Parks and Dyer
pl. 6, figs. 1, 2, 3.

Hallopora dalei var. subalta Parks and Dyer, Ont. Dept. Mines, Ann. Rept. XXX, pt. VII, p. 18, pl. III, fig. 2, 3; pl. IV, fig. 2, 3.

Zoaria frondescent, about 5 mm. wide and at least 10 mm. long. Surface smooth.

Transverse section

The zooecia are round to oblong, about 8 in 2 mm. with faint peripheral ridge. No interzooecial ridges. Mesopores rectangular; apt to form clusters. No acanthopores.

Vertical section

Diaphragms common both in mature and immature regions, and are straight. There are 4 diaphragms in 1 mm. in the autopores while in the mesopores there are 13 to 15 in the same distance.

Locality and distribution

Found commonly in the Leptaena zone along the St. Francis River, and the S. W. branch of the Nicolet River.

Bythopora striata Ulrich
pl. 5, figs. 2, 3, 4.

Bythopora striata Ulrich, Geol. Surv. Can. Contrib. Micro. Pal. Camb-Sil. pt. II, 1889, p. 36, no figures.

Bythopora striata Cummings, Indiana Geol. Nat. Hist. Ann. Rept. No. 32, 1907, p. 784, pl. XXVII, fig. 4.

FronDESCENT colonies, five to ten mm. long and about one mm. wide.

Transverse section

Zooecia elongated, oblong in shape; 3 to 4 in 1 mm. Faint interzooecial ridges, running parallel to the length of the zoarium are seen. No acanthopores are present.

Vertical section

Zooecial walls thick, showing irregular thickening in the axial regions; the mature regions are distinct. The tubes come out to the surface at very acute angles. Mesopores, if any present, are difficult to differentiate.

Locality and distribution

This species has long vertical range as it is found from the Cryptolithus - Leptaena zone to the top of the Pholadomorpha zone. However saltations of this species are found at the top of the Pholadomorpha zone along the small river, east of the village of Gentilly.

Bythopora delicatula Nicholson

pl. 8, figs. 1, 2.

Bythopora delicatula Nicholson, Geol. Soc. Lond. Quart. Jour. 30, 1874, p. 505, pl. 29, fig. 8b.

Bythopora delicatula Parks and Dyer, Ont. Dept. Mines, Ann. Rept. XXX, pt. VII, 1922, p. 18, pl. VI, fig. 4.

Small cylindrical fronds, ranging in length from 4 to 10 mm. and 0.75 mm. in diameter. The surface study of the zoarium shows that the zooecia are arranged parallel to the length of the zoarium and the individual zooecium is elongated in the same direction.

Transverse section

The walls are thick and no acanthopores are seen. The zooecia are elongated, about three in 2 mm., the larger diameter is 0.5 mm.

Vertical section

The tubes are uniform in thickness in the immature regions thickening slightly in the mature regions. No diaphragms or cystiphragms are seen.

Locality and distribution

The species is common in the Leptaena zone, the north limb of the anticline along the St. Francis River and also found in the same zone along the Nicolet River. Doubtful specimens found in South Shore #1 between 95 feet 145 feet and 275 feet to 395 feet. Also found in the Cryptolithus zone along the Nicolet River, southwest branch.

Dekayella cf. ulrichi (Nicholson)
pl. 8, figs. 3, 4.

- Chaetetes fletcheri Nicholson, Geol. Soc. Lond. Quart. Jour. vo. 30, 1874, p. 504, pl. 29, fig. 6, 6a.
Monticulipora (Heterotrypa) ulrichi Nicholson, Genus Monticulipora, 1881, p. 131, fig. 22.
Dekayella ulrichi Parks and Dyer, Ont. Dept. Mines, Ann. Rept. XXX, 1921, p. 9, pl. I, figs. 9, 11; pl. V, fig. 9.

Fronde about 4 to 6 mm. long and about 1 to 2 mm. wide were obtained in the chip samples from the South Shore #1 well. The total length is therefore probably much more than 6 mm.

Zooecia polygonal, mostly pentagonal in shape. Acanthopores abundant and are of two kinds; the larger ones occur at the junctions of the autopores while the smaller ones are found in the middle of the zooecial walls causing slight crenulations. In some of the zooecia the smaller acanthopores, being so faint, are practically absent.

The specimens resemble D. ulrichi in the size of the zooecia and the nature of distribution of the acanthopores. But it differs in the fact that Dekayella ulrichi from the Ordovician of Minnesota and other localities are from massive frondescent colonies, ranging in length from 20 to 30 mm. and are 10 to 15 mm. in width. The Quebec specimens possibly belong to a new variety.

Locality and distribution

The specimens were obtained from the 95 feet to 145 interval of the South Shore #1 well corresponding to approximately the Waynesville horizon of the Richmond group. Also found at 1990 foot level in South Shore #2. In the field the species was recorded from the Leptaena and Cryptolithus zones along the St. Francis and Nicolet rivers.

Prasopora cf. donensis Parks and Dyer

- Prasopora donensis Parks and Dyer, Ont. Dept. Mines, Ann. Rept. XXX, pt. VII, 1921, p. 7, pl. I, figs. 6, 7; pl. II, figs. 6, 7; pl. V, fig. 6; pl. VI, fig. 2.

Massive colonies, 20 to 25 mm. in diameter; thickness varies from 2 to 10 mm. No maculae or monticules seen on surface.

Transverse section

Zooecia round, the 3 to 4 small zooecia in 1 mm. whereas there are 2 large ones in the same distance. The larger ones cluster together to form maculae. Small acanthopores common.

Vertical section

Diaphragms abundant and are always straight; about 6 to 8 in 1 mm. in the autopores, while in the mesopores there are about 12 to 14 in the same distance. Cystiphragms are common, about 8 to 10 in 1 mm.

Locality and distribution

The species is common in the Pholadomorpha zone along the main branch of the Nicolet River.

Prasopora nicolettinensis, sp. nov.
pl. 8, figs. 5, 6.

Small massive colonies, 10 to 12 mm. in diameter and about 3 mm. in thickness. No monticules were seen on the surface.

Transverse section

The zooecia are round to oblong in shape, uniform in size; about 7 to 8 in 2 mm. Few round mesopores are present. No maculae or acanthopores are seen.

Vertical section

The mesopores contain 12 to 14 diaphragms in 1 mm. and produce a beaded structure. Some of the mesopores terminate at short distance from the surface of the zoarium and are termed 'blind' mesopores. Such blind mesopores are approximately at the same level in the zoarium.

In the autopores cystiphragms are common. Diaphragms range from 4 to 6 in 1 mm. in the immature region, increasing to 8 to 10 in 1 mm. in the mature region. Generally straight, these diaphragms sometimes are curved and grade into the cystiphragms. The mesopores also possess an unusual feature in that they end in a narrow point at the base.

This species of Prasopora is unique in possessing the curved and straight diaphragms and the beaded mesopores. Its complete of resemblance to the known species of Prasopora led the writer to establish a new species.

The species is named after the locality where the first specimens were found.

Locality and distribution

The species is found in the Leptaena zone along the St. Francis River and both branches of the Nicolet River. It was also found in the South Shore #1 at 1370 foot level.

Dekayia lambtonensis Parks and Dyer
pl. 6, fig. 4, fig. 7, figs. 5, 6.

Stigmatella lambtonensis Parks and Dyer, Ont. Dept. Mines, Ann. Rept. XXX,
pt. VII, 1921, p. 14, pl. II, fig. 13.

Dekayia lambtonensis Armstrong, Jour. of Paleont. vol. 19, No. 2, 1945,
p. 153, (not figured).

Large hemispheric colonies 20 mm. diameter; 2 to 5 mm. thick.

Transverse section

Polygonal zooecia; some of them are perfect hexagons. Walls amalgamate mesopores; usually square or rectangular in shape. Acanthopores common at the junctions of zooecia though not very prominent as in some other types of Dekayia.

Vertical section

No cystiphragms. The diaphragms in the autopores are irregular in number varying from 1 to 1 1/2 tube diameter apart. In the mesopores the diaphragms are abundant, 2 to 4 in one tube diameter. Comparatively in the same distance of 1 mm. there are 2 and 6 diaphragms in autopores and mesopores respectively. The mesopores are beaded and often pinch out without reaching either the bottom or top surface of the colony.

This species was previously recorded by Parks and Dyer from the Lambton shale pit. (5 foot level). It may be mentioned that on the basis of a single specimen a new species was enacted. Quebec specimens, however, have a massive growth, in contrast to the frondescent type found in Ontario.

Locality and distribution

Found in the Pholadomorpha zone along the Nicolet River (S. W. branch), and the St. Francis River.

Diplotrypa cf. petropolitana (Nicholson)

Monticulipora (Diplotrypa) petropolitana Nicholson, Pal. Tab. Corals, 1879, p. 313, pl. 13, figs. 3-3c.

Diplotrypa petropolitana Bassler, U.S. Nat. Mus. Bull. 77, 1911, p. 313, Text figs. 192-195.

Bassler's description

Zooecium massive, often hemispheric to 15 cm. wide. Maculae inconspicuous. Zooecia 0.5 mm. in diameter, three in 2 mm. mesopores variable in shape.

In mesopores tubes, diaphragms are one tube diameter apart as also in autepores. In mature regions there are 3 diaphragms in 1 tube diameter. As compared to one in 1 tube diameter in the immature regions.

The Quebec specimens, while agreeing to the description given above, have one characteristic difference. All specimens are about 6 to 10 mm. in diameter and about 1 mm. in thickness giving an incrusting appearance. Epitheca is not wrinkled.

Locality and distribution

Found in the Leptaena zone along the St. Francis River, and the both branches of the Nicolet River.

Chiloporella flabellata (Ulrich)
pl. 7, figs. 3, 4.

Fistulipora flabellata Ulrich, Conn. Soc. Nat. Hist. Jour. 2, 1879, p. 28, pl. 7, figs. 26, 26a, 26b.

Chiloporella flabellata Cummings, 32nd Ann. Rept. Dept. Geol. Nat. Res. Ind. 1907, p. 802, pl. 11, figs. 1, 1a; pl. 12, figs. Parks and Dyer, p. 2, pl. 1, figs. 1, 2; pl. 11, figs. 1, 2, pl. IV, 1b, pl. VI, fig. 11, fig. 12.

Zoarium fan-shaped, bifoliate expansions, 2 to 4 mm. thick. Zoecial apertures disposed in bent and rather irregular rows.

Surface undulatory 3 zooecia in 1 mm. Mesopores common.

Vertical section

Wide open tubes and broad interspaces with mesopores in peripheral regions only, absent in immature regions. Mesotheca very irregular, discontinuous fluctuating laminae.

Species found in association with Peropora vera in Don's Brickyard.

Locality and distribution

Found in the Leptaena zones along the St. Francis River and Nicolet River main branch.

TABLE SHOWING DISTRIBUTION OF SPECIES

INDEX OF SYMBOLS

<p>R= Richmond Ph= <u>Pholadomorpha</u> zone Pr= <u>Proetus</u> zone L= <u>Leptaena</u> zone LC= <u>Leptaena Cryptolithus</u> zone C= <u>Cryptolithus</u> zone Le= <u>Leclerville</u> U= <u>Utica</u> T= <u>Trenton</u> * Reported by Clark but not seen by the present writer.</p>	<p>1. Nicolet River, main branch 2. Nicolet River, S.W. branch 3. St. Francis River 4. Becancour River 5. Quarry in Gentilly ridge 6. River east of Gentilly 7. St. Sophie de Lervard 8. Monastary ridge near St. Angele de Laval</p>
---	---

		1	2	3	4	5	6	7	8
<u>Arthraria minor</u>	R			x					
<u>Dymocrius aff. geniculatus</u>	Pr			x					
<u>Cryptolithus bellulus</u>	C, LC	x	x	x	x				
<u>Isotelus gigas</u>	R			x					
<u>Proetus chamblensis</u>	Pr, Ph	x	x	x	x				
<u>Calymene granulosa</u>	L		x						
<u>Triarthrus becki</u>	U, Le	x		x					
<u>T. hughesensis</u>	Le	x	x	x					
<u>Spyroceras parki</u>	R			x					x
<u>Streptelasma rusticum</u>	R	x	x	x					
<u>Columnaria alveolata</u>	R		x	x					
<u>Zitteloceras hitzi</u>	R, L			x		x			
<u>Sactoceras westonense</u>	U-R	x	x	x	x	x	x	x	
<u>S. manitoulinense</u>	R		x	x					
<u>? Kindloceras triangulare</u>	R					x			
* <u>Manitouliceras cf. lysander</u>	R	x	x						

		1	2	3	4	5	6	7	8
<u>Ceraurus</u> sp.	Ph			x					
<u>Hormotoma gracilis angustata</u>	Ph	x		x					
<u>H. gracilis</u> var. <u>nicolettinensis</u>	R	x	x						
<u>Clathrospira subconica</u>	T-R	x							
<u>Liospira</u> cf. <u>micula</u>	C			x					
<u>Cyrtolites ornatus</u>	T, Ph-R	x							
<u>Lophospira lata carinata</u>	R					x			
<u>Pseudulingula</u> cf. <u>rectilateralis</u>	Pr		x	x					
<u>Lingula</u> sp.	Le	x	x	x			x	x	
<u>Leptaena rhomboidalis</u>	LC, L	x	x	x	x				
<u>L. moniquensis</u>	LC, L	x	x	x	x			x	
<u>Zygospira kentuckiensis</u>	R	x	x	x		x			x
<u>Z. modesta</u>	T-R	x	x	x					
<u>Z. recurvirostris</u>	T-R	x	x	x	x	x	x	x	
<u>Z. meafordensis</u>	L-Ph			x					
<u>Rhynchotrema tamarackensis</u>	L	x	x	x			x		
<u>R. capax</u>	T, L-R	x	x						
<u>R. perlamellosum</u>	T-R	x	x						
<u>Strophomena planumbona</u>	R, Ph	x	x	x	x	x			
<u>S. planumbona</u> var. <u>chambliensis</u>	L	x		x					
<u>Holtedahlina sulcata</u>	T-R	x	x	x	x				
<u>Platystrophia clarksvillensis</u>	R	x		x		x			
<u>Hebertella</u> aff. <u>occidentalis</u>	LC, L	x	x	x	x	x	x	x	
<u>Catazyga headi</u>	L-Ph	x	x	x	x	x	x	x	x

		1	2	3	4	5	6	7	8
<u>C. headi</u> var. <u>borealis</u>	L-R	x	x	x	x		x	x	
<u>C. erratica</u>	C-R	x	x	x	x			x	
<u>Lingula hyacinthensis</u>	C	x			x				
<u>Pholideps cincinnatiensis</u>	Ph	x		x	x				
<u>P. subtruncata</u>	C-R	x	x	x					
<u>Sowerbyella sericea</u>	T-R	x	x	x		x	x		x
<u>Dalmanella rogata</u>	T-R	x	x	x					
<u>Leptobolus insignis</u>	U, Le	x							
<u>Rafinesquina alternata</u>	T, Pr-R	x	x	x		x			x
<u>Whitella impressata</u>	L			x					
<u>W. complanata</u> var. <u>moniquensis</u>	L	x	x	x					
<u>W. sp.</u>	L	x							
<u>W. complanata</u>	L-Pr			x					
<u>W. acutiumbonis</u>	R			x					
<u>Orthodesma sp.</u>	Ph-R			x					
<u>O. postplicatum</u>	R			x					
<u>Cymatonota ? lenoir</u>	L			x					
<u>C. sp.</u>	Ph.			x					
<u>C. pholadis</u>	Ph-R	x	x	x	x	x	x		
<u>C. recta</u>	R			x					
<u>Cymatonota sp.</u>	? C	Von Somnitz Well 1600'							
<u>Cymatonota semistriata</u>	Ph-R			x					
<u>Byssonychia subrecta</u>	Pr			x					
<u>B. radiata</u>	LC-R	x	x	x	x				
<u>B. grandis</u>	R			x					
<u>B. richmondensis</u>	R	x	x	x	x	x			

		1	2	3	4	5	6	7	8
<u>B. vera</u>	R			x		x			
<u>B. hyacinthensis</u>		x	x	x	x				
<u>B. praecursor</u>	L-Pr				x				
<u>Clidophorus neglectus</u>	R			x					
<u>C. praevulotus</u>	L, Pr, R	x	x	x	x				
<u>C. sp. possibly new</u>	Ph			x					
<u>Cuneanya sp.</u>	Ph								
<u>Modiodesma modiolare</u>	L	x							
<u>Cyrtodonta sp.</u>	R	x							
<u>Pholadomorpha chamblensis</u>	Ph	x	x	x					
<u>P. pholadimorphis</u>	Ph-R	x	x	x	x		x		
<u>Pterina demissa</u>	R	x	x	x	x	x			
<u>Ctenodonta sp.</u>	? C	Von Somnitz Well						1900'	
<u>Ctenodonta albertina</u>	Ph	x	x	x				x	
<u>Ctenodonta sp.</u>	R			x					
<u>Lyrodesma postriatum</u>	C			x					
<u>L. sp.</u>	C	Von Somnitz Well						1135'	
<u>Modiolopsis sp. aff. borealis</u>	C, Ph, R								
<u>Vallatotheca sp.</u>	R					x			
<u>Modiolopsis mcalarii</u>	Pr	x		x					
<u>Eridotrypa moniquensis</u>	L			x			x		
<u>E. clarki</u>	R	x		x					
<u>Chiloporella flabellata</u>	L	x		x					
<u>Hallopora dalei subalta</u>	L	x	x	x					
<u>H. subplana deanii</u>	L	x		x					
<u>Bythopora delicatula</u>	C-L	x		x					

		1	2	3	4	5	6	7	8
<u>B. striata</u>	LC-Ph						x		
<u>Stigmatella halysa</u>	Ph	x							
<u>S. catenulata</u> var. (a)	L-C			x	x				
<u>S. stearnii</u>	Pr	x							
<u>S. ? vulgaris</u>	L	x							
<u>Dekayia lambtonensis</u>	Ph	x		x					
<u>Dekayella ulrichi</u>	C, L, R	x		x					
<u>Prasopora nicolettinensis</u>	L	x		x					
<u>Diplotrypa ? westoni</u>	R					x			
<u>P. donensis</u>	R	x							
<u>D. petropolitanus</u>	L	x	x	x					
<u>Fenestella</u> sp.	L	x	x	x	x				x
<u>Glauconomella</u> sp.	L	x	x	x					
<u>Constellaria polystomella</u>	R	x							
<u>Rhombotrypa quadrata</u>	R	x							

CONCLUSIONS

LORRAINE GROUP

Leclerville Shales

The shales and the associated sandstones and siltstones are fairly devoid of fossils. However, close to the Leclerville-Breault boundary, Lingula sp., Triarthrus hughuesensis, and T. becki are found. The presence of the first two establishes the age of the shales.

Cryptolithus zone

This zone as the name suggests is characterized by the presence of Cryptolithus bellulus and allied species. It may be noted here that in the lowest part of the Breault the beds contain very few Cryptolithus specimens. Lithologically, while the Breault and the Leclerville may be alike in general, a number of thin beds of brown weathering, medium-grained, tight limestones with abundant small fronds of Dekayella ulrichi and Bythopora delicatula are confined to the Breault. The following species are confined to the Breault formation.

Lingula hyacinthensis
Byssonychia hyacinthensis
Ctenodonta sp.
Lyrodesma cf. poststriatum

Leptaena Cryptolithus zone

This zone is characterized by the presence of Cryptolithus bellulus, Leptaena moniquensis, and L. rhomboidalis occurring together. This zone is distinct in the field. The thickness varies from 180 feet to 300 feet. Besides the above mentioned fossils, one bryozoan species, Stigmatella catenulata var. (a), is found in profusion.

Leptaena zone

This zone contains a large number of species which have a short vertical range. Most of the bryozoans species found in this region are confined to this zone, two of which (Fenestella and Glauconomella) are identifiable in the hand specimens easily.

The following species are confined to the Leptaena zone.

- Stigmatella vulgaris
 * Hallopora subplana var. deanii, n. var.
 * H. dalei var. subalta
Chiloporella flabellata
 + Diplotrypa petropolitana
 + Prasopora nicolettinensis, sp. nov.
Eridotrypa moniquensis
 + Fenestella sp.
 + Glauconomella sp.
- * Species found in the upper half of the Leptaena zone, assuming the Fenestella subzone as the dividing line.
- + Species found in the lower half of Leptaena zone.

Besides the bryozoans mentioned above, other species which are confined to Leptaena zone are as follows:

Calymene granulosa
Rhynchotrema tamarackensis
Strophomena planumbona var. chambliensis
Whitella complanata
Cymatnota ? lenoir
Cuneanya sp.

Proetus zone

The trilobite, Proetus chambliensis, as mentioned earlier in the report, cannot be regarded as an index fossil for detail subdivision of the Lorraine group. However within the limits of Foerste's Proetus zone, other fossils were found which can be used in separating this zone from the Pholadomorpha zone above and the underlying the Leptaena zone. These species are:

Ceraurus sp.
Hormotoma gracilis angustata
Lingula cf. rectilateralis
Pholidops cincinnatiensis
Byssonychia subrecta
Stigmatella stearni, sp. nov.
Modiolopsis mcalarii, sp. nov.
Dymocrinus cf. geniculatus

Pholadomorpha zone

The first appearance of either Pholadomorpha pholadimorphis or P. divaricator establishes the base of this zone. Foerste (1921) included this zone in the Lorraine group and till date its position has not been changed. It is actually a transitional zone possessing type Lorraine species extending from Leptaena Proetus below and Richmond species associated together. The following species are common to Leptaena-Proetus zones and the Pholadomorpha zones.

Proetus chambliensis
Zygospira modesta
Catazyga headi
Bythopora striata

This list does not include species such as Rafinesquina alternata, Holtedahlina sulcata which extend beyond the Pholadomorpha zone into the Richmond.

The following species are common to the Pholadomorpha zone and Richmond group.

Cymatonota pholadis
C. semistriata
Modiolopsis sp. aff. modiolare
Pholadomorpha pholadimorphis
Strophomena planumbona
Cyrtolites ornatus
 * Z. recurvirostris
 * Rhynchotrema perlamellosum
 * Holtedahlina sulcata
 * Sowerbyella sericea
 * Dalmanella rogata
Streptelasma rusticum according to Clark.
 (Q.D.M. unpublished report
 on Yamaska map-area).

* Trenton recurrent fauna.

The writer feels that the advent of younger Richmondian species within the Pholadomorpha zone should be considered more diagnostic in establishing the age of the zone than depending upon Lorraine stragglers from Leptaena-Proetus zones.

Clark (Quebec Dept. Mines unpublished reports on Yamaska, Aston, Becancour map-areas) repeatedly mentioned that Pholadomorpha zone should be incorporated within the Richmond. From this study, the present writer corroborates Dr. Clark's views. However all previous maps and interpretations by the writer were made before this paleontological study was completed. Hence even though they have included under "Lorraine group" in the legends, Pholadomorpha zone should be considered as part of the Richmond.

RICHMOND GROUP

Waynesville member

The lowest beds in the Richmond group have been correlated with the Waynesville member of the standard section of upper Ordovician. (Foerste, 1924). These beds are characterized by Zygospira kentuckiensis. Although no name has been given to that part of Richmond section which is above Zygospira kentuckiensis, it possesses a slightly different fauna than the Waynesville one. Species such as Streptelasma rusticum, Columnaria alveolata, Constellaria polystomella are generally found in the upper part of Richmond. A similar study was made along the St. Francis River by Clark (Q.D.M. unpublished report on Yamaska map-area, 1944, p. 17), where he had included the Pholadomorpha zone within the Richmond and then divided the total Richmond section into two members.

Species confined to Richmond group are:

- * Rafinesquina alternata
- * R. praecursor
Arthraria minor, n. sp.
- * Isotelus gigas
Spyroceras parksi
Streptelasma rusticum
- * Columnaria alveolata
Zitteloceras hitzi
Sactoceras manitoulinense
Kindleoceras triangulare
Manitouliceras cf. lysander
Lophospira lata carinata
Hornotoma gracilis nicolettinensis
Zygospira kentuckiensis
- * Strophomena planumbona
Platystrophia clarksvillensis
Whitella acutiumbona
Orthodesma postplicatum
Cymatonota recta
Byssonychia grandis
B. richmondensis
B. praecursor
Clidophorus neglectus
Nodiodesma mediolare
M. sp.
Pterina demissa
Ctenodonta sp.
Vallatotheca sp.
Constellaria sp.

Rhombopora quadrata
Diplotrypa ? westoni
Eridotrypa clarki sp. nov.

* Part of Black River—Trenton fauna occurring in the Richmond.

In concluding it may be mentioned here that while some individual species may be unimportant as index fossils, saltations of the same should not be overlooked. Sowerbyella sericea, Dalmanella rogata, Catazyga headi, C. erratica, Hebertella occidentalis — all form saltations in various part of the upper Ordovician section. The positions of these saltations are as follows:

<u>Dalmanella rogata</u>	<u>Pholadomorpha zone</u>
<u>Sowerbyella sericea</u>	<u>Pholadomorpha zone</u>
<u>Catazyga headi</u>	<u>Proetus zone</u>
<u>C. erratica</u>	<u>Leptaena Cryptolithus zone</u>
<u>Hebertella occidentalis</u>	<u>Cryptolithus zone</u>

A general study of the porosity shows that the Upper Ordovician rocks are tight. In the field, no intergranular or vugular porosity was seen. Individual sandstone beds may possess slight intergranular porosity, but such an occurrence cannot be predicted, since these porous beds may occur in any part of the section. However the Upper Ordovician should form good cap rock for the underlying Trenton reservoir rock.

BIBLIOGRAPHY

Clark, T. H. Unpublished reports on Yamaska, Aston, Becancour, Upton, Verchères, St. Hyacinthe map-areas; Quebec Department of Mines.

Foerste, A. F. The Upper Ordovician formations of Ontario and Quebec, Geol. Surv. Can. Mem. 83, 1916.

Upper Ordovician Faunas of Ontario and Quebec; Geol. Surv. Can. Mem. 138, 1924.

Parks, W. A. and Dyer, E. A. Stratigraphy and Palaeontology of Toronto and Vicinity; 29th Ann. Rept. of the Ontario Dept. of Mines, vol. XXX, pt. VII, 1921.

Stewart, B. H. Stratigraphy and Palaeontology of Toronto and Vicinity; 29th Ann. Rept. of the Ontario Dept. of Mines, vol. XXX, pt. VI, 1920.

Ulrich, E. O. On lower Silurian Bryozoa of Minnesota, Geol. Surv. Minn., 3, 1893.

Plate 1.

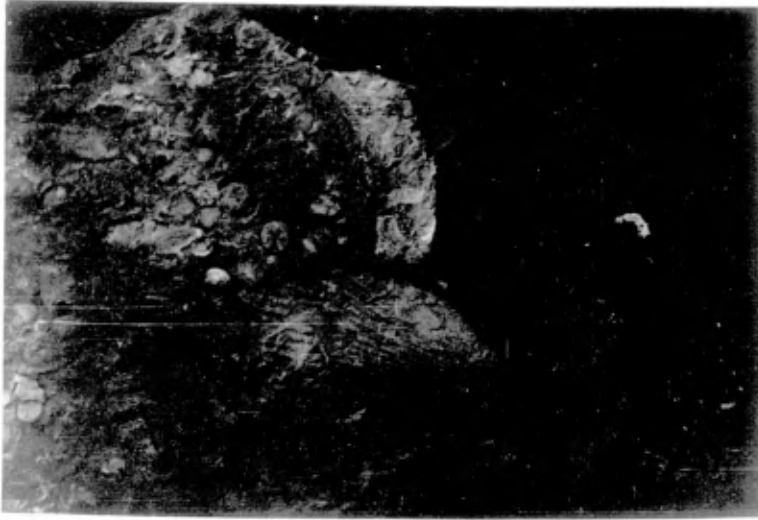


Fig. 1.



Fig. 2.



Fig. 3.

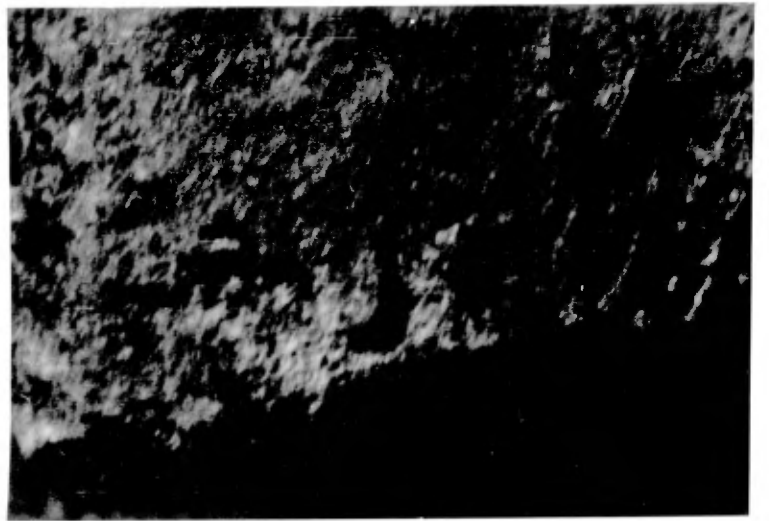


Fig. 4.

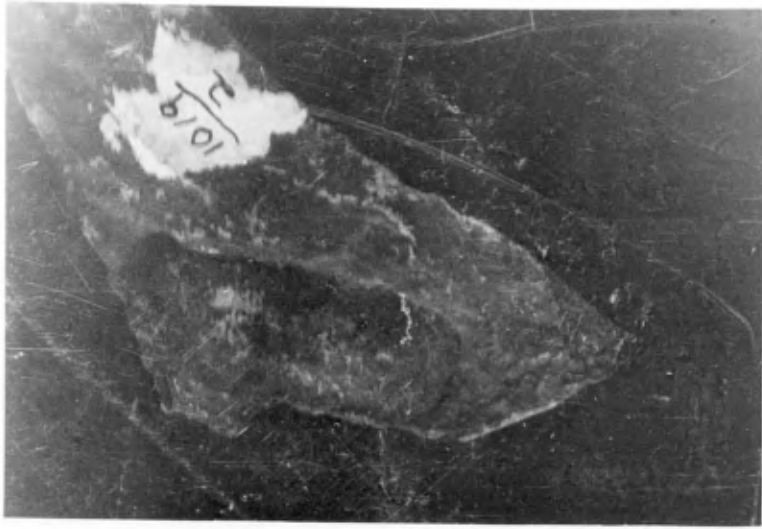


Fig. 1.



Fig. 2

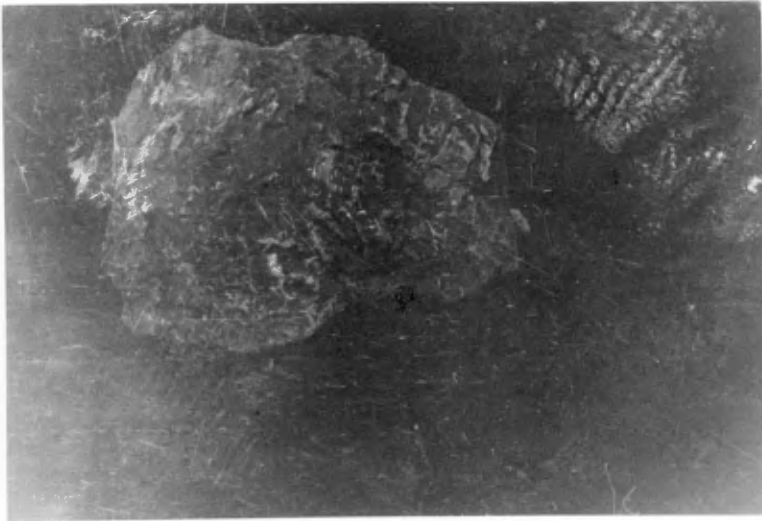


Fig. 3.



Fig. 4.

Plate 3.

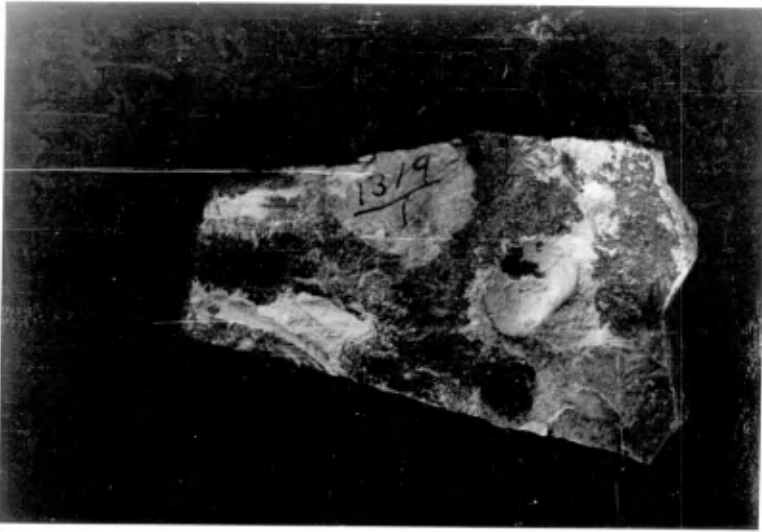


Fig. 1.

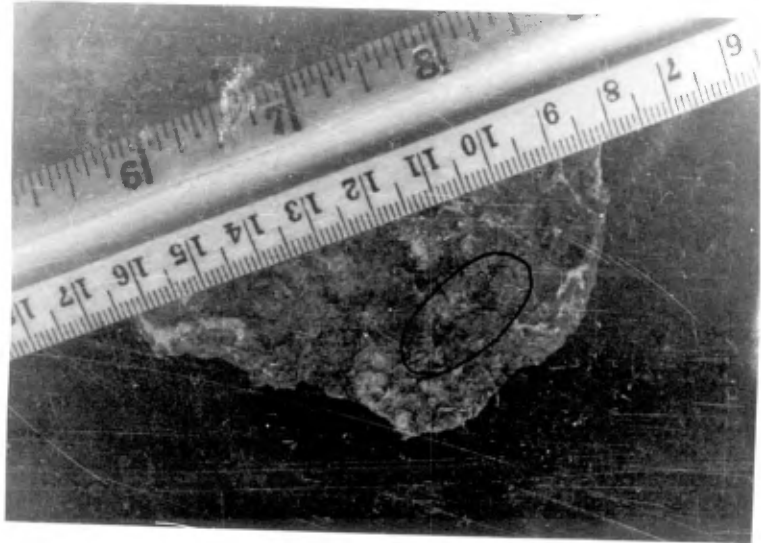


Fig. 2



Fig. 3.

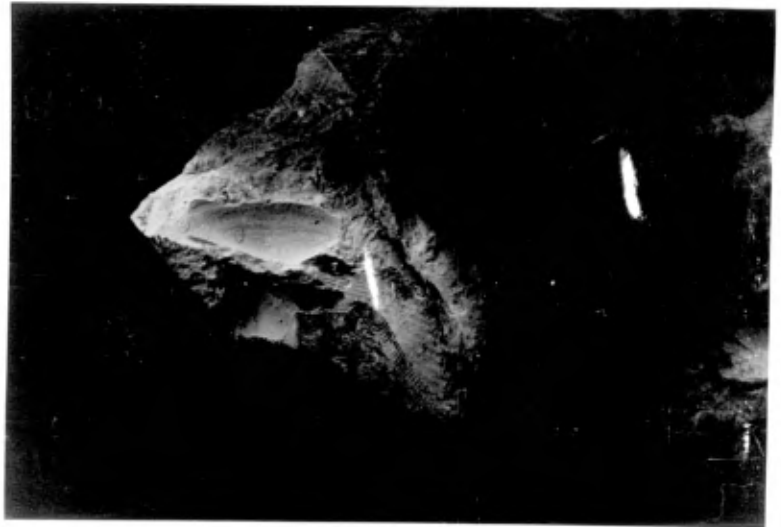


Fig. 4.

Plate 4.

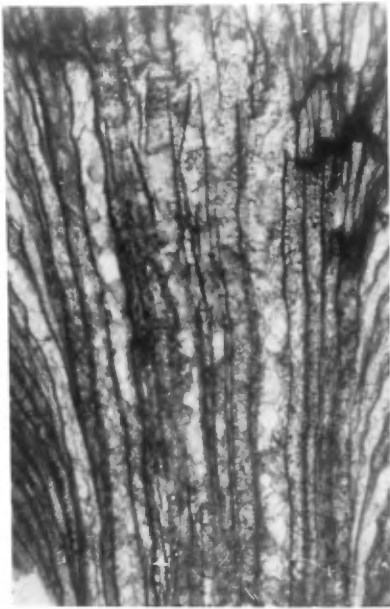


Fig. 1.

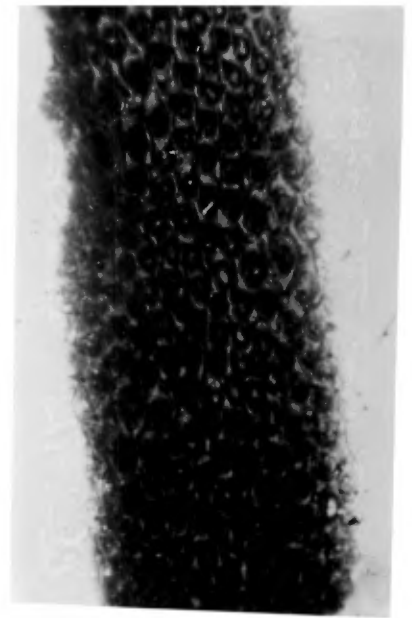
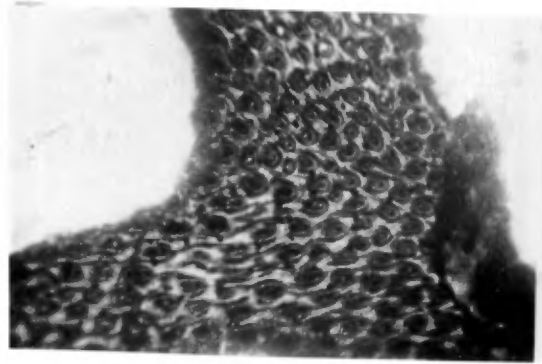


Fig. 2.

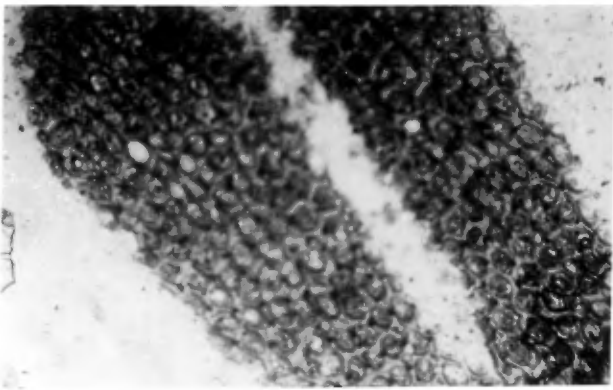


Fig. 3.



Fig. 4.

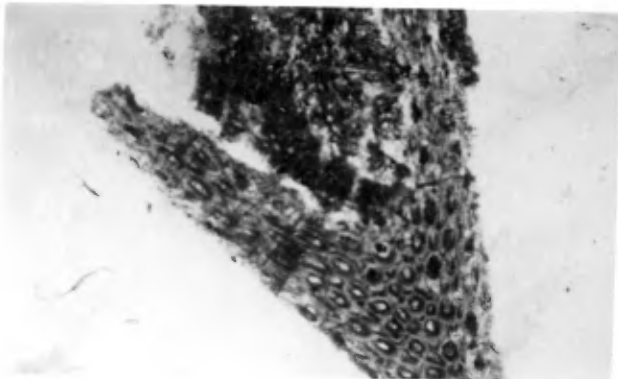


Fig. 5.

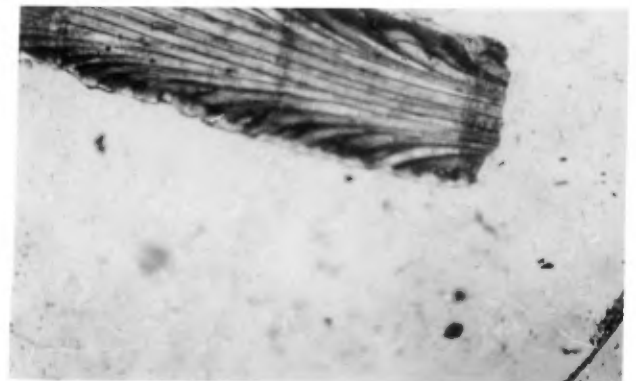


Fig. 6.



Fig. 1.



Fig. 2.



Fig. 3.

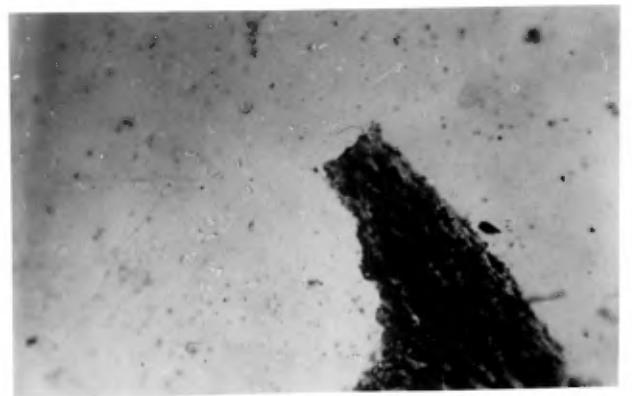


Fig. 4.

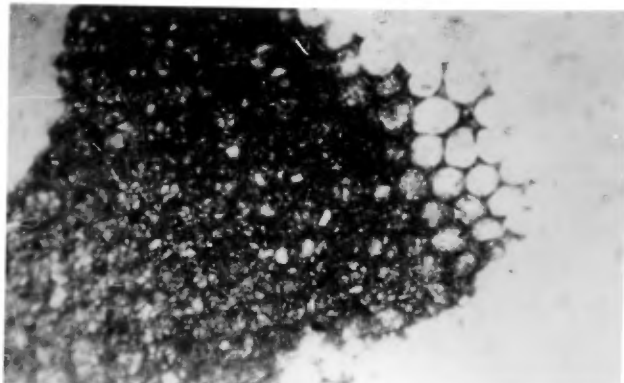


Fig. 5.



Fig. 6.

Plate 6.

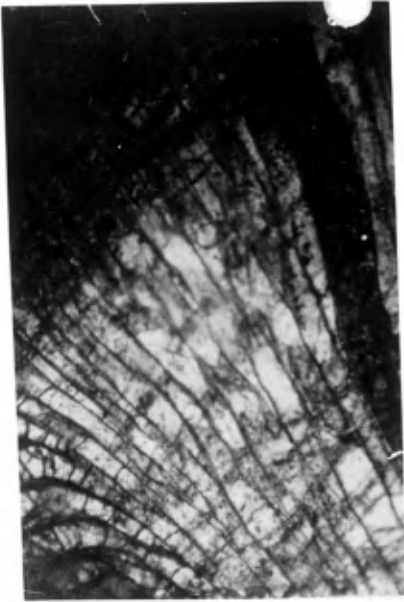


Fig. 1.

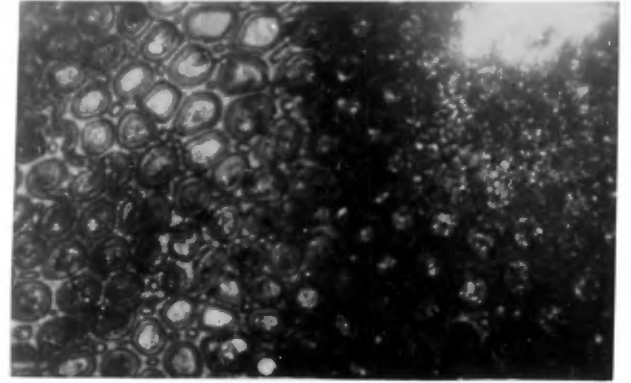
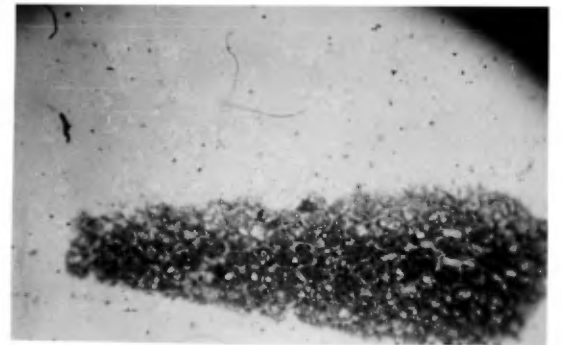
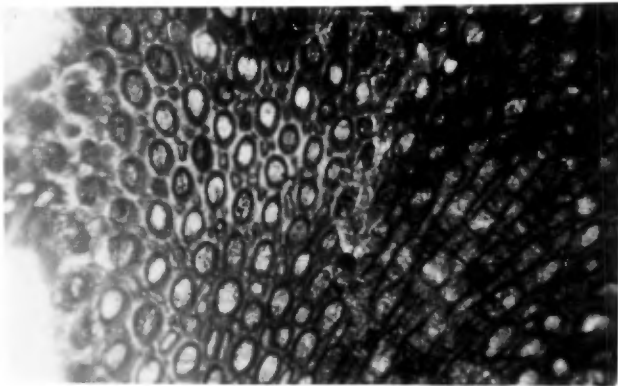


Fig. 2



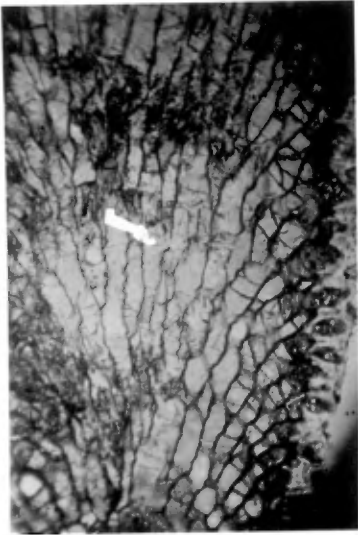


Fig. 1.

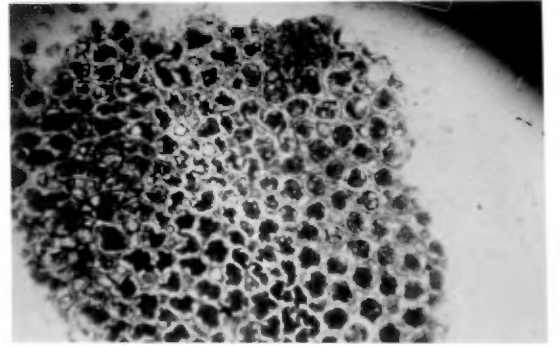


Fig. 2.

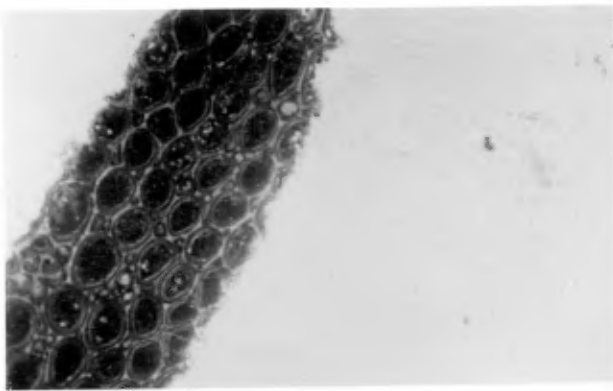


Fig. 3.

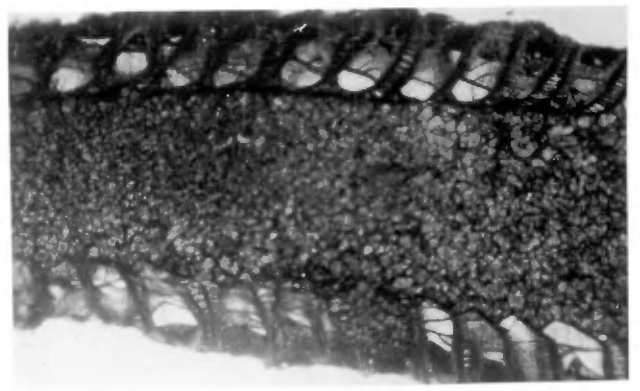


Fig. 4.

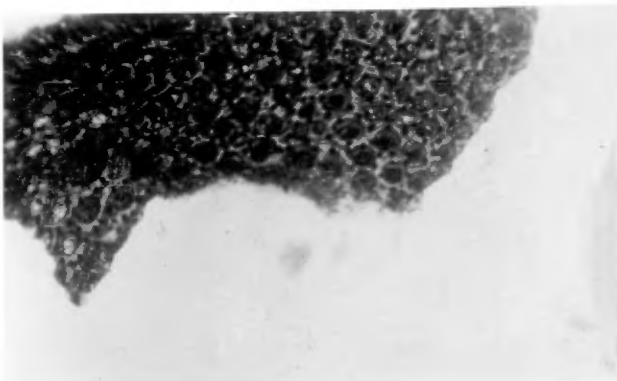


Fig. 5.

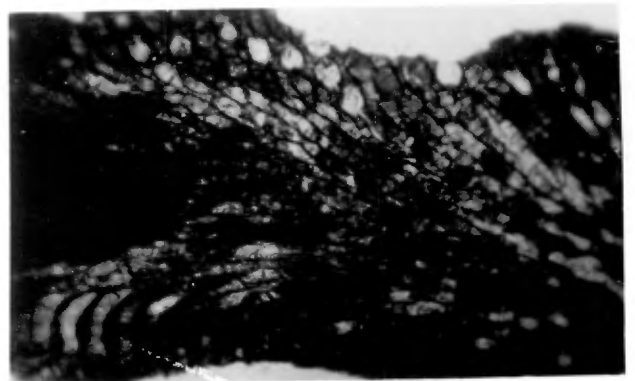


Fig. 6.



Fig. 1.

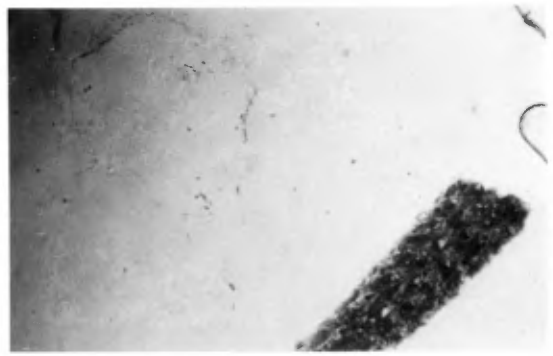


Fig. 2.

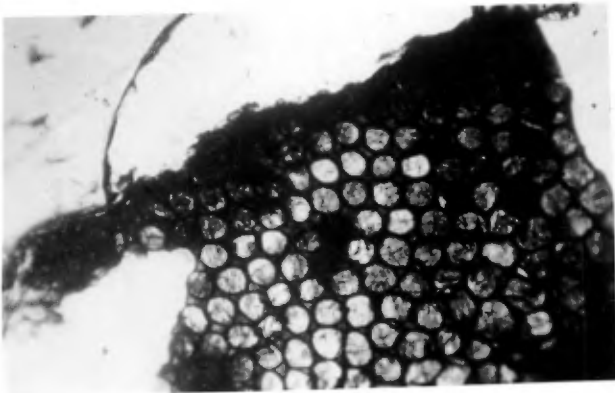


Fig. 3.

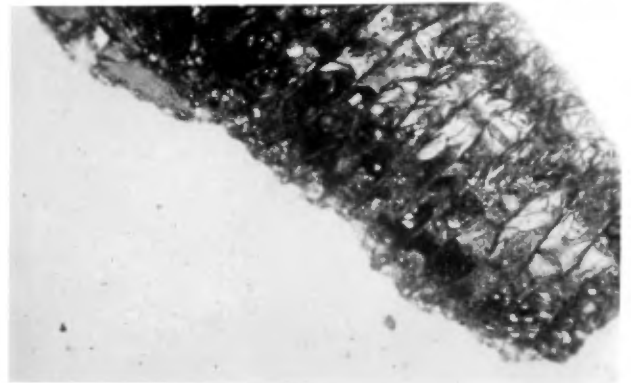


Fig. 4.

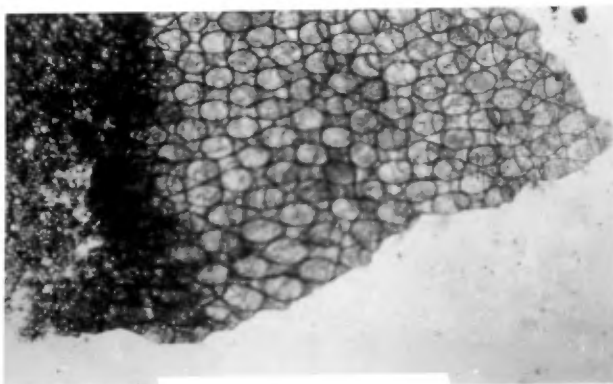


Fig. 5.



Fig. 6.