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GEOLOGICAL SERIES No. 40

FAUNAL AND SEDIMENT VARIATION IN THE ANTICOSTI SEQUENCE

By W. H. Twenhofel

INTRODUCTION

Nearly three hundred years ago, the Danish priest, Steno, stated that the materials of a deposit may be of diverse character because of the different sources from which they come. The brilliant Frenchman, Guettard, pointed out that sediments are not everywhere deposited in the same thickness. It has been shown by many other scientists that sediments vary in character consequent upon conditions prevailing at the places of deposition. These conclusions would appear to be axiomatic, yet they have not been generally applied.

The history of the past is to be read from a study of the processes of the present, but, of course, at any one time the result arising from a combination of processes would be controlled by the intensity of each process. At present it appears that at all places where accessible sediments are being deposited there is lateral gradation from one to another type, that at no time are the waves and currents depositing the same kinds of material everywhere in the same quantity and that on no land and in no sea are the animals and plants growing in the same variety and abundance over the entire area inhabited. Many things determine the type of sediment which may be deposited; the agents of transportation and precipitation, the depth and chemical character of the water, distances from sources and differences in character of material at the sources are among the most important. Many factors likewise enter into the existence of organisms

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at a particular place. The character of the sediments is only one of them. Other controls of equal and even greater importance are character of the bottom, depth of water, food, presence of other organisms, and character of the waters. If the sediments of the same stratigraphic horizon be different, different fossil organisms may be expected; if alike, they may contain the same organisms; but other important factors in the environment may have determined the presence of a different group of organisms. As illustrative of this fact the following is to the point. In a north bay on Harbour island of the Mingan group, the common sea urchin, *Strongylocentrotus drabachiensis*, was seen in 1909 by the writer in thousands of individuals, the bottom being so thickly covered that there was no room for any other organisms of equal size. They were not seen in such abundance elsewhere and in some of the bays of the islands they were not seen at all. In some parts of the shallow water about Anticosti island this animal occurs in thousands and probably millions of individuals, but in other places with a bottom not superficially different not a single one could be observed. At Bird bay and Gull cliff near the east end of Anticosti island are thousands of sea pigeons, cormorants, gulls, and other birds. There are big cliffs at scores of other places on the island composed of exactly the same kind of rock and just as long, high, and inaccessible; but birds are not present in such great numbers at any other place. What is the determining factor or factors in this variation? There must be some reason, but there is not one apparent. These thousands of birds mean that their bones and excretions and the skeletons of the food they eat are at present being deposited in considerable quantity about their habitat and that elsewhere about the island such material is not so abundant. In a recent paper Dr. T. Wayland Vaughn has given some information relating to faunal variation which should impress all geologists and particularly those engaged in stratigraphic work.[1] His illustrations are drawn from the distribution of the corals about the Cocos-Keeling islands. In the lagoon of this group are twenty-three species of corals; on the exposed barrier sixteen species. Only three species are

[1]Vaughn, T. Wayland, Bull. 103, U.S. Nat. Mus., 1919, pp. 190–193.

common to the two habitats and one of these is said to be "so modified to meet surf conditions that ordinarily the specimens from the two localities would not be recognized as belonging to the same species." This example of faunal variation obtaining over a very limited area emphasizes what may be expected in shallow seas as extensive as those of the past with their sediments coming from many directions and derived from different sources, and with shores of the irregular character typical of bodies of water resulting from submergence of land areas.

A somewhat deep-rooted—perhaps sub-conscious—feeling prevails that in many of the ancient seas, plants and animals were universally distributed and that the conditions of sedimentation were the same throughout, with the result that formations and members of formations are now continuous—with similar lithic and faunal characters—over the entire area in which deposition occurred. This theory, which assumes there was nothing different in one place from any other place is, to the writer, impossible. The tendency of those who adopt the theory of uniform sedimentation is to consider variations in lithology as evidence of distinct formations which bear a vertical and not a horizontal relation to each other. If, in addition to the lithological difference, there be a variation in faunal content the evidence is considered conclusive. Strata of similar lithology which lie on the same stratigraphic horizon, with slight differences in their faunas, are also commonly interpreted as distinct formations. In many cases such conclusions may be correct, but the matter of lateral variation should be carefully considered and fairly tested.

Lateral gradation of sediments and faunas may so develop that one type of sediment with its fauna may overlap another—the conditions responsible for one type of deposition migrating laterally with respect to the other. The common interpretation would be "overlap" of the one by the other, a withdrawal of the sea, a land interval, and the development of an unconformity. A reverse migration of the conditions of deposition would bring about "overlap" from the opposite direction and another land interval with the resultant unconformity. The evidence would be considered complete if marks of erosion could be found between the two different types of deposit. The possibility of erosion having been effected by marine scouring is generally given little consideration although it has been repeatedly pointed out that such occurs in shallow seas. Barrell, on theoretical grounds, has proved that such must occur and has proposed the term, *diastem,* for the break thus brought about.[1] Kindle has lately brought together many of the observations relating to marine scouring which have been made by earlier scientists, and has presented his own observations relating thereto.[2]

It is a significant fact that the shallow waters about the continents contain abundant examples of lateral variation of sediments and that few instances of such are recorded in geologic literature, whereas the number of unconformities and formations multiplies in constantly increasing numbers. It is the purpose of this article to describe examples of sediment and faunal variation in the shallow Ordovician and Silurian seas in which were deposited the sediments which now constitute the rocks of the Anticosti sequence, and to show that in these waters conditions in respect to the processes and results of sedimentation were little different from what they are in seas of the present day.

SECTIONS SHOWING FAUNAL AND SEDIMENT VARIATION

The Anticosti sequence consists of nearly 2,500 feet of strata divided into seven formations, three of which are Ordovician and four Silurian. These formations, named in the order of their occurrence from below upward, are as follows: English Head, Vaurial,[3] Ellis Bay, Becsie River, Gun River, Jupiter River, and Chicotte.

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[1]Barrell, J., Bull. Geol. Soc., Am., vol. 28, 1917, p. 794.

[2]Kindle, E. M., Jour.Geol., vol. xxviii, p. 339.

[3]The Vaurial formation originally was named the Charleton after Charleton point, which was believed to be the place of its typical occurrence. This was found to be a mistake and it has been renamed the Vaurial, the type section being that of Vaurial river.

The location and extent of the formations admirably show any lateral variation that may exist, as individual zones may be followed for long distances and five of the formations are exposed on both the north and south shores of the island, and thus exhibit deposits in their relations to the ancient coasts.

The English Head formation shows little variation throughout the entire extent of its exposures. To the east it appears to contain a little more shale than to the west, but the difference is not conspicuous.

The Vaurial formation in its southern exposures is largely composed of nodular limestone and grey shales, the shales not prominent and for the most part occurring as shale partings. On the north shore in the exposures extending from Oil river to the eastern limit of the formation it consists of interbedded blue and grey shales and flaggy limestones. At the top are zones of sandy shale. Corals are extremely common in portions of the southern exposures, but are rare in the northern exposures. A *Beatricia* (*Aulacera* Plummer) zone is present in this formation on both sides of the island, but is barely represented in the exposures on Vaurial river. In the northern exposures this zone contains an abundance of the bryozoan, *Batostoma billingsi*, and the brachiopod, *Rhynchotrema janea*, is quite common. Both of these forms are very rare in this zone on the south.

The Ellis Bay formation in its southern exposures begins with about 7 feet of dark-blue calcareous shale, which is immediately followed by nodular fine-grained limestones. In the middle portion it contains a great deal of calcareous shale, a coral reef limestone, and other limestones of variable characteristics. It ends with nodular, fine-grained limestones like those near the base. On the north shore the rocks are decidedly different; the shales are not calcareous, but sandy, and there is about 180 feet of sandstone. The correlation on opposite shores of the island is made certain by the presence of a *Beatricia* zone on both sides, with the fossils characteristic of this zone on the south shore also present on the north. Sandstones and sandy shales are absent in the Vaurial River section, not more than 30 miles to the southwest of the sandstone occurrences, and the sequence resembles that of the south shore. These differences are certainly due to deposition at different distances from the shore. The three sections which follow show the differences in the lithology of the same time unit within a stretch of about 100 miles.

Vaurial River Section

Becsie River Formation.

17. Well-bedded, bluish-grey limestone, very little shale. One bed is a limestone conglomerate with pebbles varying from fine gravel to boulders up to 6 inches in diameter. Some of the boulders are heads of *Lyellia affinis*. Basal zone of the Becsie River formation. 25 feet.

Ellis Bay Formation.

16. Not well exposed except near the base, where it consists of pale-blue limestone. 15 feet.

15. Bluish-grey limestone with thin shale partings. Contains many *Atrypa marginalis*. 16 feet.

14. Blue and bluish-grey limestone. 12 feet.

13. Thin-bedded, blue limestone and blue shale. 10 feet.

12. Thin-bedded, grey limestone with shale of about equal thickness. 9 feet.

11. Thin, irregularly-bedded limestone. One layer with many *Leptæna rhomboidalis*. 7 feet.

10. Concealed. 4 feet.

9. Thin-bedded, fine-grained, dark-blue limestone with conchoidal fracture. 7 feet.

8. Concealed. 6 feet.

7. Nodular, shaly, blue limestone. 4 feet.

6. One bed of pale-blue, flaggy, thin-laminated limestone. 9 inches.

5. Mostly concealed, but a 7-foot zone of mud shale at the top. The shale in some parts contains rough surfaced lime nodules and thin layers of nodular impure limestone. This zone contains many *Hindella umbonata* and *Streptelasma selectum*. 18 feet.

4. Reef limestone, no bedding, composed of corals plastered over each other. Contains an abundance of *Favosites* and *Stromatopora*. 4 feet.

3. Thin-bedded, fine-grained, blue limestone; some beds shaly, and all with thin shale partings. Contains many *Beatricia* and is the equivalent of the upper *Beatricia* zone at Ellis bay. Some limestone conglomerate is present with pebbles up to 2 inches in diameter, composed of dark-blue, flint-like limestone. 30 feet.

2. Thin, irregularly-bedded, blue limestone with a little blue shale. Many *Beatricia*. 25 feet.

1. Nodular, fine-grained, buff-coloured limestone in thin beds, essentially no shale. Resembles the rock of zone 2 of the south shore section and is correlated therewith. Forms the cliff on Vaurial river just above the falls. Base of the Ellis Bay formation. 22 feet.

Section on the South Shore, Junction Cliff to Ellis Bay

Ellis Bay Formation.

12. Thin-bedded, greyish-blue, compact limestone with conchoidal fracture. Contains colonies with abundant individuals of *Parastrophia lenticularis*, *P. reversa*, *Paleofavosites aspera*, and other corals. 60 feet.

11. Thin-bedded pale-blue limestone. Some layers covered with many *Leptæna rhomboidalis* and *Dalmanella testudinaria*. 20 feet.

10. Thin-bedded pale-blue limestone intergrading laterally with coralline limestone. Bedding decidedly undulatory. At the top a layer with well developed pillow structure. The zone approximates 7 feet in thickness, but where the reef-like masses rise into the zone above the thickness is at least 10 feet. Contains an abundance of *Halysites*, *Paleofavosites*, and *Lyellia*.

9. Fine-grained, well-bedded, pale-blue limestone. Contains an abundance of *Schuchertella pecten*, other fossils rare. 9 feet.

8. Nodular, shaly, blue limestone and shale. Contains *Hormotoma gigantea*, *Platystrophia regularis*, *Beatricia undulata*, *B. nodulosa*, and other fossils. Correlated with zone 3 of the Vaurial River section. 18 feet.

7. Concealed above water, but exposures beneath water show it to be composed of limestone. 12 to 15 feet.

6. Thin, nodular-bedded, greyish-blue limestone with thin shale partings. Contains many corals and *Beatricia*. 19 feet.

5. Thin-bedded, greyish-blue, impure limestone with conchoidal fracture. Thin shale partings. Fossils abundant in some layers. 20 feet.

4. Blue calcareous shale. Contact with 3 not exposed. Contains *Pseudolingula elegantula*, *Clitambonites diversus*, and other fossils. About 25 feet.

3. Grey and blue calcareous shale with thin limestones. This is one of the most fossiliferous zones of the Anticosti sequence, the most abundant species being *Parastrophia reversa* and *Hindella umbonata*. Believed to rest directly on zone 2, but a small thickness may be concealed. Exposed near the head of Ellis bay and a little distance east of Junction cliff. 25 feet.

2. Thin-bedded, drab and pale-blue, conchoidally fracturing limestones in 2 to 4-inch beds. Thin shale partings between the limestones. These contain many *Atrypa marginalis* and *Orthis laurentina*. 50 feet.

1. Highly calcareous, dark-blue shale with nodules of limestone and a persistent band of grey limestone 4 feet from the top. At the top a rough, nodular limestone about 7 inches thick, of which the base is covered with fossils characteristic of the zone. The zone contains an abundance of *Dinorthis anticostiensis*, *Clitambonites diversus*, *Hindella umbonata*, and other fossils. Base of Ellis Bay formation. 10 feet.

North Shore Section, Point Joseph to Fox Point

Ellis Bay Formation.

35. Granular, grey and reddish-grey limestone. Some beds contain blue mud pebbles. At the base is a 24-inch bed which is a conglomerate composed of what appear to be algal nodules. A few beds are sandy. There are also zones composed of fine-grained, nodular limestone which in places is intensely crumpled. One bed filled with *Leptæna rhomboidalis* may correlate with zone 11 of the Vaurial River section. Top of the Ellis Bay formation. Estimated at 50 feet.

34. Thin-bedded, bluish-grey limestone flagstone. Contains *Hindella umbonata* and *Beatricia undulata*. In places the zone has a crumpled structure. 8 feet.

31. Laminated, sandy, grey limestone in 2 to 7-inch beds. 3 feet.

30. Thin, limy flagstone with shale partings. 5 feet.

29. One thick bed of quartz sandstone with calcareous matrix. Irregular parting planes. 4 feet.

28. Thin-bedded, nodular, flaggy limestone with grey shales. 7 feet.

27. Sandy flagstone with separating sandy shale. At the top this zone consists of grey concretionary sandstone. Exposed in Lousey cove and Prinstie bay. Many *Beatricias*. 7 feet.

26. Thin-bedded (average about 1 inch) sandy limestones with separating shales of about equal thickness. 3 feet.

25. Thin, laminated, grey sandstone. 3 feet.

24. Intensely nodular, dark-grey shales. 8 feet.

23. Nodular, dark-grey shales with thin, grey limestones. Exposed in back of Prinstie bay and Lousey cove. 5 feet.

22. Rock like that of zone 20, but beds somewhat thicker. Exposed in Prinstie bay. 12 feet.

21. Conglomerate limestone with small quartz pebbles. 1 foot, 8 inches.

20. Shales and limestone as zone 19. 10 feet.

19. Sandy, calcareous layer, generally thin, in places swelling out into large, concretionary masses 6 to 7 feet long and 4 feet thick.

18, Thin-bedded, nodular, fine-grained, dark-blue limestone and pale-blue shale with limestone nodules. Beds vary in thickness from $\frac{3}{8}$ to 2 inches. Top of cape James. Contains an abundance of *Hindella umbonata*. 20 feet.

17. Evenly bedded, grey quartz sandstone, matrix calcareous. Contains calcareous nodules and beds of grey limestone. 8 feet.

16. Nodular calcareous shale, makes a conspicuous band across the cliff. 2 feet.

15. Calcareous shale with irregular, limestone nodules. Contains many small *Beatricias* and an occasional large one. Capped on top with smooth-bedded limestones in which are many *Hindella umbonata*. 2 feet, 4 inches.

14. Grey, calcareous quartz sandstone with occasional layers of sandy limestone. Contains an abundance of corals and *Beatricias.* 16 feet.

13. Grey shale with limestone nodules. Contains *Beatricia* rarely, and Favosite corals in abundance. 4 feet.

12. Thin-laminated, grey quartz sandstone with a dark-blue, sandy shale band near the middle. No fossils appear to be present. 7 feet.

11. Nodular, shaly, grey quartz sandstone with calcareous matrix, bedding poorly defined. 6 feet.

10. Reddish-grey, subcrystalline limestone. Contains an abundance of *Beatricia undulata, Paleofavosites aspera,* and *Liospira helena.* The zone is a channel filling, the channel having been cut in the zones below. Exposed on the south end of cape James. The thickness varies from nothing to 6 feet.

9. Thin-laminated, micaceous, grey quartz sandstone. Much cross-laminated with short and steeply inclined foresets. There is a great deal of lateral variation in respect to lamination, a bed 3 feet thick without apparent parting planes separating laterally within 30 feet into a score or more of thin beds or laminations. Shale in places is interlaminated to the extent of composing about 3 per cent of the zone. At one place at the top of the zone the rock has concretionary or pillow-like structure with spheroidal laminæ, the pillows varying up to 3 feet long and a foot high. The zone varies greatly in thickness, averaging about $4\frac{1}{2}$ feet.

8. Thin-bedded and thin-laminated, grey quartz sandstone and fine-grained, thin-laminated, sandy shale. The rocks contain small, calcareous nodules and thin layers of limestone, the latter really being conglomerates of fossils. Both bedding and laminations very undulatory. Beds thicken and thin and dove-tail into each other. The fossils in the limestone are *Paleofavosites aspera, Beatricia,* and a ramose bryozoan. The sandstones and shales are without fossils. The zone varies in thickness and grades more or less into 9 and 7. 10 ± feet.

7. Massive, grey quartz sandstone with mica flakes more or less throughout. Thin lenses of fossiliferous, grey limestone and occasional lenses of dark-blue shale are present in the sandstones. The sandstones are greatly cross-laminated and the

lenses of limestone and shale are parallel to the cross-laminations. The sandstones contain many coral heads; the limestone lenses are largely composed of *Strophomena fluctuosa* and are really conglomerates. 12 feet.

6. Thin-bedded quartz sandstones and sandy limestones. Contains many small *Beatricias*. 5 feet.

5. Undulatory, grey limestone in which are many horn corals. Bedding poorly defined with tendency toward a nodular structure. Occasional big limestone boulders up to 8 inches in diameter. Contains many young *Beatricias* and other corals. 8 feet.

4. Sandstones as in zone 3, but corals very rare. 6 feet.

3. Thin-laminated, grey quartz sandstone with occasional layers of thin, shaly limestone. Bedding very undulatory. The sandstones are much cross-laminated and contain boulders of limestone up to 6 inches in diameter. Large heads of *Favosites* up to 3 feet in diameter are common. Some beds contain *Beatricias* lying around like broken logs in fallen timber. 20 feet.

2. Grey quartz sandstone like that at Grindstone cliff with which the base of this zone may overlap. Contains rounded boulders of dark-grey limestone up to 3 inches in diameter. Near the base many *Beatricia undulata* and *Syringopora*. Basal beds of cape James. 50 feet.

1. Fine-grained, thin-laminated, grey quartz sandstone, beds up to 3 feet thick. Hardly any fossils. Forms the main portion of Grindstone cliff. Considered basal zone of Ellis Bay formation. 30 feet.

Correlated with these lithic differences are faunal differences. On the south shore *Cyphotrypa bulbosa*, *Clitambonites diversus*, *Dinorthis anticostiensis*, and *Platystrophia regularis* occur in the basal zone of the formation in great abundance. Only the last has been found in the exposures of Vaurial river and north shore. *Orthis laurentina* is extremely common in some of the zones of the basal portion in the southern exposures and with it in its lowest occurrence are many *Atrypa marginalis*. One or two *O. laurentina* have been found on the north coast in Prinstie bay, but no *A. marginalis*. In the Vaurial River section *O.*

laurentina has not been seen, but *A. marginalis* has been collected above the coral and *Beatricia* zones. *Parastrophia reversa* is present in tens of thousands of individuals in the exposures of the south shore, existing in the rocks in about the position in which they lived upon the bottom. About a half dozen worn and washed specimens have been found on the north side. A species associated on the south side with *P. reversa* is *Hebertella maria*. The writer does not recall having seen it on the north side. The coral zone on the south side contains *Halysites catenularia* in abundance. It hardly makes its presence felt on the north. A *Syringopora* occurs associated with the corals in the Vaurial section and the section of the north shore. The writer has not seen it on the south. At cape James *Liospira helena* occurs in the zone filling a channel in abundance. It has not been seen on the south. On the north shore is a bed near the top of the formation filled with what appear to be calcareous algæ. Nothing similar was seen on the south side.

On the south shore the initial formation of the Silurian, the Becsie River, is characterized by an abundance of *Phænopora expansa* and *Virgiana barrandei*. The former is equally abundant in the exposures of the north side and Vaurial river, but of the latter not more than three worn specimens have been collected, and two of these are doubtful. On both shores the basal portions of the formation consist of limestone in which are many zones of limestone conglomerate. On the south shore the character of the deposit continues unchanged to the top of the formation, but on the north shore the upper portion of the formation contains a thick zone of dark shales in which there is an abundance of *Camarotœchia glacialis* and *C. fringilla*. Small specimens of these shells have also been found in the southern exposures, but they are not common. Both species were evidently inhabitants of muddy bottoms.

The Gun River formation consists largely of limestone which on both shores contains an abundance of pebbles and boulders of limestone. The faunas of both shores are also similar.

The Jupiter River formation makes its appearance on the north shore just around the east end of the island and thence extends along the south side for about 100 miles with an interruption of about 30 miles where the Chicotte formation makes the shore. The eastern and western limits are somewhat different. In the basal zones of the western exposures is a zone from which the writer collected several hundred *Triplecia insularis anticostiensis*. The species has not been seen in the eastern exposures. In the eastern exposures an extensive coral reef succeeded by limestone occurs near the base. Such does not occur on the west where a 60-foot zone of sandy almost unfossiliferous shale, succeeded by 200 feet of highly calcareous shale—a marlite—filled with fossils, holds the interval in which the coral zone occurs on the east. In the calcareous shale and some of the limestone just above, *Lissatrypa atheroidea*, *Oncoceras futile*, and *Calymene* n. sp. occur in considerable abundance. Not one of these has been seen to the east. *Camarotoechia decemplicata* is extremely abundant in the eastern exposures; it is rare in the west. At Belle river and the mouth of Pavilion river *Orthis flabellites* is extremely common in the top zones of the Jupiter River. At the Jumpers where the same zones are exposed it is rare.

The Chicotte formation consists of coral reef limestone without bedding and inter-reef deposits of well-bedded crystalline and crinoidal limestone. In this formation one observes what the writer has previously pointed out for the Gotland sequence [1]—the organisms grew in colonies and the individuals vary with the colony, scouring occurred between the reefs and deposition in the quiet places and the bedding synclines from reef to reef. The deposits vary from place to place. At one place they are wholly crinoidal fragments, at another all brachiopods, at another all trilobite fragments, at other places fragments from many sources were washed together and elsewhere the strata are crystalline without recognizable organic remains.

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[1]Twenhofel, W. H., Bull. Mus. Comp. Zool., vol. LVI, No. 4, 1916, p. 341.

CONCLUSIONS

The sediments which formed the rocks of the Anticosti sequence are wholly of shallow water origin and they teach, in a manner which is not open to question, that the deposits of a shallow Palæozoic sea varied widely both in the character of the sediments and in its faunas. Were deeper water concerned in the deposition of these sediments it is possible that the variations of both kinds would not be so great. The sequence certainly teaches that sediments and faunal variations are to be expected in the deposits of shallow seas and, in particular, in those of restricted shallow seas as so many of the seas of the Palæozoic are considered to have been. The number of Palæozoic cases of lateral gradation recorded are few and the writer believes they have not been found to the extent that they are present because the study of the deposits has not been approached from the viewpoint of lateral gradation. Further investigation, probably, will show that many units now considered distinct formations with vertical relationship to each other will be found to lie on the same stratigraphic horizon. If this be true, there will be no necessity to postulate distinct invasions of faunas, separate troughs of sedimentation with many land barriers and tilting of the areas on opposite sides of the barrier to submerge first one side and then the other.

Fossil faunas should be studied with the knowledge that organisms are controlled by environment and that environments vary within wide limits. If index species be not present, it should be considered whether the environment admitted their presence before it is decided that some barrier prevented their entrance.

NEW SPECIES OF DEVONIAN CRINOIDEA FROM NORTHERN CANADA

By Frank Springer

Crinoids from the Great Slave Lake region, Northwest Territories, said to be from rocks of upper Devonian age, have been submitted, by E. M. Kindle, for examination. The material consists of two calices numbered 5643, and a calyx with some unidentifiable stem fragments numbered 5658, from a horizon about 200 feet higher. Both belong to the genus *Melocrinus*, having four basal plates, a characteristic fossil of the Stringocephalen-Kalk of the Eifel; they do not belong to the European type, however, but are closely related to species occurring in formations of the Hamilton group in western New York, Wisconsin, Iowa, and Missouri. Lithologically they are closest to the Missouri species.

The Missouri forms were described by Rowley[1] in 1893 and 1894 under three species derived from shales overlying the Calloway limestone, forming the upper member of the central Missouri Devonian, in Calloway county, Missouri. This formation was referred to the Hamilton by the early geologists; subsequent detailed study has led the later authorities to consider it as late Meso-Devonian, or perhaps early Neo-Devonian. The geology of the region has been discussed by Keyes[2] and Greger,[3] and its relation to the Interior Continental Devonian areas to the northward by Meek,[4] Schuchert,[5] and Weller.[6] From these discussions it is clear that the fossils of the Missouri and Mackenzie Devonian belong to the same palæontological province, and are of approximately the same age. The characters of the crinoids in question are consistent with these

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[1]Am. Geol., vol. 12, p. 303, and vol. 13, pp. 151, 153.

[2]Geol. Surv., Miss., vol. 4, 1894, p. 43; Bull. Geol. Soc. Am., vol. 13, 1902, pp. 271–273.

[3]Am. Jour. Sc., vol. 27, 1909, p. 374.

[4]Trans. Acad. Sc., Chicago, vol. 1, 1869, pp. 61–144.

[5]Am. Geol., vol. 32, 1903, p. 143; Bull. Geol. Soc. Am., vol. 20, p. 545

[6]Jour. Geol., vol. 17, 1909, p. 264.

correlations. Wachsmuth and Springer[1] in 1897 described a species from equivalent beds in Iowa; and Weller in 1898[2] described three species and two varieties from shales of the Hamilton group at Milwaukee, Wisconsin, which have a facies very similar to that of the Missouri species. The whole of the Hay River section from which the crinoids described in this paper were obtained is referred by Kindle[3] to the upper Devonian. He finds the Portage fauna in beds below those which furnished the crinoids.

The most abundant crinoid species of the Missouri locality is the form described by Rowley as *Melocrinus tersus*. It is of medium size, having a rather elongate calyx, with tumid, but according to description not acuminate, plates. A number of specimens since obtained from the type locality show a considerable range of variation within the species—all specimens tending to have more or less acutely pointed plates, usually confined to the radial series; these are sharper and accompanied by delicate radiating ridges in younger specimens, which are represented in these respects by Rowley's *M. Lylii*.

The Canadian form numbered 5643 is closely related to the prevalent Missouri species, from which it is separable by characters of minor value—the result of variations due to migrational changes in a vigorous and wide-ranging type. It may take the name—

Melocrinus borealis n. sp.

Plate I, figures 1, 2

A medium-sized species, of the type of *M. tersus* Rowley, but having the calyx proportionally shorter and more rotund; plates of the dorsal cup more strongly tumid, often surmounted by one to three fine papillæ; tegmen plates more numerous, flatter, and also bearing fine tubercles. A few brachials preserved in one ray show the arms to be small and delicate. Size of largest calyx: height and width each 20 mm.

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[1]N. A. Crinoidea Camerata, p. 300.

[2]Annals New York Acad. Sc., vol. 11, 1898, pp. 117–124. Wisconsin Geol. Surv. Bull. 21, 1911, pp. 38–42.

[3]Geol. Surv., Can., Bull. No. 29, 1919, p. 4.

Horizon and Locality. Type from lowest beds of shaly limestones in Alexandra Falls section. Hay river, below Alexandra falls 9 miles (just above first island below the falls). Collector, E. J. Whittaker. A second nearly perfect specimen was found by Mr. Lowe, geologist of the Imperial Oil Company, and presented to the Canadian Geological Survey.

No. 5658, from an horizon about 200 feet higher than the last, is of a larger and more robust type, with very low, flat plates. Unfortunately the only specimen lacks the basal plates and is only partly free from the matrix; but even with these meagre points for comparison it is clearly distinct, and should be given a name, for which is proposed—

Melocrinus canadensis n. sp.

Plate I, figure 3

In the flatness of the plates this form is comparable with one from the Hamilton of western New York figured by Hall, but never described, under the name *M. breviradiatus*, as figures 18, 19, of Plate I, of the photographic plates privately distributed about 1872, as part of Bulletin 1, of the New York State Museum.

Estimated dimensions of calyx: 28 mm. high by 26 mm. wide.

Locality and Horizon. Near top of Devonian section. About 7½ miles above Alexandra falls, Hay river, and ½ mile above second island above the falls. Collector, E. J. Whittaker.

The mutual relations of the species of *Melocrinus* pertaining to the above correlated formations may be shown by the following analysis:

alyx plates convex to sharply acuminate.
  Calyx elongate, higher than wide, with sides little curved.
    Plates low convex, frequently with small central spine on those of radial series, but these may be absent; basal plate projecting with sharp point or edge downward over the top columnals; width of base to radial circlet is 9 to 13 mm.
      Specimens of medium size................*M. tersus* Rowley.
      Specimens small; central spine usually on both radial and interradial series, with centres connected by fine, radiating ridges.
        May be young of *M. tersus*................*M. lylii* Rowley
        Spines relatively larger; basals not so sharply projecting......................*M. milwaukeensis* Weller.

  Calyx rotund, or about same height and width; sides strongly convex.
    Plates of dorsal cup strongly tumid, bearing one or more small tubercles; tegmen plates numerous, flat, finely tuberculous; basal plates strongly projecting; width of base to radial circlet as 6 to 11 mm.
      Specimens of medium size.................*M. borealis* n. sp.
    Plates of dorsal cup elevated into short, sharp spines. Calyx wider than high; height to width 35 to 39 mm.; expanding suddenly from base 13 mm. diameter to radial circlet 24 mm.
      Specimens large and robust..............*M. gregeri* Rowley

Calyx plates flat
  Calyx rotund, higher than wide; sides strongly convex.
    Plates low, without connecting ridges, spines, or ornament.
      Specimens large........................*M. canadensis* n. sp.

Compare also: *M. calvini* W. and Spr.; *M. subglobosus* Weller; *M. nodosus* Hall (Weller); *M. nodosus* var. *spinosus* Weller; *M. milwaukeensis* var. *rotundus* Weller.

THE RANGE OF CERTAIN LOWER ORDOVICIAN FAUNAS OF THE OTTAWA VALLEY WITH DESCRIPTIONS OF SOME NEW SPECIES

By ALICE E. WILSON

INTRODUCTION

This paper is a comparative study of the faunal relationships revealed by collections from the lower Ordovician strata at three points in the Ottawa valley, one at Rockland east of Ottawa, one at Ottawa, and one at MacLaren landing, at the western end of lake Deschenes (see Figure 1). The formations represented include Chazy, Black River, and Trenton rocks. The Rockland and Ottawa sections include beds from the base of the Lowville to the top of the Rockland member of the Trenton as defined by Raymond.[1] The MacLaren Landing section commences in the shale and sandstone beds of the Chazy and includes the strata up to the lower portion of the Rockland beds.

The faunal relationships of these strata and the absolute conformity of the Rockland beds with the Leray at the Rockland quarry suggested a comparative study of the range of species in beds common to the sections measured, and it is for this comparative study of range that the corresponding part of the Ottawa section has been introduced.

The author is indebted to Dr. P. E. Raymond for assistance in placing some of the more doubtful species, to R. R. Hibbard, of Buffalo, who kindly made some of the microscope sections, to Dr. R. S. Bassler for advice and assistance in connexion with the identification of the bryozoa, and especially to E. M. Kindle, whose suggestions and criticisms have been invaluable.

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[1]Geol. Surv., Can., Sum. Rept., 1912, p. 349.

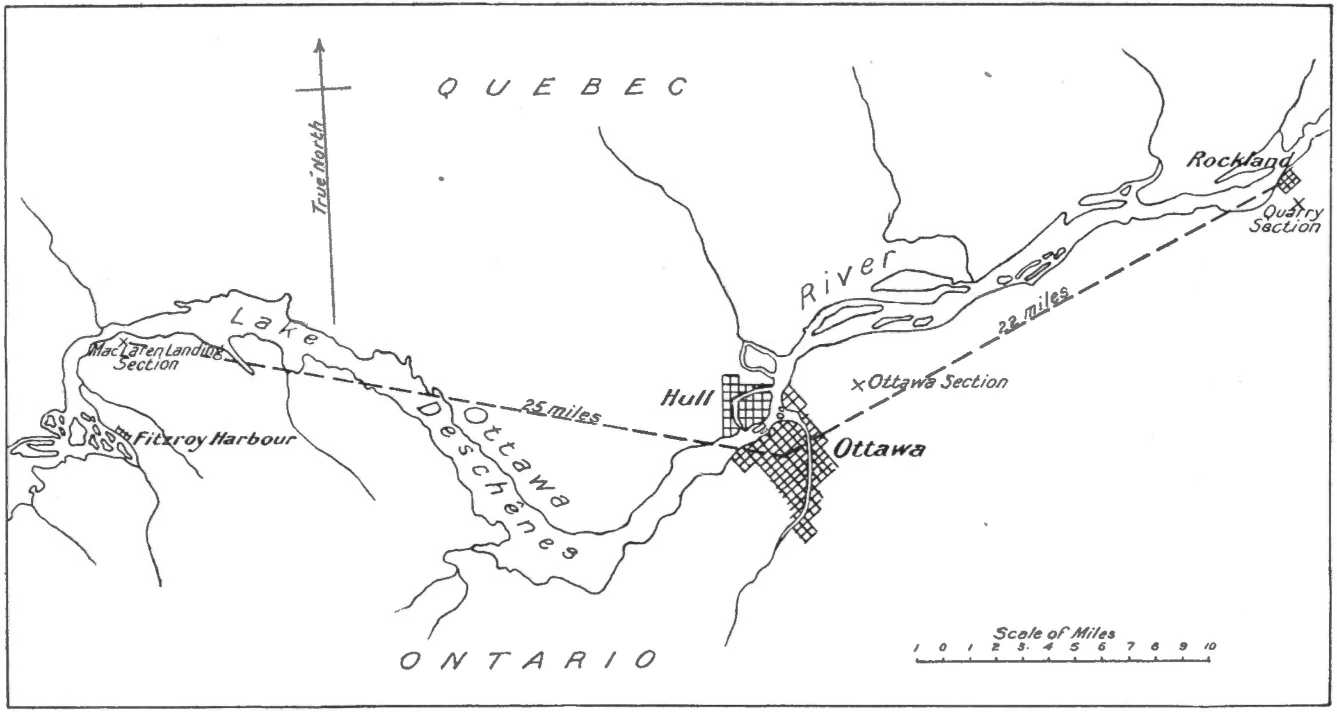

Figure 1. Sketch map showing geographical relations of sections studied. Location of sections marked by X. Scale about 5 miles to 1 inch.

DESCRIPTION OF SECTIONS STUDIED

The Stewart quarry at Rockland lies about 2 miles south of the Ottawa river just beyond Rockland. The exposure is continuous and one face of the quarry is a perpendicular precipice which includes strata ranging from the Lowville beds of the Black River into the lower Trenton. The strata have a slight dip to the southeast but lie quite conformably.

The corresponding section at Ottawa is found about 3 miles east of the city on the first road east of the Robillard quarry running north to the river from the Montreal road. It does not show a continuous section of any one of the formations, but the contact between the Lowville and the Leray beds of the Black River is exposed. Like the beds in the Rockland quarry, the strata have a slight general dip to the southeast, which is increased in some of the Trenton layers by small local faults.

MacLaren landing is on low ground, but about a quarter of a mile south of it an escarpment rises. A quarter of a mile to the west of the road leading up from the landing the hill encroaches on the low land reaching down to the river shore. The exposures show in a series of terraces extending from the shore-line to the crest of the ridge about a third of a mile inland. Several parts of the section which form the sloping top of a terrace are covered with drift, notably the long sloping pasture field extending from the *Tetradium* beds of the Lowville to the top exposures of the Chazy limestone.

The general dip of the whole section is, as at Ottawa and Rockland, inclined towards the south and slightly east, but the Chazy beds are much more disturbed than the beds above. It is evident that the fault in the Chazy, which is very pronounced at Quyon on the Quebec side of the Ottawa, extends to the Ontario side, continuing its course obliquely across the river. The disturbance on the Ontario side is not so marked nor does it affect so great a thickness of beds as at Quyon. The greatest irregularity of dip takes place in the limestone beds just above the interbedded shale and limestone strata of the old quarry mentioned below. The Chazy beds above are less distorted. Another fault on the face of the hill, in the Chazy beds, is at right angles to the main Quyon fault. On the east side of this minor fault so much is covered that it is not possible exactly to correlate the beds with those on the west side of it except near the top of the formation. Several covered areas occur in which there are probably further irregularities in the angle of the dip as shown by the accompanying section, page 28, which in the Chazy beds deals mainly with the west side of the minor fault.

These disturbances and irregularities may account for the Chazy limestones and shales apparently having a much greater thickness than farther east.[1] Between the Chazy formation and the lowest exposure of the Black River is the long terrace noted above. The Black River and Trenton exposures above this are undisturbed except for the slight general dip to the south and east.

The Trenton limestone is coarse-grained and of a dove-tinted colour that weathers to grey. Some of the beds appear massive but when weathered they break up into thin layers. The Rockland quarry contains numerous layers of brownish shales from 2 to 8 inches thick which weather light. These shales abound in well-preserved fossils. They are only very slightly represented in the Ottawa section and even the few layers that exist do not have the abundant fauna. These shales are almost completely absent at MacLaren landing. The Trenton section at MacLaren landing is taken from the edge of a plateau-like area. The plateau is long and narrow stretching out in a southeastern direction, having the general south and east dip of the Trenton beds that form it. The list of fossils on page 30 includes species from the top of this plateau, farther around the hill than the limited area just at the top of the MacLaren Landing section. From con. XII, lot 24 (6132), Fitzroy tp., to the southwest of this area, pieces of coarse Trenton limestone include some small, worn, irregular, limestone pebbles. The bed was not found in the MacLaren Landing section.

The Black River limestone is finer-grained and purer grey than the beds above. The shales are very dark and, like the shales of the Trenton, they thin out farther west. The Leray member of the Black River is heavy-bedded, fine-textured, and

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[1]See synoptic table by H. M. Ami.

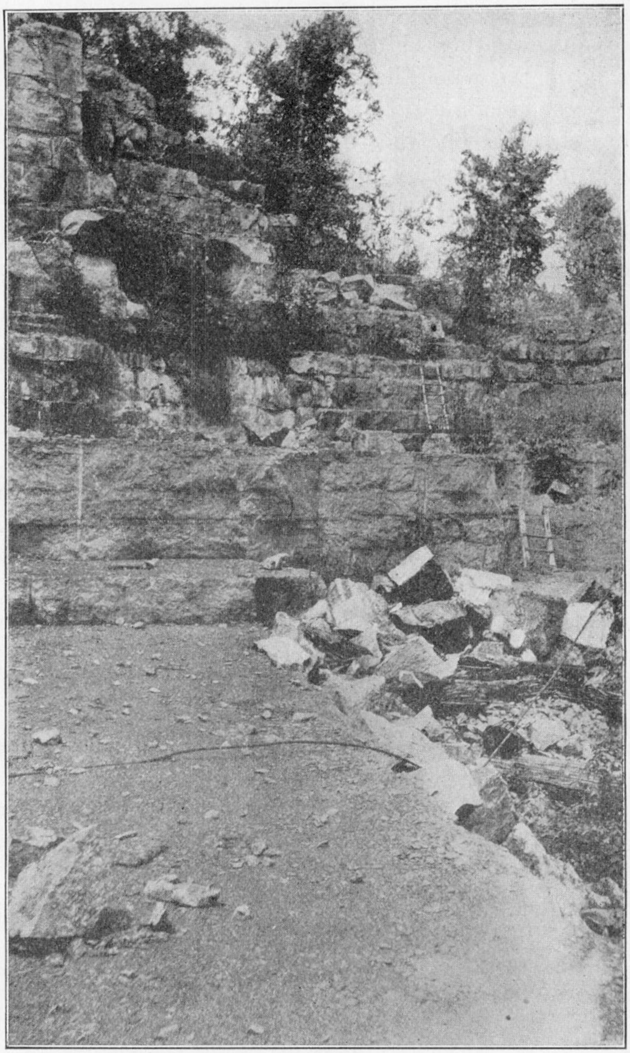

Figure 2. Part of the western face of the Stewart quarry at Rockland, showing the conformity between the Leray beds and the lowest Trenton. The " transitional zone " occupies about the central third of the layers shown here. The black line (foot of upper ladder) indicates the contact of the Black River and Trenton.

dark grey. In some layers the rock breaks with a conchoidal fracture and weathers into irregular nodules. The Lowville portion is on the whole lighter in colour than the Leray beds. In the lowest layers, exposed at Rockland, it is inclined to split into thin sheets. The massive, fine-grained, light grey bed in the upper part of the Lowville which forms so definite a feature in the Rockland exposure is undiminished in thickness at Ottawa, but it was not found in the MacLaren Landing section, although both the zone made up of almost solid *Tetradium* and the layer characterized by worn gastropods are present.

The Chazy beds are included in the MacLaren Landing section only. The limestone is on the whole much more impure that that of the beds above it. The uppermost exposed layer is purer than those below, and of a lighter grey colour. Below these beds appear interbedded strata of somewhat greenish limestones intermingled with more sandy layers. There are frequently red-brown streaks at a fresh fracture. Gradually the impure limestones give place downwards to shales. At the old quarry the chief fossil content of the thin limestones is ostracods. The base of the section is composed of a very impure, mud-coloured limestone, and shales often arenaceous. About a third of a mile west of this section, along the shore, the underlying Chazy beds of shale and sandstone are brought to the surface by the eastern tendency of the dip. No fossils were found in these beds, whose thickness it is difficult to ascertain as they extend out into the river. Where exposed they appear to have the general southerly and easterly dip.

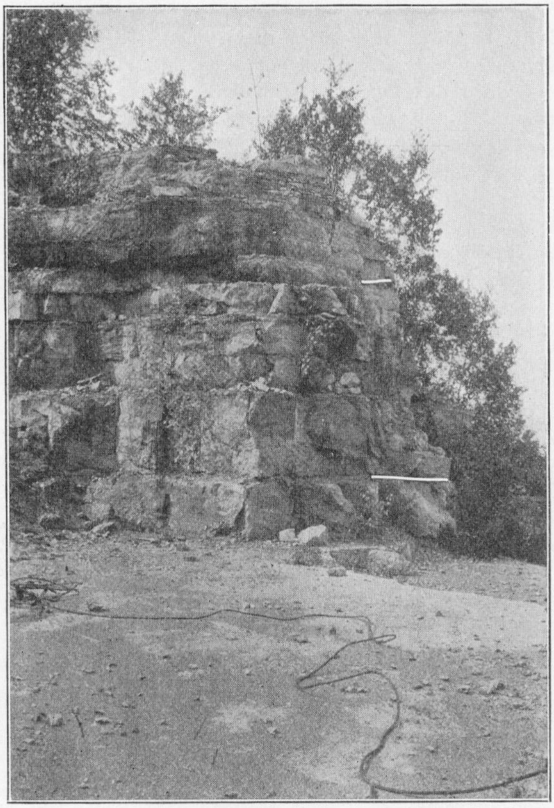

Figure 3. Western end of Stewart quarry, Rockland, showing the upper part of the Lowville, all of the Leray beds, and the lowest section of the Trenton. The lower white line indicates the contact of the Lowville and Leray beds of the Black River, the upper white line indicates the contact of the Leray and lowest Trenton formations.

Section, Stewart Quarry, Rockland

	Ft.	In.
10. Irregularly bedded, dove-tinted limestone weathering grey, fossils not very numerous, except in bands	10	0
9. Heavy-bedded grey limestone with shaly partings. Limestone containing *Receptaculites* and *Streptelasma*. Shale weathering grey, not very fossiliferous	10	0
8. Heavy-bedded limestone with shaly partings varying from 2 to 10 inches. Fossils numerous, apparently increasing in abundance as the limestone gives place to the shaly layers. Upper beds contain numerous gastropods	11	9
7. Heavy-bedded limestone, weathering a warm grey, fresh fracture with a pinkish tinge. Fossils numerous in both limestone and shale	8	6
Base of Trenton.		
5, 6. Heavy-bedded, dark grey limestone, with partings of dark shale. Fossils not so numerous as in No. 7. *Columnaria halli* present	8	8
4. Heavy-bedded, dark grey limestone, with partings of dark shale. Shale and weathered surface of the limestone very fossiliferous	9	6
Base of the Leray beds of the Black River.		
3. Fine-grained, light-grey, massive limestone, upper part full of *Tetradium cellulosum*	5	0
2. Dark grey limestone, thin shaly partings containing some concretions	10	0
Covered by debris	9	7
1. Interbedded limestone and shale. Colour pink-tinted weathering rusty	2	9
Base of Lowville exposed.		
Total	85	9

In the following section only that part of "Ottawa section" is taken which corresponds to the "Rockland section" in order to make a comparison in the study of the range of species in the upper Black River and lower Trenton.

Section 3 Miles East of Ottawa [1]

	Ft.	In.
7. Coarse-grained limestone, irregular fracture. Dove-tinted in colour. Fossils present in the upper layers, but scarce elsewhere. The lower beds of this exposure appear to overlap those of 5 and 6	15	6
6. Thick layers of coarse-grained limestone with irregular fracture. Dove-tinted in colour weathering grey. Fossils few	7	6
Bed disturbed by a local fault.		
5. Coarse-grained limestone interbedded with more shaly layers. Weathering rubbly. Fossiliferous	5	6
Beds disturbed by a local fault.		
Base of Trenton exposed here.		
Covered, in field	2 ±	
4. Grey limestone. Finer in texture than above	5	0
Covered	2	0
3. Grey limestone, weathering shaly. Very fossiliferous	4	6
Covered	1	6
2. Grey limestone weathering rubbly containing numerous cephalopods	5	4
Base of the Leray beds of the Black River.		
1. Massive bed of fine-grained, light-grey limestone capped by 1 ft. 6 in. layer almost solid *Tetradium cellulosum*	5	4
Covered	2	0
1a. Thin-bedded layers of light-grey limestone, full of gastropods, etc.	2	0
Base of Lowville exposed		
Total	58	±

[1]For details of location see page 21.

The MacLaren Landing section, which follows, contains the beds corresponding to the section at Ottawa and Rockland, but also includes the Chazy limestones and shales. A good Chazy section of the lower sandstones and shales occurs at Aylmer, on the north shore of Ottawa river about 10 miles above Ottawa, but the amount of limestone exposed is not great, and the fossils apparently are not numerous.

Section at MacLaren Landing

	Ft.
10. Coarse limestone, dove-tinted grey on fracture, weathering grey, fossils numerous	10
9. Limestone, weathering lighter than above. Fossils not numerous.	12
Base of Trenton.	
Covered	11
8. Thicker bedded, fine-grained limestone, weathering lighter, conchoidal fracture	9
Covered	6½
7. Fine-grained, grey limestone, containing cephalopods, stromatoporoids, and also chert	6½
Covered	7
6. Lighter grey than above, containing chert beds 1 ft. to 1½ ft. thick	8
Base of Leray beds of Black River.	
5. Light grey beds. *Tetradium* very common	7
Base of exposed strata of Lowville beds of Black River.	
Covered	25
4. Light grey limestone, filled with fossils, gastropods predominating	1½
3. Green-tinted limestone, alternating with light grey. The beds at the base showing red streaks when freshly fractured, contain *Camarotœchia plena* and fucoid markings	11
Covered	3
Thin beds, fine-grained, no fossils	3
Covered	8
Grey limestone, red-streaked, much disturbed	1½
Covered	5
2. Interbedded shale and thin limestone layers, ostracods numerous in some layers	10
1. Thick-bedded, dark grey, impure limestone, somewhat arenaceous. Badly broken up by weathering	10
Base of Chazy (omitting the interbedded sandstone and shale member to the west)....	
Total	165

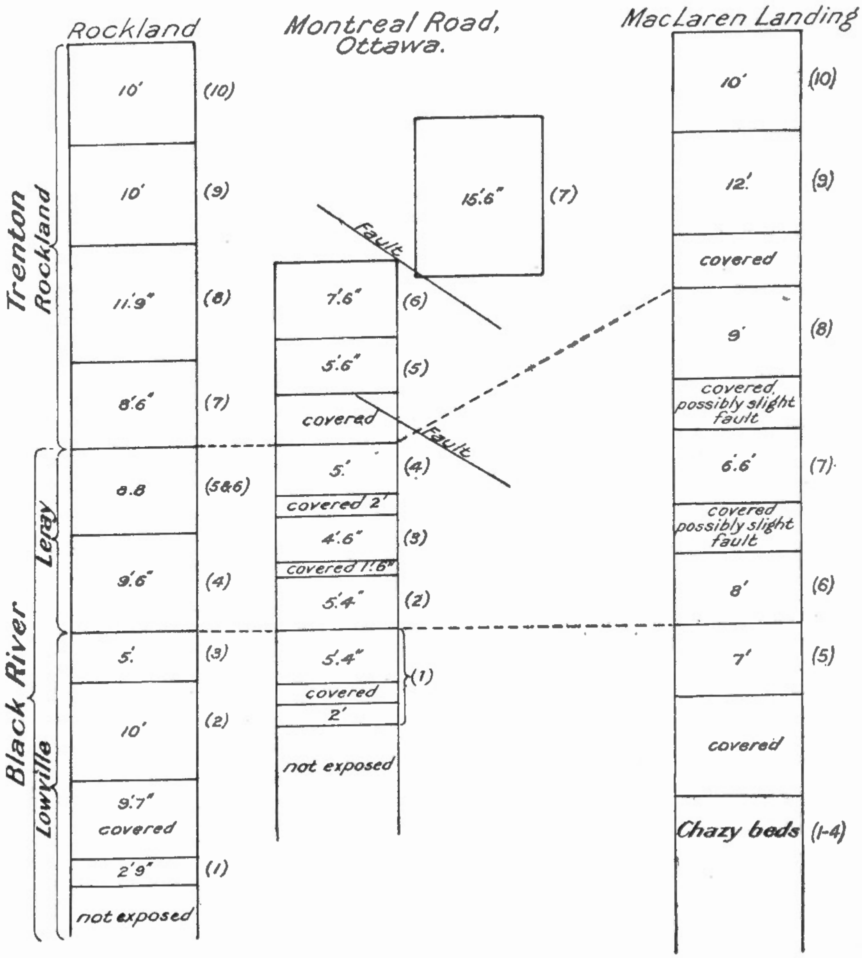

Figure 4. Comparative section of the Black River and Trenton strata. (Figures in brackets refer to detailed sections on pages 30 to 39.)

NOTE. The apparent increase in thickness of the Black River beds at MacLaren landing is due probably to slight faulting under the covered area. Between the exposures "7," and "6" is a very long field, and the similarity of the fossil content also points to the probability of a duplication of a portion of the beds.

Table of Range of Lower Ordovician Species of Preceding Sections[1]

Genera and species	Rockland												Ottawa							MacLaren Landing							
	Black River							Trenton					Black River				Trenton			Ch.	Black River					Tr.	
	Lowville				Leray			Rockland					Low.	Leray			Rock-land			Ayl.	Low.	Leray				Rock.	
	Un	1	2	3	Un	4	5, 6	Un	7	8	9	10	1	2	3	4	5	6	7	1–4	5	Un	6	7	8	9	10
Plantæ																											
Fucoid markings																				c							
Spongia																											
Hindia parva Ulrich					r	c	c r																				
Incertæ Sedis																											
Receptaculites occidentalis Salter							rr	r			cc	cc															cc
Anthozoa																											
Columnarea halli Nicholson							c									r							cc	c			
cf. *Phytopsis tubulosa* (Hall)																					c						
Streptelasma corniculum Hall							rr	cc	cc	c	cc	c						c	r							r	cc
Streptelasma profundum (Conrad)						c	r		r r							r								c	c		
Streptelasma sp.										r																	
Tetradium cellulosum Hall	cc		cc	cc									c c								c c						
Tetradium cylindricum n. sp.																				r							
Tetradium halysitoides Raymond				r																							
Tetradium fibratum Safford	c					cc	cc c		c							c											
Stromatoporoidea																											
Stromatopora sp.																			r								
Stromatocerium rugosum Hall																								c			

Vermes																											
Cornulites sp.	r																										
Crinoidea																											
Dendocrinus sp.		r																									
Crinoid stems					r																						
Bryozoa																											
Batostoma winchelli Ulrich							c																				
Batostoma sp.								r																			
Batostoma sp.								c																			
Coeloclema sp.																											
Dekayella praenuntia Ulrich								r																	r		
Dianulites rocklandense n.sp.						r		r		r																	
Eridotrypa trentonensis (Nicholson)	cc		?																								
Escharopora frondosa n. sp.						c																					
Escharopora sp.															c												
Favositella laxata (Ulrich)						c																					
Hallopora multitabulata (Ulrich)						c																					
Hemiphragma tenuimurale Ulrich								c																			
Nicholsonella ottawaensis n. sp.								r							r												
Pachydictya acuta (Hall)	c	r						c		r																	
Prasopora grandis Ulrich								cc																			
Prasopora cf *insularis* Ulrich								cc																			
Prasopora simulatrix var. *orientalis* Ulrich								cc		c																	
Rhinidictya fidelis Ulrich						r																					
Rhinidictya mutabilis Ulrich		r				c																					
Rhinidictya sp.						c																					

[1]Numbers at head of columns indicate divisions of sections.

Abbreviations: Low. for Lowville, Ch. for Chazy, Ayl. for Aylmer.

For collections from Rockland and MacLaren landing made by others, in which the horizon was not designated, the abbreviation "Un" (undifferentiated) has been used.

Table of Range of Lower Ordovician Species of Preceding Sections—CONTINUED

Genera and species	ROCKLAND												OTTAWA							MACLAREN LANDING							
	Black River							Trenton					Black River				Trenton			Ch.	Black River					Tr.	
	Lowville				Leray			Rockland					Low.	Leray			Rock-land			Ayl.	Low.	Leray				Rock.	
	Un	1	2	3	Un	4	5, 6	Un	7	8	9	10	1	2	3	4	5	6	7	1–4	5	Un	6	7	8	9	10
Brachiopoda																											
Camarotoechia plena Hall																				c							
Camerella panderi Billings								r																			
Camerella sp.								r																			
Crania trentonensis Hall						r																					
Crania sp.														r													
Cyclospira bisulcata (Emmons)								r																			
Dalmanella rogata (Sardeson)			?				r	cc	c	c	cc	c					r		r							r	r
Dinorthis sp.									r																		r
Glyptorthis bellarugosa (Conrad)					r	c	r		?																		
[1]*Lingula narrawayi* n. sp.													r														
[2]*Lingula obtusa* Hall																											r
Lingula sp.																				r							
Orthis disparilis Billings								r	c																		
Orthis tricenaria Conrad							r	cc	cc	c	cc	cc				r	r		c								c
Parastrophia hemiplicata Hall								r			r																c
Petrocrania ulrichi (Hall and Clarke)										r																	
Pianodema subaequata (Conrad)					c	cc	cc							r	cc	cc											

Plaesiomys sp.								r	r								r										
Platystrophia amoena McEwan																											r
Plectambonites sericeus (Sowerby)						r		cc	cc	cc	cc	cc							c								c
Plectorthis pectinella Hall									r			r					r										
Rafinesquina alternata (Emmons)					r	r	r	c	c	c		cc			c	r	cc		c				r	r			cc
Rafinesquina minnesotensis (N. H. Winchell)														c													
Rafinesquina rugosa n. sp.												cc							r								
Rafinesquina sp.												c											r				r
Rhynchotrema ainslei N. H. Winchell	r																										
Rhynchotrema increbescens Hall					c	c	c	c		r					c												c
Strophomena canadensis n. sp.																				r							
Strophomena filitexta Hall				r	r	cc	c	c	c	r		r		c	cc	r	c		r			r					cc
Strophomena cf. Scofield Winchell and Schuchert						r																					
Triplecia cuspidata (Hall)								r																			
Triplecia extans (Emmons)								r		r	r	r							?								
Zygospira recurvirostris (Hall)									r	r	r				c				c			c	r		r	c	c
Pelecypoda																											
Allodesma ? umbonata n. sp.																				r							
Clionychia ottawaensis Whiteaves																				r							
Clionychia sp.						r																					
Ctenodonta cf. *contracta* Salter						r																					
Ctenodonta levata Hall						r	r																				
Ctenodonta nasuta (Hall)							r																				
Ctenodonta sp.																				r							

[1]Some distance west of the Ottawa section.
[2]Found on plateau area but not at locality at top of the rest of section.

Table of Range of Lower Ordovician Species of Preceding Sections—CONTINUED

Genera and species.	ROCKLAND												OTTAWA							MACLAREN LANDING							
	Black River							Trenton					Black River				Trenton			Ch.	Black River					Tr.	
	Lowville				Leray			Rockland					Low.	Leray			Rock-land			Ayl.	Low.	Leray				Rock.	
	Un	1	2	3	Un	4	5, 6	Un	7	8	9	10	1	2	3	4	5	6	7	1–4	5	Un	6	7	8	9	10
Pelecypoda—*Con.*																											
Cyrtodonta cf. *billingsi* Ulrich									r																		
Cyrtodonta breviuscula Billings																				r							
Cyrtodonta canadensis Billings	c						r							r	c								c				
Cyrtodonta huronensis Billings	r						c		r																		
Cyrtodonta cf. *huronensis* Billings						r																					
Cyrtodonta planumbona n. sp.																				r							
Cyrtodonta subcarinata Billings	c																										
Cyrtodonta sp. (see Kingston sp.)		r	r	r									r		?						?						
Cyrtodonta sp.								r				r															
Cyrtodonta sp.																				r							
Endodesma sp.																			r								
Modiolopsis compacta n. sp.																				r							
Modiolopsis parviuscula Billings																				r							
Modiolopsis sp.																				r							

Pterinea sp.						r																					
Sowteria canadensis Raymond																				r							
Whitella subtruncata Hall	r																										
Gastropoda																											
Bellerophon sp.																					c						
Bucania halli Ulrich						c									r												
Bucania punctifrons Emmons										c																	
Bucania sp.								r	r								r										
Eccyliomphalus sp.	r																										
Eotomaria rotunda n. sp.																				r							
Helicotoma planulatum Salter	r																				c						
Hormotoma bellicincta (Hall)											c																
Hormotoma gracilis (Hall)	r					cc	r						r	r	r	c					c	c					
Hormotoma trentonensis Ulrich and Scofield										r	r	r															
Hormotoma sp.								r																			r
Liospira abrupta Ulrich and Scofield						r																					
Liospira americana (Billings)								c																			
Liospira progne Billings					r	r	r																				
Liospira vitruvia (Billings)																?			r								
Liospira cf. *vitruvia* (Billings)																						c					
Liospira sp.																											r
Lophospira bicincta (Hall)						r	r	r					r			r					c	r	c				
Lophospira cf. *bicincta* Hall				r																							
Lophospira perangulata Hall						r							r							r		r					
Lophospira cf. *perangulata* (Hall)																						r					
Lophospira ? *notabilis* Ulrich	c																										
cf. *Lophospira* ? *notabilis* Ulrich		r											r														
Lophospira sp.							r																				
cf. *Maclurina cuneata* Whitfield												r															

Table of Ranges of Lower Ordovician Species of Preceding Sections—CONTINUED

Genera and species.	ROCKLAND												OTTAWA							MACLAREN LANDING							
	Black River							Trenton					Black River				Trenton			Ch.	Black River					Tr.	
	Lowville				Leray			Rockland					Low.	Leray			Rock-land			Ayl.	Low.	Leray				Rock.	
	Un	1	2	3	Un	4	5, 6	Un	7	8	9	10	1	2	3	4	5	6	7	1–4	5	Un	6	7	8	9	10
Gastropoda—*Con.*																											
Maclurites logani Salter....								r		r																	
Maclurites sp. (opercula)...											r																
Maclurites sp.............																	r										
Metoptoma estella Billings...								r																			
Omospira alexandra Billings						r																					
Phragmolites compressus Conrad...............								cc	r	c	r																r
Phragmolites fimbriatus Ulrich and Scofield........	r																										
Protowarthia sp...........						r																					
Raphistoma distincta n. sp..																				cc							
Raphistomina cf. *lapidica* Salter.................					r																						
Raphistomina cf. *modesta* Ulrich.................		r																									
Salpingostoma sp..........										r																	
Sinuites cancellatus (Hall)..								c																			r
Straparollina sp..........																				r							
cf. *Strophostylus tectilis* Ulrich and Scofield.........						r																					

Subulites conradi Ulrich and Scofield															r											
Subulites elongatus Conrad								c																		
Tetranota bidorsata (Hall)																	r									
Trochonema umbilicatum (Hall)										r																
Trochonema sp.	r																									
Cephalopoda																										
Actinoceras bigsbyi Bronn						c								c										r		
Barrandeoceras cf. *vagrans* (Billings)														r												
cf. *Cyrtactinoceras champlainense* Ruedemann																				r						
Cyrtoceras sp.										r																
Cyrtoceras sp.													r													
Oncoceras huronensis Billings																r										
Oncoceras sp.																						r				
Orthoceras amplicameratum Hall					r																					
Orthoceras junceum Hall															r				c							
Orthoceras cf. *modestum* Ruedemann																				r						
Orthoceras multicameratum Emmons	c			r			r																			
Orthoceras recticameratum Hall	r																									
Orthoceras cf. *tenuistriatum* (Hall)															r											
Orthoceras sp.	r																									
Orthoceras sp.																						r				
Orthoceras sp.																										
Trilobita																										
Bathyurus extans (Hall)	c	c																								
Bathyurus cf. *extans* (Hall)			r																							

Table of Range of Lower Ordovician Species of Preceding Sections—Continued

Genera and species	Rockland													Ottawa							MacLaren Landing							
	Black River								Trenton					Black River				Trenton			Ch.	Black River					Tr.	
	Lowville				Leray				Rockland					Low.	Leray			Rock-land			Ayl.	Low.	Leray				Rock.	
	Un	1	2	3	Un	4	5, 6		Un	7	8	9	10	1	2	3	4	5	6	7	1–4	5	Un	6	7	8	9	10
Trilobita—*Con.*																												
Bathyurus spiniger (Hall)	r	r															r											
Bumastus indeterminatus (Walcott)													r															
Bumastus milleri (Billings)					r	cc	r																					
Bumastus trentonensis Emmons													r															
Bumastus sp.													r															
Bumastus sp.																					r							
Calymene senaria Conrad									c	r																		
Ceraurus dentatus Raymond and Barton																												r
cf. *Ceraurus dentatus* Raymond and Barton										r																		
Ceraurus pleurexanthemus Green									r																			
Ceraurus sp. (hypostoma)									r																			
Ceraurus sp.																											r	
Ceraurus sp.																								r				
Encrinurus cybeleformis Raymond																												r

Encrinurus cf. *cybeleformis* Raymond											r																
Encrinurus cf. *trentonensis* Walcott												r															
Illaenus angusticollis Billings						c	c																				
Illaenus sp.																r											
Isotelus gigas deKay	c					c		c													r					c	
Isotelus cf. *harrisi* Raymond																				r							
Pterygometopus sp.												r															
Trilobite hypostoma																											r
Ostracoda																											
Aparchites concinnus (Jones)																										r	
Isochilina armata Walcott		r																			r						
Isochilina cf. *Ottawa* (Jones)																				c							
Isochilina sp.		r																		r							
Leperditia fabulites (Conrad)		r				r																					
Leperditia trentonensis n. sp.																										r	
Leperditia sp.		r	r																		?						
Leperditia sp.										r	r																
Leperditia sp.																										r	
Leperditia sp.																				r							
Macrocypris? *siliqua* (Jones)																										r	
Primitia sp.																				r							

It will be noted from the preceding table that the sections at Ottawa and MacLaren landing are not as fossiliferous as that at Rockland, owing, partly, to the absence of the shale layers which at Rockland hold an abundant and well-preserved fauna. Not only are there fewer species, but very few species are abundant.

The absence of an echinoderm fauna in the Trenton beds in these sections is explained by the fact that the usual echinoderm-bearing strata in the vicinity of Ottawa and in the Trent valley are higher than the Rockland beds.

In the quarry at Rockland the Trenton beds lie conformably upon the Black River so that there appears to have been no emergence of the sea-bottom during the transition to the Trenton sea. Additional evidence of continuous deposition is afforded by the gradual change in the fossil content of the strata. A few specimens like *Tetradium fibratum* found in the upper part of the Lowville persist into the Trenton. The same may be said of *Strophomena filitexta*, but in both cases the height of the curve is reached in the Leray beds of the Black River. In layer No. 4 of the Black River there is a large *Tetradium* measuring 2 feet or more in diameter. Higher up in the Trenton beds the species is represented by specimens a few inches in diameter. Within the Black River there is, as is to be expected, a group of fossils confined to the Lowville, such as *Tetradium cellulosum;* and a group confined to the Leray beds, for example, *Pianodema subaequata;* while there are others which are found in both divisions, as *Orthoceras multicameratum*. Comparing the fossil content of the Black River with that of the Trenton we find evidence of the same condition, though different in degree. *Triplecia extans*, *Hormotoma trentonensis*, *Calymene senaria*, and others are confined to the Trenton beds. *Plectambonites sericeus*, on the other hand, makes its first appearance in the Leray beds of the Black River. Though this is generally fairly frequent in the Leray beds elsewhere, the specimens found here were few and far between, though they are quite common in the Trenton beds. The same history holds good for *Rafinesquina alternata* and others. There is, then, in the upper beds of the

Leray and in the lower beds of the Trenton a transition zone, during which period the life of the Black River sea gradually gave way to the life of the Trenton sea. This transition fauna is given in detail in the following tables. The same gradation is evident in the lithology; the fine-grained grey limestone of the Black River grades into the dove-tinted, coarser limestone of the Trenton beds. In the Ottawa section the lowest exposed beds of the Trenton and the top of the Leray beds are separated by a field concealing the contact. The former are tilted much more than those above or below, probably the result of a small fault. A small, abandoned quarry to the east of the road shows in one small area the line of a local fault. As remarked above, the interbedding of shale both in the Black River and Trenton, forms a less evident feature than at Rockland, and where it is present in some of the Trenton beds, the shales, unlike those at Rockland, are almost unfossiliferous. The lithology shows the same change as at Rockland, but on account of the lack of continuity in the exposures the gradations are not so evident. The fossil content also exhibits in the same way the evidence of a transitional period at the close of the Black River and the opening of the Trenton era.

The close relationship of the Trenton and Black River faunas is shown in the following table:

Comparison of faunas in Trenton and Black River	Leray	Rock-land
Spongiæ		
Hindia parva Ulrich	c	r
Incertæ Sedis		
Receptaculites occidentalis Salter	r	c
Anthozoa		
Columnaria halli Nicholson	c	–
Streptelasma sp.	–	r
S. corniculum Hall	rr	cc
S. profundum (Conrad)	cc	rr
Tetradium fibratum Safford	cc	c
Stromatoporoidia		
Stromatopora sp.	–	r
Stromatocerium rugosum Hall	c	–

Comparison of faunas in Trenton and Black River	Leray	Rock-land
Bryozoa		
Batostoma winchelli Ulrich	c	–
B. sp.	–	c
B. sp.	–	r
Coeloclema sp.	r	–
Dekayella praenmitia Ulrich	–	r
Dianulites rocklandense n. sp.	r	r
Escharopora frondosa n. sp.	c	–
E. sp.	c	–
Favositella laxata (Ulrich)	c	–
Hallopora multitabulata (Ulrich)	c	–
Hemiphragma tenuimurale (Ulrich)	–	c
Nicholsonella ottawaensis n. sp.	r	r
Pachydictya acuta (Hall)	–	c
Prasopora grandis Ulrich	–	cc
P. cf. *insularis* Ulrich	–	cc
P. simulatrix var. *orientalis* Ulrich	–	cc
Rhinidictya fidelis Ulrich	r	–
R. multabilis Ulrich	c	–
R. sp.	–	c
Brachiopoda		
Camerella panderi Billings	–	r
C. sp.	–	r
Crania trentonensis Hall	r	–
C. sp.	r	–
Cyclospira bisulcata (Emmons)	–	r
Dalmanella rogata (Sardeson)	r	cc
Dinorthis sp.	–	r
Glyptorthis bellarugosa (Conrad)	c	?
Lingula obtusa	–	r
Orthis disparilis Billings	–	c
Orthis tricenaria Conrad	r	cc
Parastrophia hemiplicata Hall	–	c
Petrocrania ulrichi (Hall and Clarke)	–	r
Pianodema subaequata (Conrad)	cc	–
Plaesiomys sp.	–	r
Platystrophia amoena McEwan	–	r
Plectorthis pectinella (Hall)	–	r
Plectambonites sericeus (Sowerby)	r	cc
Rafinesquina alternata (Emmons)	r	cc
Rafinesquina minnesotensis (N. H. Winchell)	c	–
Rafinesquina rugosa n. sp.	–	cc
Rafinesquina sp.	r	c
Rhynchotrema increbescens (Hall)	c	c
Strophomena filitexta Hall	cc	c
Strophomena cf. *scofieldi* Winchell and Schuchert	r	–
Triplecia cuspidata (Hall)	–	r
Triplecia extans (Emmons)	–	c
Zygospira recurvirostris Hall	c	c

Comparison of faunas in Trenton and Black River	Leray	Rock-land
Pelecypoda		
Clionychia sp.	r	–
Ctenodonta cf. *contracta* Salter	r	–
Ctenodonta levata (Hall)	r	–
Ctenodonta nasuta (Hall)	r	–
Cyrtodonta cf. *billingsi* Ulrich	–	r
Cyrtodonta canadensis Billings	c	–
Cyrotodonta huronensis Billings	c	r
Cyrotodonta cf. *huronensis* Billings	r	–
Cyrtodonta sp.	–	r
Endodesma sp.	–	r
Pterinea sp.	r	–
Gastropoda		
Bellerophon sp.	–	c
Bucania halli Ulrich and Scofield	c	–
Bucania punctifrons Emmons	–	c
Bucania sp.	–	r
Hormotoma bellicincta (Hall)	–	c
Hormotoma gracilis (Hall)	c	–
Hormotoma trentonensis Ulrich and Scofield	–	r
H. sp.	–	r
Liospira abrupta Ulrich and Scofield	r	–
Liospira americana (Billings)	–	c
Liospira progne Billings	r	–
Liospira vitruvia (Billings)	?	r
Liospira cf. *vitruvia* (Billings)	c	–
L. sp.	–	r
Lophospira bicincta (Hall)	c	r
Lophospira perangulata (Hall)	r	–
Lophospira sp. near *perangulata* (Hall)	–	r
L. sp.	r	–
cf. *Maclurites cuneata* (Whitfield)	–	r
Maclurites logani Salter	–	r
M. sp.	–	r
M. sp. (opercula)	–	r
Metoptoma estella Billings	–	r
Omospira alexandra Billings	r	–
Phragmolites compressus Conrad	–	cc
Protowarthia sp.	r	–
Raphistoma distincta n. sp.	–	cc
Raphistomina cf. *lapidica* Salter	r	–
Salpingostoma sp.	–	r
Sinuites cancellatus (Hall)	–	c
cf. *Strophostylus textilis* Ulrich and Scofield	r	–
Subulites conradi Ulrich and Scofield	r	–
Subulites elongatus Conrad	–	c
Tetranota bidorsata (Hall)	–	r
Trochonema umbilicatum (Hall)	–	r

Comparison of faunas in Trenton and Black River	Leray	Rock-land
Cephalopoda		
Actinoceras bigsbyi Bronn	c	–
Barrandeoceras cf. *vagrans* (Billings)	r	–
Cyrtoceras sp.	–	r
Oncoceras huronensis Billings	r	–
O. sp.	r	–
Orthoceras amplicameratum Hall	r	–
O. junceum Hall	r	c
O. multicameratum Emmons	r	–
O. cf. *tenuistriatum* Hall	r	–
O. sp.	r	–
Trilobita		
Bathyurus spiniger (Hall)	r	–
Bumastus indeterminatus (Walcott)	–	r
B. milleri (Billings)	cc	–
B. trentonensis Emmons	–	r
B. sp.	–	r
Calymene senaria Conrad	–	c
Ceraurus dentatus Raymond and Barton	–	r
cf. *C. dentatus* Raymond and Barton	–	r
C. pleurexanthemus Green	–	r
C. sp. (hypostoma)	–	r
C. sp.	–	r
C. sp.	r	–
Encrinurus cybeleformis Raymond	–	r
E. cf. *cybeleformis* Raymond	–	r
E. cf. *trentonensis* Walcott	–	r
Illaenus angusticollis Billings	c	–
I. sp.	r	–
Isotelus gigas Dekay	c	c
I. sp.	r	–
Pterygometopus sp.	–	r
Ostracoda		
Aparchites concinnus (Jones)	–	r
Leperditia fabulites (Conrad)	r	–
L. trentonensis n. sp.	–	r
L. sp.	r	–
L. sp.	–	r
Macrocypris ? siliqua (Jones)	–	r

In this table the comparison has been made of species in the lower Trenton and the upper Black River beds only, taking as a centre the transition zone mentioned above and including below, those beds which contain a strictly Black River-Leray fauna, and above, those beds which contain a strictly Trenton fauna. A study of the table reveals the gradual change from one fauna to the other.

About nineteen species common to both the Black River and the Trenton are shown in these three sections. Two are rare in both formations; five are relatively abundant in both, though some are more frequent in one or in the other; five are common in the Black River and rare in the Trenton; and eight are rare in the Black River and abundant in the Trenton. Of the remaining species, forty-nine do not appear above the Black River beds, and sixty-seven are confined to the Trenton. Of the forty-nine Black River specimens seventeen are found abundantly. Eight of these may be regarded as typical horizon markers for this district. These index species of the Black River are *Columnaria halli* Nicholson, *Stromatocerium rugosum* Hall, *Pianodema subaequata* (Conrad), *Rafinesquina minnesotensis* N. H. Winchell, *Cyrtodonta canadensis* Billings, *Bucania halli* Ulrich and Scofield, *Actinoceras bigsbyi* Bronn, *Bumastus milleri* Billings. A ninth species, *Hormotoma gracilis* (Hall), is common in these beds and does not appear in the lower Trenton section though it is found in higher Trenton beds at Hull and elsewhere, suggesting that it is a recurrent species. Of the sixty-seven species confined to the Trenton beds twenty are abundant, and of these twenty some of the most distinguishing horizon markers are *Prasopora simulatrix* var. *orientalis* Ulrich, *Triplecia extans* Hall, *Plectorthis pectinella* (Hall), *Parastrophia hemiplicata* Hall, *Sinuites cancellatus* (Hall), *Bucania punctifrons* Emmons, *Phragmolites compressus* Conrad, *Hormotoma trentonensis* Ulrich and Scofield, *Hormotoma bellicincta* (Hall), *Encrinurus cybeleformis* Raymond, *Calymene senaria* Conrad, and *Ceraurus dentatus*, Raymond and Barton.

DESCRIPTION OF NEW SPECIES

Tetradium cylindricum n. sp.

Plate III, figure 3

Figure 5. A. Cross section of an average cylindrical corallite.
B. Cross section of a mature corallite, showing the tendency to become four-sided.
C. Budding of young corallite.

This *Tetradium* is similar to *Tetradium cellulosum* in every respect except in the shape of the average corallite. When growing singly or on the edge of a 'bundle' there is a marked tendency to a cylindrical form, whereas the mature corallite of *Tetradium cellulosum* is four-sided. Also, in the few specimens at hand there appears to be less of a tendency to closely unite in bundles, and there is a larger proportion of individual corallites. A larger collection, however, might show this to be an accidental feature.

The young corallite buds from the mature one, enlarging its diameter fairly rapidly; it continues its growth, in the majority of cases, in the same cylindrical form. The walls of some specimens, in advanced age, thicken half-way between the septa, resulting in a tendency to a four-sided corallite. The Lowville species *Tetradium cellulosum* in its nepionic stage has the same cylindrical form, but each corallite soon assumes the typical *Tetradium* form. The Lowville species, apparently, is the direct descendant of the Chazy species.

Formation and Locality. Chazy: Aylmer limestone. MacLaren landing.

Dianulites rocklandensis n. sp.

Plate II, figures 1, 2

Large, irregular branches measuring about 7 mm. in diameter.

Internal Characteristics. The walls of the tubes have a pronounced granular structure. A vertical section shows that they are somewhat crenulated especially at the initial stage of the young tubes which expand very rapidly. Diaphragms wanting in the axial region but present in the peripheral region being from half their width to their width apart. A tangential section emphasizes the granular structure of the walls. The tubes are polygonal, partly separated from one another by angular mesopores. The mesopores are so variable in size that it is sometimes difficult to distinguish the larger ones from the true zooecia.

D. rocklandensis differs from the only other known American species in its ramose growth, in having few diaphragms and smaller tubes. It averages about five tubes in 2 mm. more nearly than four. It resembles the Russian species *D. fastigiatus* in the variability of the size and shape of its mesopores, but differs from it in its general shape and in its diaphragm system.

Formation and Locality. The Leray beds of the Black River and the Rockland beds of the Trenton at Rockland, Ont.

Nicholsonella ottawaensis n. sp.

Plate II, figures 3, 4

Zoarium, irregular, flattened mass. The complete colony was not found. The surface is too worn to preserve its characteristics.

Internal Characteristics. A tangential section shows large zooecia averaging from three to four in 1 mm. Near the surface the apertures are round and completely isolated, the interspaces being occupied by prominent tubuli, the larger ones of which have their origin in the older region where they are exhibited as strong, definite, numerous acanthopores, as shown by the section taken farther below the surface. This section also shows the zooecia as varying from round to polygonal and only slightly separated from one another by a few angular mesopores.

In a vertical section the walls are seen to be slightly crenulated, never definite, and exhibit a diffuse granular structure. The young tubes arise in the axial region and expand rapidly as in *Nicholsonella pulchra*. The diaphragms are few and far between in the axial region, but in the peripheral region are more numerous, averaging from once to twice their own length apart.

The species is readily distinguished from others of this genus by the size of its zooecia, the strong numerous acanthopores, and the fewness of the mesopores and diaphragms.

Formation and Locality. Leray beds of the Black River, 3 miles east of Ottawa and Rockland beds at Rockland.

Escharopora frondosa n. sp.

Plate II, figures 5, 6

A bifoliate frond having fairly numerous monticules with only slightly enlarged zooecia. The apertures have the typical intersecting *Escharopora* arrangement and are surrounded by sloping hexagonal areas. The longitudinal axis is the greater. In 2 mm. there are from eight to nine zooecia taken across the frond, seven taken on the diagonal, and four taken vertically. This difference in number is due in the main to the arrangement of the zooecia, not to the difference in the length and breadth of the apertures. It will be seen that the intersection of rows means that there will be at least three apertures of an adjacent row dove-tailed into any four that are taken in a true vertical measurement.

Internal Characteristics. A vertical section is almost identical with *E. confluens* except that the frond is thinner. A tangential section, however, shows that the zooecia of *E. frondosa* are not as elongated as those of *E. confluens*, although they do exhibit some tendency towards the "confluent" form of the latter. The species, however, is readily distinguished by the form of growth of the colony.

Formation and Locality. In the Leray beds of the Black River at Rockland.

Lingula narrawayi n. sp.

Plate III, figure 4

The shell is subspatulate in general outline and inclined to be convex. A somewhat sloping surface, varying from rounded to plane, on the top of the brachial valve, forms an isosceles triangle extending with the apex at the beak to a rounded base at the anterior margin. The brachial valve is oval, pedicle valve ovate, beak acuminate, and the anterior margin rounded. The ratio of the maximum length to the maximum width of the average shell is about as 5 to 3, the widest part being a little in front of the middle. From this point to the front margin the sides are almost parallel; toward the beak, however, they converge more rapidly. The pedicle valve, particularly, has a very acuminate beak, and from its average length, which is somewhat greater than that of the other valve, it is probable that the beak projects beyond that of the brachial valve. No specimen was found having the two valves together. The largest pedicle valve observed shows a broken scar of a long septum extending anteriorly two-thirds the length of the shell, but otherwise the markings of the interior are very obscure.

The surface is covered with fine, concentric striæ, and some specimens show an exceedingly minute radial striation.

The shell is punctate and evidently extremely thin and tenuous, as all of the larger shells are much wrinkled.

The specimens are very small, the largest pedicle valve found measuring only 10 mm. in length, and 6 mm. in width at the widest place; the largest brachial valve found is 8 mm. in length and 4½ mm. in width; the average shell being only 5 mm. in length and 3 mm. in width.

Lingula narrawayi appears to be distinct from any described species of *Lingula*. It is similar in shape to *Lingula daphne* Billings, and *Lingula riciniformis* Hall, but is a much thinner shell, and differs from them in details of surface sculpture. The pedicle valve, too, is somewhat longer and narrower than that of either of these forms.

Formation and Locality. Lowville, Parkdale avenue Ottawa, some distance west of the rest of the Ottawa section.

The specimens are in the private collection of Mr. J. E. Narraway, Ottawa, for whom the species is named.

Strophomena canadensis n. sp.

Plate III, figure 7

Width of shell slightly greater than length, the greatest width being about the middle of the shell. The measurements of the best preserved valve are: length 13 mm.; width 17 mm.; width of hinge line 14 mm.

The shell in its nepionic stages is comparatively flat; the complexity increases gradually with age until at maturity it has an evenly-rounded convex form slightly resupinate at the extremities of the cardinal edge. A shallow depression begins at the beak, broadens out over the umbonal region, and gradually becomes more shallow and almost disappears at the ventral margin. Striæ fine, from 9 to 11 in 12 mm. towards the anterior margin, increasing by bifurcation and implantation, principally the latter. There is a general gradual increase in the number of striæ with increased growth, but at two places there is a marked increase, almost entirely by implantation, one about half-way between the beak and the margin, and the other, and more marked one, about two-thirds of the distance from the beak. The added striæ are fine and with the more mature ones produce an effect of alternating coarse and fine radiations. The shell is crossed by fine growth lines, which towards the anterior margin almost become crenulations. The whole surface is finely punctuate.

The interior is not shown except that a slight exfoliation at the apex of the beak of one of the specimens shows the extreme point of the plates bordering the dental sockets.

The shell averages smaller than *S. prisca* Raymond, and the alternations of the stria differ. *S. prisca* has two or three finer ones between the stronger striæ. *S. canadensis* generally alternates one large and one small. *S. canadensis* differs also in possessing the shallow but evident depressión.

Locality and Formation. Several brachial valves were found in the Chazy limestone at MacLaren landing.

Rafinesquina rugosa n. sp.

Plate III, figures 8, 9

The general shape is concavo-convex. The greatest width of the shell is along the straight hinge line. The width averages 10·1 mm.; the length 7·1 mm. The sides and cardinal area make an angle of 90 degrees; the sides are almost straight for two-thirds of the length. The anterior margin is broadly rounded. The striations increase by interpolation and bifurcation, several fine striæ lying between the coarser ones. Concentric growth lines are present. The surface is rugose, with alternating elevations and pits, the elevations being arranged in concentric series greatly exaggerating the effect of the concentric growth lines, particularly on the anterior margin, and on the wings of the hinge line.

The pedicle valve is rounded with an even rising on the umbonal region, which terminates in a small but acute beak projecting beyond the hinge line. In the anterior third the convexity of the shell is decidedly increased, and a slight, narrow fold rises into prominence, topped by the largest median striation which is not particularly conspicuous in the umbonal region. The rugose surface ornamentation is somewhat more conspicuous on the pedicle valve, on account of its greater convexity.

The brachial valve is slightly concave at the beaks becoming convex along the last quarter towards the anterior margin. The sinus is very slight, not being present in a great many of the specimens. The ornamentation is the same as in the pedicle valve but less conspicuous.

It is readily distinguished from the other Trenton *Rafinesquina* by its smaller size. It is, perhaps, most nearly related to *Rafinesquina declivis* James, from which, however, it differs in its smaller size and straighter sides without any tendency to the triangular form; and in its unique ornamentation. In the latter respect it shows an affinity with *Leptaena charlotta*, from which it is easily distinguished by its general shape and proportions.

Locality and Horizon. In the top of the lowest Trenton beds exposed at the Stewart quarry, Rockland, and at an exposure of the same horizon about 3 miles east of Ottawa.

Rafinesquina?, sp. undt.

Plate III, figures 10, 11

In the upper beds at Rockland and less frequently at Ottawa is found a Rafinesquina-like brachiopod. Only the pedicle valve is present and no specimen is sufficiently well preserved to admit of an adequate description. In general size and shape it resembles *Rafinesquina alternata*, but numerous exfoliated specimens show a long, medium septum with a shorter one on each side. Along the hinge line are small but evident crenulations and the whole surface is highly punctate. One specimen was found in the top of the Leray beds at MacLaren landing. In spite of the weathering of the specimens the three septa are well defined.

Formation and Horizon. In the lowest Trenton at Rockland and Ottawa and in the uppermost Black River at MacLaren landing.

Cyrtodonta? planumbona n. sp.

Plate IV, figures 1, 2

The measurements of the best-preserved specimen are: length 28 mm.; height 16 mm.; depth of convexity 5 mm. Shell evenly convex, umbonal ridge not distinct, beak in anterior quarter of shell. Posterior margin evenly-rounded with a rather narrow curve, ventral margin gently convex, anterior marginal curve narrower than that of the posterior. The interior mould —the only specimen at all well preserved—shows three concentric growth ridges, broad, and so rounded as to be hardly perceptible. Across the umbonal region are faint traces of three radiating striæ, far apart and indistinct. The anterior muscle scar is fairly prominent, the posterior is larger and but very faintly impressed. The pallial line is present, though indistinct.

It differs from *Cyrtodonta scala* and *C. solitaria* in size and general shape, from *C. lamellosa* in outline, particularly the form of the anterior and posterior margins.

The three radiating, almost imperceptible, impressions are not features of *Cyrtodonta*, but as the muscle scar, the position of the beak, and the general outline of the shell agree with *Cyrtodonta*, it is placed provisionally in that genus.

Horizon and Locality. Chazy: Aylmer limestone at MacLaren landing.

Modiolopsis compacta n. sp.

Plate IV, figure 3

Average length 20 mm.; average width 12 mm.; average depth of convexity 4 mm.

The size is rather variable. One specimen procured is only 16 mm. in length and 10 mm. in width; another specimen is 14 mm. in width, and, were the complete length preserved, must have been about 25 mm. Valves very inequilateral. The anterior portion of the shell is short and narrowly rounded; the posterior is much broader and longer. The hinge line forms an angle with the curve of the posterior margin at about the middle of the shell. The valves are deepest at about one-third from the anterior margin. The beaks are small incurved, and placed at about a quarter of the distance from the anterior end. The umbonal region is prominent, almost sharp in casts, particularly in the anterior portion; specimens having the test preserved are more uniformly rounded. A shallow sinus is present, commencing at the beak and broadening out until at the ventral margin it only slightly alters the convexity of the marginal outline. The surface is marked with concentric growth lines. The muscle scars are faintly impressed.

Of the Chazy *Modiolopsis* already described it seems most closely allied to *Modiolopsis fabaeiformis* Raymond but differs from it in size, in the proportionate length of the hinge line, and the length of the posterior portion, also in the position of the most convex portion of the shell.

Horizon and Locality. Chazy: Aylmer limestone at MacLaren landing.

Allodesma? *umbonata* n. sp.

Plate IV, figure 4

Shell small, exact measurements not available, as there is no complete specimen; the contour, however, indicates a small shell, the largest specimen being approximately 14 mm. long and 8 mm. wide. The other two fragments when completed would apparently be about two-thirds of that size. Anterior margin rounded, posterior margin not preserved. Umbonal ridge prominent, somewhat flattened on the top, ending anteriorly in a small prominent beak, only slightly incurved. Towards the posterior the umbonal ridge gradually disappears in the generally moderate convexity of the shell. A shallow sinus crosses the shell obliquely, broadening out and almost disappearing towards the ventral margin. Concentric growth lines are present and are more prominent towards the margin. On one of the moulds is the impression of two obscure rays on the posterior umbonal slope.

Anterior muscle scar very marked, bounded on the top and posterior side by a deep groove, extending downward from the hinge in front of the beak. There is no trace of the posterior scar, but, if present on the somewhat imperfect posterior, it must be very faint. The pallial line is not apparent on the specimens found.

One specimen exhibits a piece of a broken cardinal tooth; the rest of the tooth-bearing portion is crushed and mixed with the matrix.

The placing of this species in the genus *Allodesma* is not quite satisfactory, and cannot be so until a specimen is found showing the tooth system more clearly. Also, the one species of that genus already described comes from the Trenton formation. The Chazy species differs from *Allodesma ellipticum* in having a more obtusely-rounded anterior margin, and a more prominent umbonal ridge which results in producing the shallow sinus anterior to the ridge. The concentric growth lines and the obscure radial lines are coarser than in the Trenton species. Also, the groove marking the ridge at the posterior border of the anterior muscle scar is curved, not linear.

Formation and Locality. Three specimens were found in the Chazy: Aylmer limestone at MacLaren landing.

Eotomaria rotunda n. sp.
Plate IV, figures 5, 6, 7

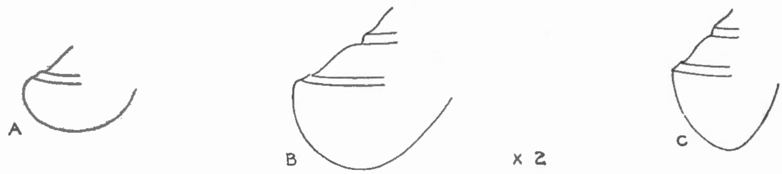

Figure 6. Comparison of umbilicus slope and upper surface of
A. *Eotomaria rotunda* n. sp.
B. *E. supracingulata.*
C. *E. dryope*

Width 21 mm.; height 14 mm.

The shell has four whorls, gradually expanding. Aperture not well preserved, but a portion broken out of the last whorl shows a section very similar to *E. supracingulata.* The band is on the upper side of the whorl, which is concave from the band to the suture line. Each whorl rises a little above the outer one next it, giving a slightly turreted effect. Umbilicus large, being considerably more than one-third the width of the shell. Surface markings obliterated, except faint indications on one whorl, which as far as they go correspond to the markings of *E. supracingulata.* It differs from *E. supracingulata*, however, in size, in having the upper portion of the whorl concave on the whole surface from the band to the suture line, instead of being convex on the upper portion of this surface, and in more abrupt walls of the umbilicus. The size and upper surface more nearly correspond to *Eotomaria dryope*, though unlike *E. rotunda* Billings, species has narrow but marked convexity of the upper surface of the whorl near the suture line. The greatest difference, however, is shown on the under side. In the MacLaren Landing species the under side of the whorl is more evenly rounded and almost flat in the middle, making a rounded drop to the umbilicus. The sides of the umbilicus of *E. supracingulata* have a more gradual slope and the section of the whorl is more acute on the under side. This difference is more strongly contrasted in *E. dryope*. The umbilicus of the latter is narrower with still more abrupt sides. A cross section shows the angle of the underside more acute than either *E. rotunda* or *E. supracingulata*, and farther from the margin of the shell.

Horizon and Locality. Chazy: Aylmer limestone at MacLaren landing.

Raphistoma distincta n. sp.

Plate IV, figures 9, 10, 11

The shell varies in width from 6 mm. to 22 mm. An average specimen is 15 mm. in width, spire 2½ mm., total height 9 mm. The low spire consists of three volutions gradually enlarging, flat on the top, acute on the peripheral margin, convex below. It is noticeable that the larger and older a specimen is, the more acute the margin becomes; in some of the older specimens the peripheral border is raised. The younger specimens are more rounded in every particular. The umbilicus is about a third of the width of the shell. It is well defined by the angle of the underside of the whorl. In no specimen, however, among more than fifty examined, is it entirely free from the matrix. In very few specimens is the marking preserved, and always but faintly. The striæ commence at the suture and pass forward for about one-third the width of the top of the whorl, where they curve back sharply to the peripheral edge. There is no specimen showing the striæ passing over the margin, but on the lower side they again turn forward until the most convex portion of the underside of the whorl is reached, where they again curve backward and continue down the slope of the umbilicus.

In general outline and in size and shape of the umbilicus, this species resembles *Raphistoma apertum*, except that the upper surface of the whorl is flat instead of convex near the suture line and concave near the periphery, in the more accentuated curves of the striæ, which proceed much farther towards the lip of shell before they curve backward again. The species differs from *R. peracutum* in having a slight spire and in the course of direction of the striæ. It differs from *R. immaturum* (Billings) in having fewer whorls, in the angle at the peripheral margin, in the shape and size of the umbilicus, and in the pronounced curves of the striæ.

Horizon and Locality. Chazy: Aylmer limestone at MacLaren landing.

Leperditia trentonensis n. sp.

Plate IV, figures 12, 13

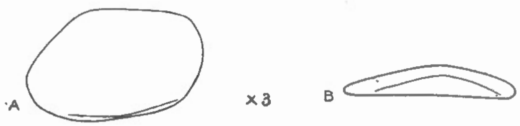

Figure 7. *Leperditia trentonensis* n. sp.
A. View from above, showing outline.
B. Profile of the specimen taken from the ventral margin, showing the spine-like tendency of the convexity of the shell.

Length 8 mm.; width 4½ mm.

The surface is smooth but not shiny. The eye-spot is very indistinct. The most striking feature is the abrupt inturning of the convexity of the shell, just anterior to the centre of the ventral margin, almost producing a resemblance to a blunt spine when viewed in profile.

In general outline this species differs from *Leperditia canadensis louckiana* in that it is on the whole less convex, and the maximum of its convexity is near the ventral margin. Except for the abrupt termination of its convexity, it is more closely in accord with Black River species of Paquette Rapids *Leperditia canadensis paquettiana* Jones, but it differs from it in being less convex and in being longer in proportion to its width.

Paquette Rapids species, 7: 4½ mm.

MacLaren Landing species, 8: 4½ mm.

It differs from *Leperditia ovata* Jones in the position of its greatest convexity, in having the ventral and dorsal margins more nearly parallel, and in its proportionate length and width.

Leperditia ovata, 7: 5 mm.

MacLaren Landing species, 8: 4½ mm.

Horizon and Locality. Lowest Trenton at MacLaren landing.

THE FOSSIL MOLLUSCAN FAUNAS OF THE MARL DEPOSITS OF THE OTTAWA DISTRICT

By E. J. WHITTAKER

INTRODUCTION

Many deposits of marl throughout the Ottawa district contain freshwater molluscan remains and, more rarely, terrestrial shells. One of the most accessible and best known occurs at McKay (formerly Hemlock) lake, Rockcliffe, 3 miles east of Ottawa. Deposits of the same character occur at Colton lake, near Renfrew, and Mink lake, near Eganville. [1]Another locality is represented by a collection of fossils in the Victoria Memorial Museum labelled marl, lot 7, Junction gore, Gloucester tp., Carleton co., now included in the town of Eastview.

Marl from all these localities was formerly used in making lime and also, when mixed with clay, in the manufacture of cement. In the early days, and even yet in places, marl is used for whitewashing buildings.

The McKay Lake marl beds which are of Recent age were deposited just after the retreat of the last marine invasion and antedate the historic period by many centuries. The other deposits are somewhat younger.

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[1] The writer is indebted to E. M. Kindle, of the Geological Survey, Canada, at whose suggestion this study was initiated, for valuable assistance and advice; to Dr. F. C. Baker, of the University of Illinois; and to Miss A. E. Wilson and M. E. Wilson, of the Geological Survey, for procuring material for him from Mink and Colton lakes respectively.

RELATIONSHIPS OF THE MARL DEPOSITS

McKay lake is 500 yards long and 200 yards wide, with its longer axis approximately north and south. On the west side there is an escarpment of Chazy sandstone, but on all other sides Pleistocene and Recent deposits form the shore. Cross-bedded gravel and sand border the south side, but on the south-east only sand occurs. To the north are typical Leda clays, rising, like the sand and gravel, 18 to 25 feet above the present level of the lake, or about 40 feet above Ottawa river. Above the sands, on the south and east sides of the lake, extending to its northern end, is the marl deposit which at present is disconnected owing to the large amount of material removed for commercial purposes. At the time of the retreat of the Champlain sea from Ottawa valley the water of McKay lake stood at an elevation at least 20 feet higher than at present. The waters from the lake commenced eroding a channel to Ottawa river through the soft, unconsolidated, marine clays now found at its north end. The marl was deposited while the water remained at this high level. Its source was doubtless lime leached from the marine clay and subsequently precipitated either from solution chemically, or by the Chara which is still found in the lake, or in both ways. The marl consists in part of shells and shell fragments, but for the most part of a fine, impalpable powder. Owing to the high grade of the outflowing stream through this material, erosion must at first have been very rapid. When the stream had cut back to the outlet, the waters of the lake probably fell rapidly to about their present level, and being no longer so continuously in contact with the marine clay, marl deposition practically ceased. The valley of the stream is from 80 to 100 feet wide at the top and from 25 to 40 feet deep. Owing to its low grade the stream is now eroding its channel much more slowly.

The marl as noted above is from 18 to 25 feet above the present level of the lake, and overlies crossbedded gravels and sands. It is from 3 to 5 feet thick and is overlain thinly by soil and peaty matter on which grows a luxuriant forest of large trees and underbrush. The marl is yellowish white to pure white, and very slightly coherent. A block placed in water breaks down like loaf sugar. In procuring fossils a large block was placed in a pail of water and allowed to soak for some hours. As most of the shells contained small quantities of air, they floated to the top when the block disintegrated, and were removed with a sieve. A partial account of the McKay Lake fauna has already been published.[1]

At Colton lake and at Mink lake the marls occur only a short distance above the present water level, and on account of the greater differentiation of the fauna, as well as the slightly fresher appearance of some of the shells, it would appear that the McKay Lake deposit is much older than the others.

GENERAL CHARACTERISTICS OF THE FAUNA

Most of the specimens are so perfectly preserved that the finest ornamentation remains unabraded, but the original colour has been lost and most of the shells are pure white. In addition to the freshwater species, a few terrestrial molluscs which are found in the marl beds are included in the description of the fauna. Such forms, of course, have been washed accidentally into the water. In the descriptions of the species which follow, the characteristics of the living animal and the colour of the shell when living have been omitted, so that only those characters which can be recognized in fossil forms have been enumerated. Certain genera and species are difficult to differentiate in the fossil state, as they have been founded on anatomical differences in the living animal. As most of these species are still extant, this description may be used to identify these forms in present lakes and streams, so far as this may be done from shell characters.

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[1] Whittaker, E. J., "The relationships of the fossil marl fauna of McKay lake, Ottawa, to the present molluscan fauna of the lake." Ottawa Naturalist, vol. 32, No. 1, April, 1918.

LIST OF SPECIES

The following species have been found in the marl deposits:

MOLLUSCA

Class PELECYPODA

Family *Sphaeriidæ*
- *Sphaerium simile* Say
- *Sphaerium solidulum* Prime
- *Sphaerium stamineum* Conrad
- *Pisidium abditum* Haldeman
- *Pisidium compressum* Prime

Class GASTROPODA

Family *Helicidæ*
- *Polygyra albolabris* Say
- *Polygyra* (*Stenotrema*) *monodon* Rackett

Family *Endondontidæ*
- *Pyramidula* (*Patula*) *alternata* Say
- *Helicodiscus lineatus* Say

Family *Succinidæ*
- *Succinea ovalis* Say

Family *Lymnaeidæ*
- *Lymnaea stagnalis appressa* Say
- *Lymnaea obrussa* Say
- *Lymnaea obrussa decampi* Streng
- *Lymnaea galbana* Say
- *Planorbis antrosus* Conrad
- *Planorbis campanulatus* Say
- *Planorbis altissimus* Baker
- *Planorbis deflectus* Say

Family *Physidæ*
- *Physa gyrina* Say

Family *Amnicolidæ*
- *Amnicola limosa* Say
- *Amnicola porata* Say
- *Amnicola lustrica* Pilsbry

Family *Valvatidæ*
- *Valvata sincera* Say
- *Valvata tricarinata* Say

DESCRIPTION OF SPECIES

Sphaerium simile Say

Plate VI, figures 1a–1d

Shell large for the genus, transversely oval, umbones inflated just in front of middle of shell, making it thus nearly equilateral; dorsal margin almost straight; ventral margin gently rounded, anterior and posterior margin rounded; lines of growth distinct but not very coarse, with occasional concentric ridges. Cardinal teeth small, lateral teeth double in the right and single in the left valve.

[1]L. 16 H. 11·25 B. 8·25

Locality. Lot 7, Eastview.

This bivalve is not common. It is by far the largest of the fossil Sphaeriidæ and hence is readily recognizable. The nearly median position of the beaks is a feature distinguishing this form from others likely to be encountered in the Ottawa valley.

Sphaerium striatinum Lamarck

Plate VI, figures 2a–2d

Shell inequilateral, solid; umbones placed anterior to centre of shell, smooth or covered by fine lines, dorsal margin arched, ventral rounded, posterior margin obtusely angled, anterior margin rounded. Lines of growth coarse toward the ventral margin of the shell; cardinal teeth small and inconspicuous, lateral teeth more prominent, double in the right, single in the left.

L. 9·75 H. 8 B. 5·5

Locality. Lot 7, Eastview.

From the preceding species *S. striatinum* may be distinguished by its more markedly inequilateral shell and smaller size. It is fairly common.

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[1] Abbreviations used throughout report: H.=height in mm.; B.=breadth in mm.; L.=length in mm.; G.D.=greater diameter in mm. b.D.=smaller diameter in mm.; L.D.=lesser diameter in mm.; W.=width in mm.; A.H.=aperture height in mm.; A.W.=aperture width in mm.

Sphaerium solidulum Prime ???

Plate VI, figures 3a–3d

Shell approximately trigonal in outline, solid, inflated, umbones elevated anterior to centre of shell covered with fine ridges, growth lines coarse with finer lines between; ventral margin rounded, dorsal strongly arched.

L. 8·5 H. 7·5 B. 6

Locality. Lot 7, Eastview.

Several specimens in the old collections at the Victoria Memorial Museum seem to be referable to this species. The writer was unable to find any specimens and it is included here with a query. It is a compact, stout little shell with a pronounced trigonal outline, and is quite different from either of the preceding forms.

Pisidium abditum Haldeman

Plate VI, figures 5a–5b

Shell small, full, inequilateral, sub-oval; umbones placed a little behind the centre, inconspicuous; surface shiny, growth lines faint; dorsal and ventral margins rounded, anterior and posterior margins rounded; cardinal teeth small, lateral teeth conspicuous projecting above the edge of the valve, double in the right and single in the left valve, cavity of the beak small.

L. 2·5 H. 2·0 B. 1·25

Locality. McKay, Colton, and Mink lakes.

Pisidium abditum is the most common of the small pelecypods in the marl.

Pisidium cf. *compressum* Prime

Plate VI, figures 4a–4c

The specimen figured resembles P. compressum, but varies from the typical form in not having the anterior margin produced so far forward and in its less trigonal outline.

L. 4·1 H. 3·9 B. 2·4

Locality. Colton lake.

This form is rather uncommon. Other species of Pisidium will, perhaps, be found in these marl beds.

Polygyra albolabris Say

Plate VI, figures 6a–6c

Shell large, fairly solid, depressed globose. Whorls covered by fine oblique striæ, somewhat more prominent on apical than umbilical aspect, revolving lines irregular, very minute; whorls five to six, rounded above and below, gradually increasing; sutures deeply impressed, periphery rounded, aperture rounded; shell constricted just behind the aperture; peristome thick, smooth, and reflected, not continuous; lower end of peristome reflected over the umbilicus rendering it imperforate.

G. D. 29 S. D. 23 H. 18

This gastropod is much larger than any other in the vicinity and can be readily distinguished by its reflected aperture, semi-globose shape, and covered umbilicus.

Polygyra monodon Rackett

Plate VI, figures 10a–10d

Shell small, solid, surface covered with minute growth lines, but occasionally almost smooth, convex above and below, periphery rounded, sutures deep; whorls five to five and a half, slightly flattened on top, broadly rounded below, increasing gradually, though slowly, last whorl constricted just back of the aperture; spire somewhat elevated; aperture narrow lunate; peristome thick, reflected, smooth; thin callus on the parietal wall, on which is a long, thin tooth between the terminations of the peristome and roughly parallel to its lower edge; umbilicus partly open, occasionally imperforate.

G. D. 10·5 S. D. 9·00 H. 6

Locality. Marl beds, McKay lake.

This shell is readily distinguished by the large tooth on the parietal wall, narrow aperture, and open umbilicus.

Pyramidula (Patula) alternata Say

Plate VI, figures 7a–7c

Shell fairly large, thin shelled, depressed globose; surface covered with coarse, oblique lines of growth, periphery sub-carinate; sutures deeply impressed; whorls five or five and a half gradually expanding; aperture obliquely rounded; peristome simple, thin, incomplete. A thin callus occasionally present between the terminations of the peristome; umbilicus very large, round, showing all the volutions.

G.D. 22 L.D. 20 H. 10

Locality. Marl beds, McKay lake.

This form is readily distinguished from all others likely to be encountered. From *Polygyra albolabris* it varies in having a simple, non-reflected peristome and a large, wide-open umbilicus. Living individuals of this species have brilliant red colour markings, especially on the upper surface. These, however, have mostly disappeared in the fossil specimens.

Helicodiscus lineatus Say

Plate VI, figures 9a–9c

Shell small, thin, flat, discoidal, surface covered by oblique growth lines and numerous fine parallel revolving lines; periphery rounded, sutures deep; whorls four to four and a half, rounded, not increasing in size; spire flat, on same plane as the whorls. Aperture small, oblique, outer lip bearing several small conical teeth; peristome thin, sharp, terminations connected by a thin callus, umbilicus large in proportion to the shell, showing all the volutions and also the oblique lines of growth.

G.D. 3·00 L.D. 2·85 H. 1·25

Locality. Colton lake; also from marl beds, McKay lake, fragments only.

This very small land shell is readily recognized by the pronounced parallel revolving lines upon its surface as well as by its very large umbilicus, which show the volutions so distinctly. Fragments are often found, but the complete shell is not common.

Succinea ovalis Say

Plate VI, figures 8a–8b

Shell thin, very fragile, obliquely ovate. Surface covered by fairly coarse lines of growth. Whorls three, rapidly expanding, expecially the last; spire short, sutures fairly deep; aperture very large, oblique, oval, occupying nearly three-quarters of the whole shell. Peristome very thin, simple, with the termination connected on the parietal wall by a thin callus; umbilicus absent.

H. 11 W. 7·25 A.L. 8·5 A.H. 6

Locality. Marl beds, McKay lake.

Succinea ovalis is a form whose very large aperture is sure to attract attention. The forms encountered here are smaller than usual. It is a rather common gastropod at present and is generally found close to water.

Lymnaea stagnalis appressa Say

Plate VII, Figures 12a–12b

Shell elongated, thin; surface showing numerous rather fine growth lines; revolving lines numerous but irregular, very minute; whorls six to six and a half, rapidly increasing, especially the last whorl, which is much dilated and enlarged; spire long, very acute; sutures distinct; aperture large, ovate; peristome thin, sharp, lower part rounded; umbilicus covered by a spreading callus.

H. 19·5 W. 10·5 A.H. 10 A.W. 6

Locality. Lot 7, Eastview.

The above measurement is that of the best specimen found, but the average measurements of the species are over twice those given above. This Lymnaea is common at the present day and is plentiful in the marl beds in a fragmentary condition, but, owing to its thin shell and large size, it is seldom found complete. The large size of the last whorl compared to the others and the large aperture with its thin peristome, serve to distinguish it from other Lymnaeas. This form varies in height and width and has been given many varietal names.

Lymnaea obrussa Say

Plate VII, figures 11a–11b

Shell solid, elongate ovate in shape; surface dull, lines of growth coarse and covered by fine spiral lines, the body whorl occasionally malleated; whorls five or six regularly expanding, rounded; spire acutely conic, sutures deeply impressed; aperture roundly ovate; outer lip thin, sharp; inner lip reflected over the umbilical region leaving a very narrow chink; callus on the parietal wall heavy and smooth; shell sometimes nearly imperforate.

H. 18·0 W. 9·0 A.H. 8·0 A.W. 4·1

Locality. Marl beds, McKay lake.

This shell is rare and in the marl beds it is almost impossible to find complete specimens. The fossil form has in many cases the spiral ornamentation completely obliterated. Its shell is much larger than either of the succeeding species and there is no other fossil form in the Ottawa valley which is at all similar. A closely related species *L. catascopium*, which is more globose and has the inner lip closely appressed to the parietal wall, completely closing the umbilical chink, should be looked for in these marl deposits. It has not yet been found here as a fossil.

Lymnaea obrussa decampi Streng

Plate VII, figures 14a–14f

Shell small, thick and solid, subconic, growth lines distinct, but fine revolving lines absent; whorls five, flattened above and convex below, periphery somewhat flattened. Sutures deeply impressed; spire short, of about the same length as the aperture; aperture long and narrow, rounded below and narrowed above, forming a shoulder with the parietal wall of the previous whorl; inner lip slightly reflected, but not flattened against the parietal wall; umbilical chink fairly conspicuous, but in some cases nearly covered by the inner lip of the aperture.

H. 9·75 W. 5·25 A.H. 5·0 A.W. 2·5

Locality. Marl bed, Colton lake.

Lymnaea obrussa decampi is a very characteristic species of the marl beds at the above locality. It has not been discovered living in Ontario. In the fossil form its range extends from Illinois to New York. This little shell would not be readily confused with any except *L. galbana* (See the following species). In general, it is less robust and globose than *L.galbana*, the aperture is much narrower, and the upper portion of the aperture is distinctly arched. Figure 14d, Plate VII, shows one specimen with an aperture wider than usual, but figures 14e, f, show the characteristic differences. Many of the specimens of *obrussa decampi* have additional secretions inside the aperture by which the latter is still further constricted.

Lymnaea galbana Say

Plate VII, figures 15a–15f

Shell small, robust, solid, subovate; surface shining, lines of growth distinct though not conspicuous. Whorls five, convex, roundly shouldered, increasing rapidly in diameter, the body whorl being much longer than the others; sutures deeply impressed; spire short, broadly conical, aperture ovate, rounded above and below; outer lip simple, acute; inner lip reflected over the parietal wall as a thin callus which emargins the umbilicus. Umbilicus narrowly open, but occasionally shell is imperforate.

H. 9·5 W. 5·5 A.H. 5·5 A.W. 3·2

Locality. Marl bed, McKay lake.

This is a very characteristic fossil of post-glacial time and like the preceding species seems to have been well adapted for the cold waters of that period. It is a more robust shell than the preceding species. Its whorls are not as flatly shouldered as those of *L. obrussa decampi* and its aperture is not so narrow and is more equally rounded above and below.

Planorbis antrosus Conrad

Plate VII, figures 16a–16i

Shell sinistral, discoidal, angulated. Surface covered by fine, numerous, oblique lines of growth and occasionally by irregular revolving striæ. Apex minute, but can be seen at the bottom of the deeply depressed spire; whorls thin, rapidly increasing in height and width, discoidal, sharply carinated above and below; spire exhibits all the volutions in form of a depressed cone; aperture regularly lunate ovate, sharp above and more broadly rounded below. Top of aperture rises far above the preceding whorl; peristome thin, expanding slightly, thickened within by a callus; thin callus on parietal wall, base of shell forming a deep, wide, umbilical depression exhibiting all the volutions.

H. 4·9 W. 8·75 A.H. 4·15 A.W. 3·5

Locality. Marl beds, McKay lake, and elsewhere throughout the Ottawa valley.

This is a characteristic species from these deposits. It is readily recognized by the funnel-shaped depression both above and below, and by the V-shaped portion of the aperture which rises far above the preceding whorl. It is a widely-distributed species at the present day, extending well over North America except on the Pacific slope. Many marl specimens show traces of former apertures by an irregular transverse thickening of the shell at intervals, with a change in direction of the whorl. Figure 16e shows one individual in which the whorls increase in size with great rapidity. *P. antrosus* var. *striatus* with strong spiral lines, should be sought in these marl deposits.

Planorbis campanulatus Say

Plate VII, figures 17a–17d

Shell sinistral, discoidal, more or less rounded; surface, shiny, with lines of growth oblique, raised, numerous, and largely equidistant; whorls four and a half, rounded above and below, but occasionally sub-carinated above; whorls increasing in size uniformly; spire flat or slightly depressed below the general level of the whorls, exhibiting all the volutions; sutures distinct; periphery rounded; base of shell rounded with a deep umbilicus showing two volutions; aperture irregularly lunate, slightly expanded above, more so below; mouth of the aperture dilated to a great extent forming a bell-shaped expansion; last whorl contracts slightly just before commencement of dilation; heavy callus ridge beneath constriction forms narrow throat; peristome thin, slightly reflected, joined to the parietal wall by thin callus; campanulate expansion, rarely showing traces of revolving lines and lines of growth which are more irregular than on remainder of shell.

H. 5·2 W. 9·2 A.H. 4·5 A.W. 3·7

Locality. Marl beds, McKay lake, Colton lake, and elsewhere in the Ottawa valley.

One of the most common shells in these deposits. It is readily recognized by the characteristic bell or campanulate expansion. Marl specimens as a rule show little variation.

Planorbis altissimus Baker

Plate VIII, figures 18a–18f

Shell small, dextral, rounded; surface shining, lines of growth fine, oblique, slightly elevated; apex slightly below the general level of the whorls; whorls four, rapidly enlarging, periphery rounded; in some cases sub-carinated, spire slightly depressed or flat showing all the volutions, sutures deeply impressed; base concave, with wide, shallow umbilicus showing all the volutions; aperture oblique ovate, nearly on same plane as last whorl; peristome, thin, slightly expanded, upper edge produced over lower margin unthickened by callus. Termination of peristome connected by thin callus on parietal wall.

H. 1·25 W. 4·1 A.H. 1·15 A.W. 1·35

Locality. Marl bed, McKay, Colton, and Mink lakes. This is one of the most common of the small *Planorbes* in these deposits, though not as common as *Amnicola porata*. It can be readily distinguished from *P. exacuous* Say by the absence of the sharp peripheral carina of the latter. From *P. deflectus* and *P. hirsutus*, it can be differentiated by its smooth shell and much smaller size.

Planorbis deflectus Say

Plate VII, figures 13a–13b

Shell small, dextral, flat. Lines of growth numerous, fine, oblique; apex below level of the whorls; whorls four to five and a half, rapidly expanding, periphery sub-carinate, all of the whorls in the same plane except the first which is depressed; whorls flattened above, slightly rounded below, last whorl deflected downward; aperture oblique suboval; peristome thin, acute; callus on the parietal wall; umbilicus wide, shallow, exhibiting all the volutions.

H. 2·25 W. 6·0 A.H. 1·5 A.W. 2·0

Locality. Colton lake.

This small planorbis is rather uncommon in the marl beds, good specimens being rare. It is much larger than *P. altissimus*, from which it also differs in the subcarinate periphery of its whorls and the deflection of the last whorl. It probably is more widely distributed than is indicated by the single locality given above.

Physa gyrina Say

Plate VIII, figures 19a–19i

Shell sinistral, polished shiny, subovate, growth lines fine but distinct, revolving lines faint or absent; whorls four, expanding rapidly; spire moderately elevated, sutures fairly deeply impressed; aperture very large, elongate-ovate, occupying over two-thirds of the total length of the shell; peristome thin, thickened just inside the aperture by a pronounced callus, which is frequently of a reddish colour, terminations of peristome connected by a callus on the parietal wall; shell imperforate; columella straight.

H. 11·5 W. 7·50 A.H. 8·75 A.W. 4·25

Locality. Marl beds, McKay, Colton, and Mink lakes.

This form, which is quite common in the marl beds, resembles *P. heterostropha* Say. Its sinistral shell, short spire, and very large body whorl and aperture render it quite distinct from any other gastropod in the area. At present it is found in ponds and streams adhering to sticks and stones.

Amnicola limosa Say

Plate VIII, figure 22a

Shell small, bulbous, surface shining, lines of growth very fine, numerous; sutures well impressed; whorls four, gradually expanding; aperture rounded ovate; peristome sharp, barely attached to the parietal wall of the preceding whorl and occasionally thickened slightly; umbilicus almost covered and shell frequently nearly imperforate.

H. 3 W. 2·25 A.H. 1·5 A.W. 1·15

Locality. Marl bed, Colton lake.

This small shell is rather uncommon in this area and seems to merge gradually into the variety next described.

Amnicola limosa porata Say

Plate VIII, figures 22b–22f

This form is very similar to the above species, but differs in being more globose; the whorls are more swollen and the umbilical opening is larger and more rounded.

H. 4·2 W. 3·5 A.H. 2·23 A.W. 1·75

Locality. Marl beds, McKay lake and throughout the Ottawa valley.

This species is, with *Valvata tricarinata*, by far the most common form in the marl faunas. It is very uniform in size, but the shells in these marl beds are somewhat smaller than those living to-day. Its very globose shape makes this stout little shell easily recognized.

Amnicola lustrica Pilsbry

Plate VIII, figures 20a–20d

Shell thin, acutely turreted, surface shining; lines of growth minute, numerous; whorls five to six, well-rounded, increasing regularly; sutures much impressed; spire elongate; aperture roundly ovate; peristome thin, continuous, slightly reflected ; base of shell rounded; umbilicus small, round, and deep.

H. 4·0 W. 2·0 A.H. 1·5 A.W. 1·15

Locality. Colton lake.

This species is readily distinguished from other *Amnicolidæ* by its very slender shell. Though fairly abundant, it is much less common than *A. porata*.

Valvata sincera Say

Plate VIII, figures 21a–21b

Shell depressed, discoidal; surface shining, lines of growth numerous, fine, crowded; apex large, spire flat; whorls rounded three to three and a half expanding gradually, rapidly, the last whorl being deflected downward; sutures deeply impressed;

aperture round, continuous; peristome simple, continuous, inner portion being pressed against the wall of the preceding whorl; umbilicus round, deep, showing all the volutions.

H. 2·25 W. 3·5 A.H. 1·25 A.W. 1·25

Locality. Colton lake.

This little shell is not as common as *Valvata tricarinata.* It varies considerably in height and width, but has a very characteristic appearance. An occasional *V. tricarinata* lacking the carination of the whorls might be confused with it, but the whorls of *V. sincera* are more completely rounded.

Valvata tricarinata Say

Plate VIII, figures 23a–23f

Shell translucent, tinged with green; surface shining, lines of growth numerous, fine; spire elevated; whorls three to three and a half, rapidly and regularly expanding, strongly carinated; usually three carinæ are present, one on the base of the shell, one on the periphery, and one on the shoulder of the whorls, but one or more of these may be absent; aperture rounded ; continuous; columella straight; base of shell rounded or keeled; umbilicus round and deep.

H. 2·7 W. 3·9 A.H. 1·8 A.W. 1·65

Locality. Marl beds, McKay lake and throughout the Ottawa valley.

This species is very abundant in the marl deposits. The figures show well the great variation in the carination of this form. The marl specimens are much smaller than the forms living to-day. Walker[1] has divided this species into several varieties, *normalis, perconfusa, simplex,* etc., but as these marl forms merge into each other, in this paper such varieties are not differentiated.

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[1] Walker, Bryant, " Revision of the Carinate Valvatas of the United States." Nautilus, vol. 15, No. 11, pp. 121-125.

KEY TO GENERA AND SPECIES

The identification of some of the species is not easy, and the following key is given to facilitate their recognition. This key is based solely on the shell characters. As noted elsewhere the foundation of many of the genera, and their grouping into families, rests upon the anatomy of the living animal; hence a key based upon shell characters alone cannot be considered complete, nor in many cases very satisfactory. From the shell characters alone Lymnaea and Planorbis could not be grouped into the Lymnaeidæ. However, only such a key can be used for the fossil forms.

A. Shell bivalve, two valves symmetrical, united by a dorsal hinge.
  a. Shell small, two sets of cardinal teeth in each valve.
    Family *Sphaeriidæ*
      G1. More or less rounded, or ovate, seldom trigonal in outline, usually not less than 6 mm. in length.
        Genus *Sphaerium*
          1. Shell large, oval, beaks nearly in a median position.............................. *S. simile*
          2. Shell inequilateral, solid; umbones small, almost smooth...................... *S. striatinum*
          3. Shell solid, more or less trigonal in outline; umbones anterior to centre of shell...... *S. solidulum*
      G2. Shell small, fragile, rounded to trigonal in outline, beaks posterior of middle of shell, mostly less than 4 mm. in length.
        Genus *Pisidium*
          4. Shell small, more or less rounded, beaks inconspicuous nearly in middle of shell. Shell covered with fine growth lines........... *P. abditum*
          5. Shell small, trigonal, umbones very much posterior to middle of shell, anterior end produced.......................... *P. compressum*

B. Shell univalve, usually coiled such as the snails
  b. Shell depressed, globose
    Family *Helicidæ*
      G3. Genus *Polygyra*
          6. Shell large, imperforate; tooth lacking; peristome widely reflected, white........... *P. albolabris*
          7. Shell depressed, minute growth lines, peristome simple, prominent parietal tooth.... *P. monodon*
  c. Ribbed or striated; umbilicated; aperture simple

Family *Endodontidæ*

G4. Genus *Pyramidula*

8. Shell large, depressed, thin; aperture simple; strong rib-like striæ; wide umbilicus...... *P. alternata*

G5. Genus *Helicodiscus*

9. Shell small, discoidal, widely umbilicated; covered by parallel, equidistant, revolving lines............................... *H. lineatus*

d. Thin, almost transparent, aperture very large in proportion to the small, short spire, whorls rapidly expanding

Family *Succinidæ*

G6. Genus *Succinea*

10. Shell large, thin, fragile; aperture occupying over two-thirds of the shell.............. *S. ovalis*

e. Spire elevated and dextral, or flat; some sinistral

Family *Lymneidæ*

G7. Spire elevated and dextral
Genus *Lymnaea*

11. Shell thin, high, large, whorls rapidly expanding...................... *L. stagnalis appressa*
12. Shells stout, solid, small, shouldered whorls and small aperture narrow at the top *L. obrussa decampi*
13. Shell stout, inflated, shouldered whorls and rounded aperture........................ *L. galbana*
14. Shell solid, high, subconic, long pointed apex and elongate-ovate aperture............... *L. obrussa*

G8. Spire flat
Genus *Planorbis*

15. Shell sinistral, with funnel-shaped umbilicus and depressed spire, whorls carinate above and below............................ *P. antrosus*
16. Shell sinistral with flat spire; small umbilicus and pronounced bell-shaped expansion of last whorl behind the aperture. *P. campanulatus*
17. Shell small, up to 4 mm. in diameter, dextral, flat above; wide, shallow umbilicus below, periphery of whorls rounded...... *P. altissimus*
18. Shell small, dextral, flat above, last whorl deflected downward, periphery of whorls subcarinate........................... *P. deflectus*

f. Shell elevated and sinistral

Family *Physidæ*

G9. Genus Physa

19. Shell large, sinistral with aperture occupying two-thirds the length of the shell. Fine growth lines, revolving lines faint or absent. . *P. gyrina*

g. Shell small, not over 5 mm. in length, umbilicus small

Family *Amnicolidæ*

G10. Genus *Amnicola*

20. Shell low conic, apex rounded, four to five whorls. . . . . *A. limosa*

21. Shell inflated, more globose, more widely umbilicated than above *A. porata*

22. Shell narrow and high, five to six whorls. . . *A. lustrica*

h. Shell small, not over 6 mm. in width, widely umbilicated

Family *Valvatidæ*

G11. Genus *Valvata*

23. Shell thin, with rounded whorls without carinæ. . . . . *V. sincera*

24. Shell thin, whorls usually bearing three carinæ, on base, periphery, and shoulder of whorl, but occasionally one or more may be absent. . . . . *V. tricarinata*

TWO NEW NORTH AMERICAN CYCADEOIDS

By G. R. Wieland

Towards the end of 1919 the writer was asked to examine a specimen of cycad from the Belly River beds near Red Deer river, Alberta. The specimen was discovered by C. M. Sternberg who furnished notes on its occurrence.

It is proposed to include, with a description of this specimen, notes on a small petrified trunk from Texas, found, some years ago, by Dr. Emilio Böse, and forwarded by Dr. J. A. Udden, who had still earlier discovered the petrified cycadeoid, named by the writer *Cycadeoidea Uddeni*, in the Upson shales of Maverick county, Texas. Of these two sole Texas cycadeoids the Böse specimen is rather the more interesting, because quite complete.

These two new cycadeoids afford a complete contrast, in both space and time, for the North American distribution. They delimit the occurrence of the robust type of stem from the 30th to the 54th parallels, and about through Cretaceous time.

The occurrence in the Belly River beds appears to be the latest recorded from North America. But it is evident that the then rapidly disappearing cycadeoid type was still broadly distributed, as the very distinct species *Cycadeoidea Uddeni* of the Upson shale is little older.

In the larger sense the finding of a cycad in the Trinity beds indicates a further geographic extension for the fine series of trunks from the lower Potomac of Maryland, and the Como cycads of the Freeze Out hills of Wyoming. The greater cycadeoid series, with marked specific variation, comes a little later in the Black hills, the collections being mainly from Minnekahta and Piedmont, with isolated occurrences in Colorado and California. In a few words, the known petrified cycadeoids come in with a certain abundance, quickly culminate in variety and number, and then after long continental distribution, these uniquely specialized forms slowly disappear towards Tertiary time, to recur no more. With them, too, go the Araucarias, save that these still persist in South America.

It is possibly an over-emphasis of evidence to call attention to such general facts. It is probable, however, that for Cretaceous time, the period of driest intra-continental climates is marked by the culmination of the cycadeoids; and it is moreover unlikely that a single species so far recovered lived far from the border of open and dry country. No other fossil plants are more obviously xerophyllous. Though reference is made solely to the large-stemmed forms with a great pith and thin woody cylinder; it should be emphasized that many of the relatives, both near and distant, must have had the capacity to live in every zone and climate.

It is desirable to add that the exact position of the Trinity beds is only in a general way indicated as equivalent to the lower Potomac by the cycad found by Dr. Böse. But the specimen is so like the Potomac forms that it could be a constituent of one and the same forest. Dr. Böse says it came from the base of the Wise County Cretaceous sandstones as they transgress the Pennsylvanian. But he adds that this is scarcely the lowermost Cretaceous in the European sense, being rather an equivalent of the Aptien, or uppermost part of a true Lower Cretaceous. His views on the position of the Trinity are more fully given in a monograph on the Cerro de Muleros brought out by the Instituto Geologico of Mexico, and a satisfactory notice with tabulation may be found in Willis' "Stratigraphy of North America" (page 588 et seq.).

Some further facts of interest here are found in an earlier paper of Fontaine[1], who describes some twenty-three species of fragmentary leaves and twigs from the bed of Paluxy river, 2 miles above Glen Rose, Texas, or only 60 miles south of the point in Wise county which yielded the petrified stem (accompanied by petrified forests). These plants are found in a grey

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[1] Notes "on some fossil plants from the Trinity beds of the Comanche series of Texas," Proc. U.S. Nat. Mus., vol. XVI, 1893, pp. 261–282, plates XXXVI–XLIII.

limestone interpolation, "quite free from sand and clay". They are simply the more durable cycads and conifers which could better withstand maceration. With *Brachyphyllum* twigs and *Pagiophyllum* twigs and cones, there are cycad pinnules and a small double whorl of smooth bracts surmounting a heavy stem (?), called *Williamsonia texana*. These are all of a lower Potomac caste, and accompany Neocomian invertebrates. A reference to this paper, page 882 of the 4th edition of Dana's "Manual", implies that *Cycadeoidea munita*, a Kansas form of equivalent age, also occurs in Texas. But if any petrified cycads other than those mentioned have ever been found in Texas, the fact has wholly escaped the writer. And similarly the Alberta type here illustrated stands alone, with only the partial exception of a single Cycas-like seed from the Cretaceous of Vancouver island, described by Dawson.

Cycadeoidea Sternbergii sp. nov.

Plates IX and X

Type consisting in the cast and carbonized portions of a large armour fragment (with one lesser armour superficies) in the collections of the Geological Survey, Canada, at Ottawa. Found by Charles M. Sternberg near Red Deer river, Alberta, along the west branch of Sand Hill creek, in the uppermost Belly River beds, near the Pierre overlap.

In many of the cycadeous plants ancient and modern, as the large fronds wilt down, the heavy woody bases long persist in the form of a quite continuous heavy outer envelope of the cortical region, the so-called armour. This armour tends to a continual excision by layers of periderm which form in the outer and still green tissues of the individual leaf bases. And this cutting-off process, if at all rapid, would soon leave the stem quite smooth and covered by a thick, soft bark tissue not very different from the soft bark of a concolour fir. But, especially in the cycadeoids, there is a heavy growth of chaff or ramentum in many of the species which protected the old leaf bases from decay, and slowed down their excisions. The armour, in those species in which it is thickest, being thus left of very even depth, proves in not a few instances to be the most durable part of the plant, or even all that is left behind. An interesting armour specimen, quite entire, has been described by Fliche from the Albien greensand of the Argonne.[1]

The Alberta type is just such a heavy armour fragment quite 10 centimetres deep, as shown in the plates. There is a moderate development of ramentum investing the leaf bases to a depth of several millimetres, and apparently the separate scales are quite coarse, as they run nearly the full length of the leaf bases. No fruits or bracts disturb the course of the spirals. But as the leaf bases are of the decidedly rhombic form finely exemplified by the Black Hills species *Cycadeoidea Stillwelli*, and as no bundle patterns appear on the outer faces or scars, the specimen is not easy to orient. It is quite as consistent to stand it on the longer as on the shorter edge.

Similarly, because of this crushing down of the leaf base spirals in the type, it is not certain whether the small accompanying armour fragment is of exactly the same species. The scars are in it a little larger, not distorted, and evenly lozenge-shaped. What is of decided interest to note is that in one instance the ends of leaf base bundles are aligned unmistakably along the lower or keel sides of the leaf base in the true cycadeoid manner. It is conclusive that a cycadeoid is present, not a cycad of modern type (Figure 8).

Owing to the difficulty of preparing these casts, which are of rather soft clay, or ironstone, traversed by, or invested by, very soft carbon of the original tissues, no thin sections have been made. The methods ordinarily employed for obtaining these sections are useless, but efforts should not be abandoned to procure the histologic detail. It is probable that some of the ramentum is conserved, and possibly the leaf base structures in certain limited areas.

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[1] See also "American fossil cycads," vol. II, Carneegi Institution of Washington, Pub. 34.

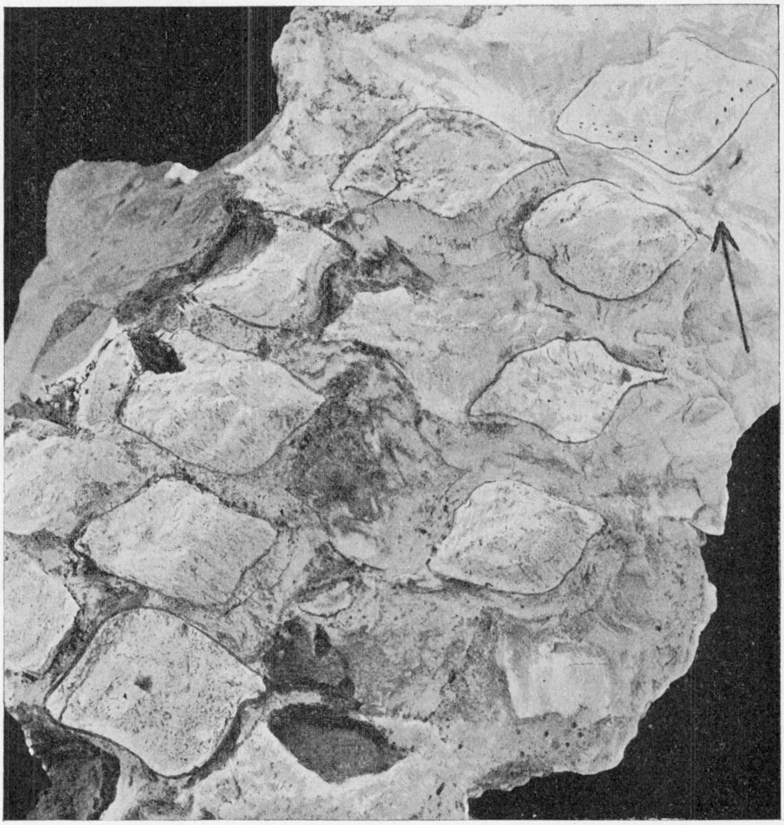


Figure 8. *Cycadeoidea Sternbergii* sp. nov.
An outer armour fragment shown natural size. Note to left below normal uncrushed leaf base form, and to right above (indicated by arrow), another well-outlined form with the keel bundle series of cycadeoid type.

In lieu of measurements the plates can be examined. They yield the proportions as far as these can have value in comparing species. There need not be the least hesitation, however, in assigning a new species. Reference to the description of the *Cycadeoidea Uddeni*[1] shows three or four times as heavy a development of ramental chaff in the Texas form of comparable age, with variation in leaf base outline. All this suggests generic rather than specific remoteness. The Black Hills *Cycadeoidea Stillwelli*, already mentioned, is a cycadeoid type with pauciform ramentum, and much closer, perhaps as close as any known American specimen. But decided difference in the thickness of the armour and greater age, without details concerning fructification in either case, at once compel separation.

Cycadeoidea Boesiana sp. nov.

Plates XI and XII

Type, a low, rather small, quite complete, well-silicified trunk with a good terminal bud. Reposed with the Yale collections. Found by Dr. Emilio Böse, along with much petrified wood in the lowermost Cretaceous of Wise county, Texas (near Bridgeport) about 60 miles northwest of Fort Worth.

Only a preliminary notice of the fine stem shown in the plates is conveniently given here. It is intended to follow with a histologic study in a continuation of the volumes on the "American fossil cycads" now in course of preparation. The specimen is one of the squamous forms resembling the Isle of Portland "crows' nests," but of better conservation. It has nearly the diameter, and about half the height, of the Potomac *Cycadeoidea marylandica*. To this form there is the greatest resemblance, and if found closely associated, there would be need to question whether the minor differences might not better be called varietal.

As found well to the southwest, however, the fact that the leaf bases average far smaller than those of *C. marylandica* or that small scale leaves were much more numerous, may be

[1] "American fossil Cycads," vol. II, pl. I.

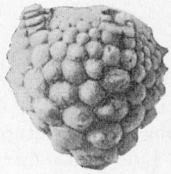
taken as the index of a new species. In any case the presence of scattering bract groups with marked development of ramentum indicates the normal cycadeoid type. Also, the very marked variation in the size of the leaf has a special interest. A few of the leaf bases on one side of the stem are as large as those of *C. marylandica*. But over the whole of the opposite side the bases are all very small. Taken with the low, subglobular stem and the heavy ramentum, these features complete the picture of a slow-growing desert plant producing sparse crowns, or only scattering foliage leaves, at varying intervals, with the terminal bud enveloped, for the greater part of the time, in a thick crown of scale leaves.

PLATE I

FIGURE 1. *Melocrinus borealis* n. sp. Lateral view of calyx, right posterior interradius. (Page 16.)

FIGURE 2. Tegmen of same, posterior side below, showing anal opening. (Page 16.)

FIGURE 3. *Melocrinus canadensis* n. sp. Lateral view of imperfect calyx; the missing plates restored in outline. (Page 17.)



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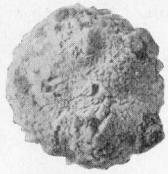

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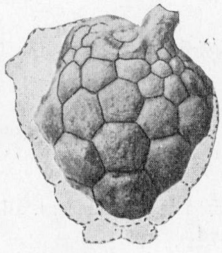

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PLATE II[1]

Dianulites rocklandensis n. sp.

FIGURE 1. Specimen illustrating wall structure and diaphragms. (Page 47.)
FIGURE 2. Tangential section showing the granular walls. (Page 47.)

Nicholsonella ottawaensis n. sp.

FIGURE 3. Specimen showing wall structure. (Page 47.)
FIGURE 4. Tangential section, the portion to the right being cut deeper than the darker piece to the left. (Page 47.)

Escharopora frondosa n. sp.

FIGURE 5. Vertical section, exhibiting a slight irregularity. (Page 48.)
FIGURE 6. Tangential section. (Page 48.)

Batostoma winchelli (Ulrich)

FIGURE 7. Tangential section.
FIGURE 8. Vertical section.

Prasopora grandis (Ulrich)

FIGURE 9. Tangential section.
FIGURE 10. Vertical section.

Pachydictya acuta (Hall)

FIGURE 11. Tangential section.
FIGURE 12. Vertical section.

Hemiphragma tenuimurale Ulrich

FIGURE 13. Vertical section.
FIGURE 14. Tangential section.

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[1]All bryozoa are magnified ten diameters, all others natural size except where magnification indicated.

PLATE II.

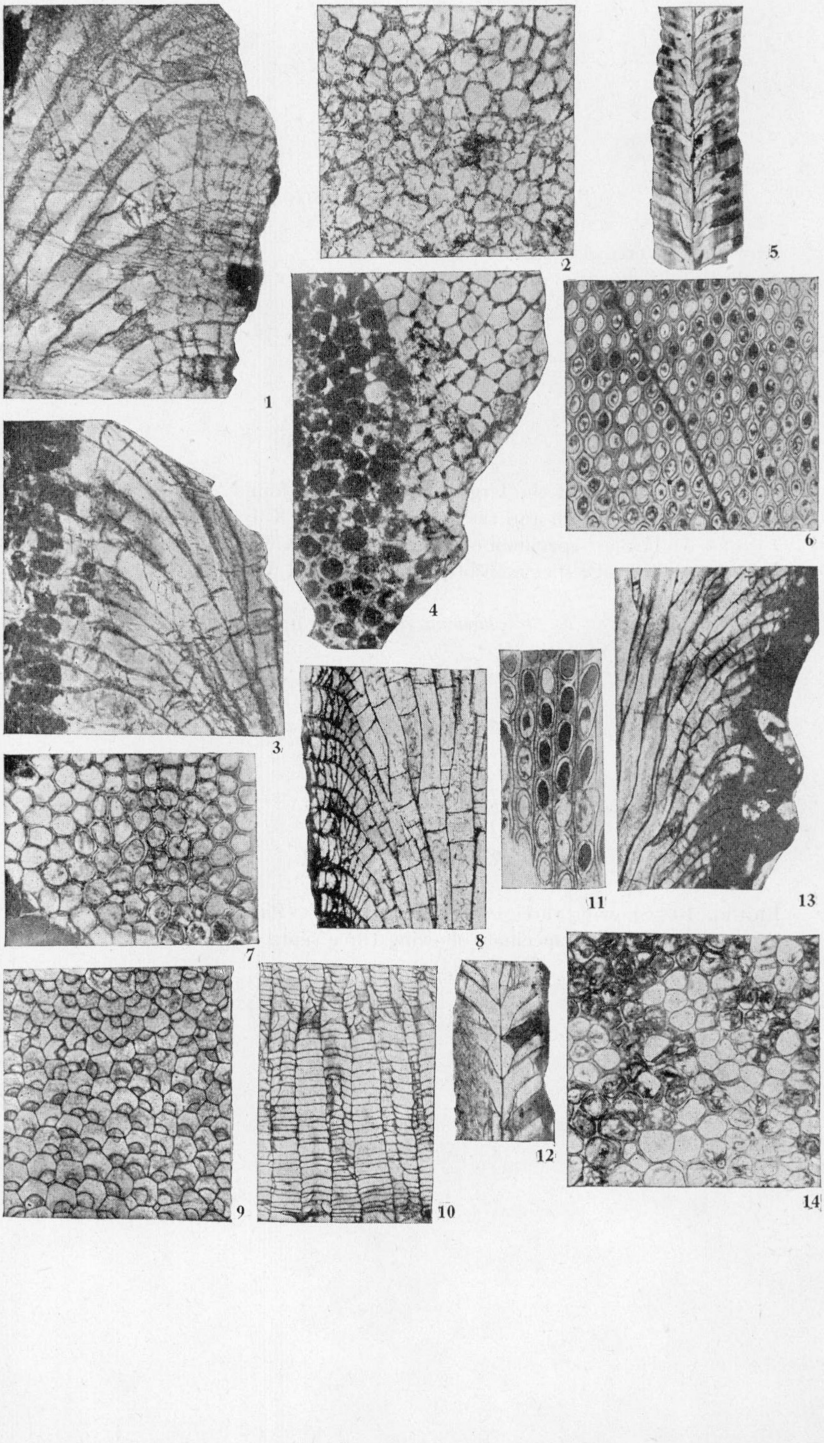

Plate III

Prasopora simulatrix orientalis Ulrich

Figure 1. Vertical section.
Figure 2. Tangential section.

Tetradium cylindricum n. sp.

Figure 3. Vertical section. (Page 46.)

Lingula narrawayi n. sp.

Figure 4. Interior of the largest pedicle valve found, showing the broken scar of the septum and the acuminate beak, X 3. (Page 49.)
Figure 5. Largest specimen of brachial valve, X 3.
Figure 6. Average specimen of pedicle valve, X 3.

Strophomena canadensis n. sp.

Figure 7. Pedicle valve, X 2. (Page 50.)

Rafinesquina rugosa n. sp.

Figure 8. Pedicle valve, X 2. (Page 51.)
Figure 9. Brachial valve, X 2. (Page 51)

Rafinesquina sp. undt.

Figure 10. Showing three septa, natural size. (Page 52.)
Figure 11. Another specimen showing three septa, natural size. (Page 52.)

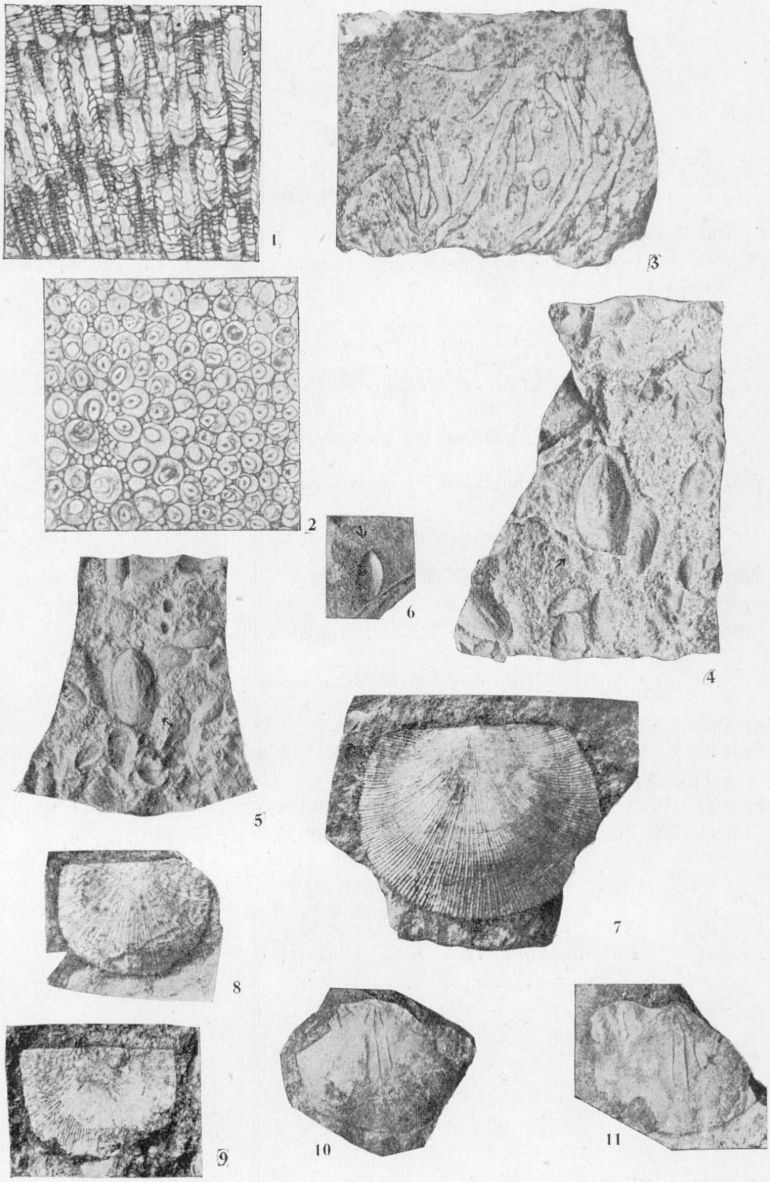
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PLATE IV

Cyrtodonta planumbona n. sp.

FIGURE 1. View of natural cast of right valve. (Page 52.)
FIGURE 2. Anterior view showing the even convexity of the species. (Page 52.)

Modiolopsis compacta n. sp.

FIGURE 3. Left valve of a partly exfoliated shell. (Page 53.)

Allodesma umbonata n. sp.

FIGURE 4. View of fragments of left valve, X 2. (Page 54.)

Eotomaria rotunda n. sp.

FIGURE 5. View from above, X 2. (Page 55.)
FIGURE 6. View of umbilicus, X 2. (Page 55.)
FIGURE 7. View from the side, X 2. (Page 55.)

Raphistoma distincta n. sp.

FIGURE 8. View from above, X 2.
FIGURE 9. View showing the course of the striæ on the upper portion, X 2. (Page 56.)
FIGURE 10. View of the umbilicus of a second specimen, X 2. (Page 56.)
FIGURE 11. Side view of No. 10, X 2. (Page 56.)

Leperditia trentonensis n. sp.

FIGURE 12. View from above, X 2. (Page 57.)
FIGURE 13. Lateral profile view, X 2. (Page 57.)

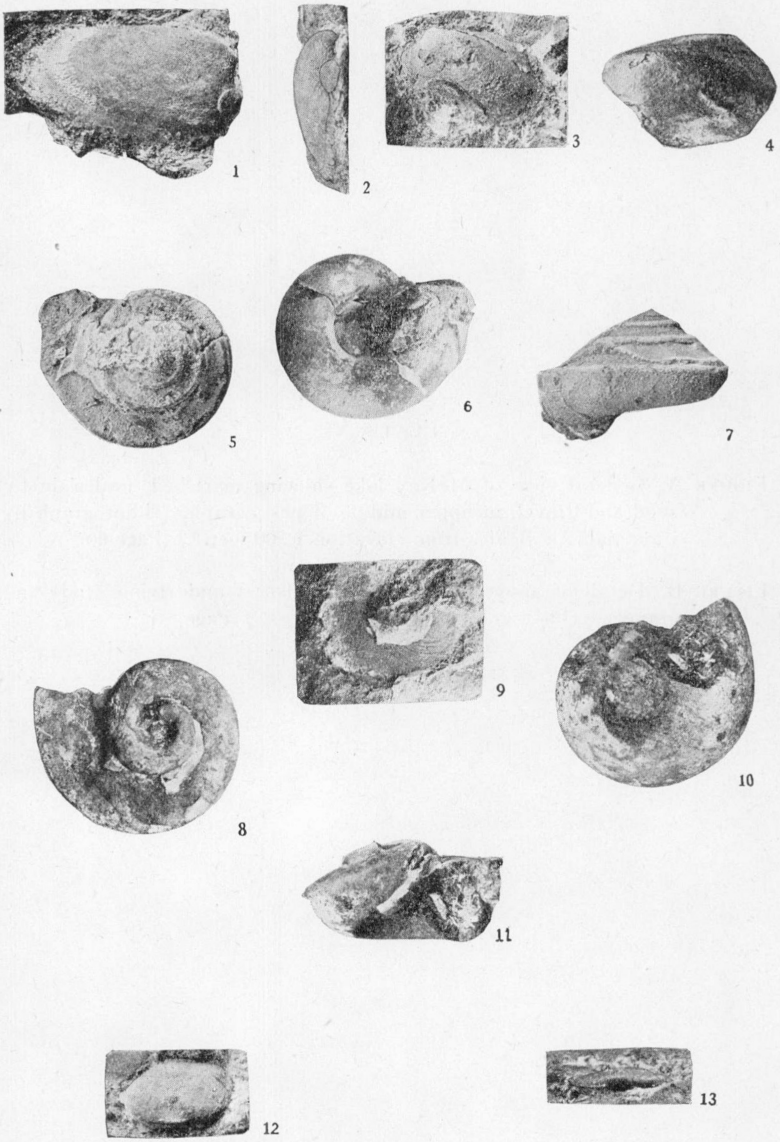

Plate V

Figure A. General view of McKay lake showing marl bed, underlain by sand and gravel, in upper middle of photograph. (Photograph by Canadian Air Board, from elevation 1,300 feet.) (Page 60.)

Figure B. Detail of above showing marl bed and underlying sands and gravels. (Photograph by E. M. Kindle.) (Page 60.)

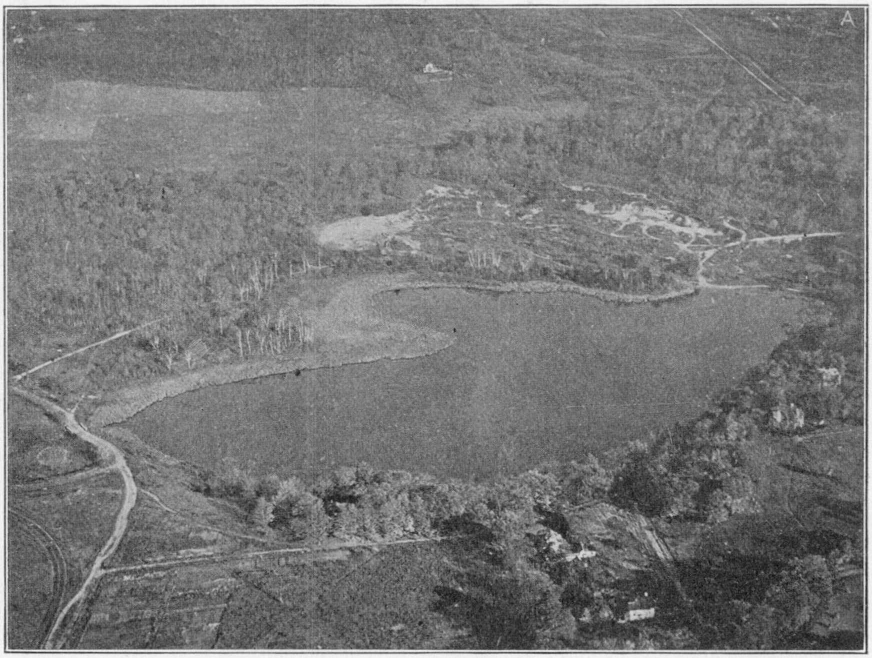

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Plate VI[1]

Sphaerium simile Lamarck

FIGURES 1a, 1b. Exterior of right and left valves respectively. Marl beds, lot 7, Eastview, near Ottawa. (Page 63.)

FIGURES 1c, 1d. Interior of right and left valves respectively. Locality same as above. (Page 63.)

Sphaerium striatinum Lamarck

FIGURES 2a, 2b. Exterior of right and left valves respectively. X 2. Same locality as above. (Page 63.)

FIGURES 2c, 2d. Interior of same. X 2. Same locality. (Page 63.)

Sphaerium solidulum Prime

FIGURES 3a, 3b. Exterior of right and left valves respectively. X 2. Same locality. (Page 64.)

FIGURES 3c, 3d. Interior of same. X 2. Same locality. (Page 64.)

Pisidium compressum Prime

FIGURES 4a, 4c. Exterior and interior of right valve respectively. X 3. Colton lake, Ont. (Page 64.)

FIGURE 4b. Interior of left valve. X 3. Colton lake, Ont. (Page 64.)

Pisidium abditum Haldeman

FIGURE 5a. Exterior of left valve. X 8. (Drawing.) McKay lake, Ont. (Page 64.)

FIGURE 5b. Exterior of left valve, McKay lake, Ont. (Page 64.)

Polygyra albolabris Say

FIGURES 6a, 6b, 6c. Frontal, apical, and umbilical aspects respectively. Marl beds, McKay lake. (Page 65.)

Pyramidula (Patula) alternata Say

FIGURES 7a, 7b, 7c. Frontal, apical, and umbilical aspects respectively. Marl beds, McKay lake. (Page 65.)

Succinea ovalis Say

FIGURES 8a, 8b. View of aperture and side opposite aperture. Marl beds McKay lake. (Page 66.)

Helicodiscus lineatus Say

FIGURES 9a, 9b, 9c. Frontal, apical, and umbilical aspects respectively. X3. Marl beds, McKay lake. (Page 66.)

Polygyra (Stenotrema) monodon Rackett

FIGURES 10a, 10b. Frontal and apical views respectively. Marl beds, McKay lake. (Page 65.)

FIGURES 10c, 10d. Umbilical aspect, showing reflected peristome, long parietal tooth, and difference in size of umbilical openings. Marl beds, McKay lake. (Page 65.)

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[1] In this and succeeding plates, unless otherwise stated, illustrations are of natural size.

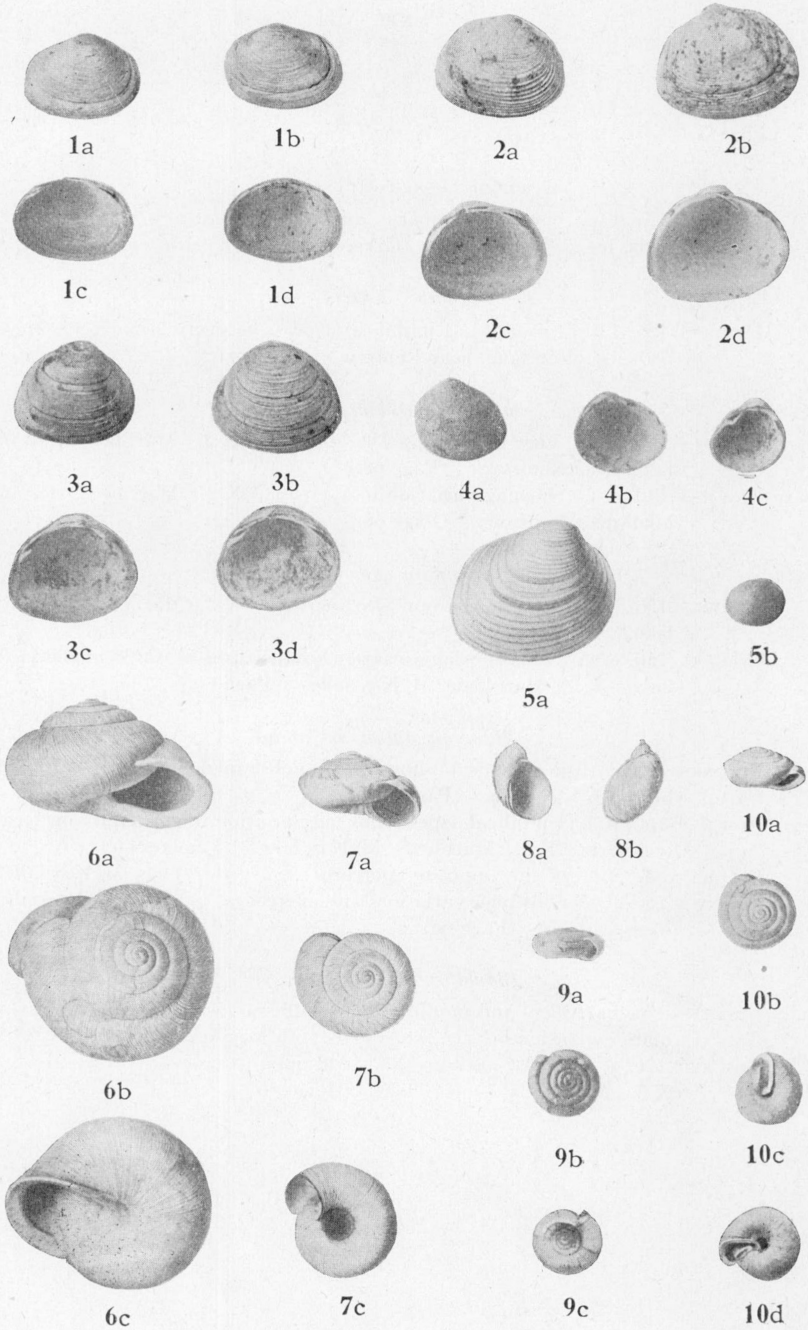
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Plate VII

Lymnaea obrussa Say

Figures 11a, 11b. View showing aperture and side opposite aperture. Marl beds, McKay lake. (Page 67.)

Lymnaea stagnalis appressa Say

Figures 12a, 12b. Showing aperture and side opposite aperture. Marl beds, lot 7, Junction gore, Gloucester tp., Carleton co. (Page 67.)

Planorbis deflectus Say

Figures 13a, 13b. Frontal and umbilical aspects respectively. X 3. Marl beds. Colton lake, near Renfrew. (Page 71.)

Lymnaea obrussa decampi Streng

Figures 14a, b, c. View of side opposite aperture. X 2. Marl beds, Colton lake, near Renfrew. (Page 68.)

Figures 14d, e, f. Showing variation in aperture. X 2. Marl beds, Colton lake, near Renfrew. (Page 68.)

Lymnaea galbana Say

Figures 15a, b, c. View of side opposite aperture. X 2. Marl beds, McKay lake. (Page 69.)

Figures 15d, e, f. View showing variation in apertures in different individuals. X 2. Marl beds, McKay lake. (Page 69.)

Planorbis antrosus Conrad

Figures 16a, c. Apical aspect showing funnel-shaped spire. X2. Marl beds, McKay lake. (Page 69.)

Figures 16b, h, i. Umbilical aspect showing variation in carination on base of whorls. X 2. Marl beds, McKay lake. (Page 69.)

Figure 16d. View of side opposite aperture. X 2. Marl beds, McKay lake.

Figures 16e, f, g. Showing variation in apertures. X 2. Marl beds, McKay lake. (Page 69.)

Planorbis campanulatus Say

Figures 17a, b. Apical and umbilical aspects respectively showing campanulate expansion. X 2. Marl beds. McKay lake. (Page 70.)

Figures 17c, d. View of aperture and side opposite aperture respectively. X 2. Marl beds, McKay lake. (Page 70.)

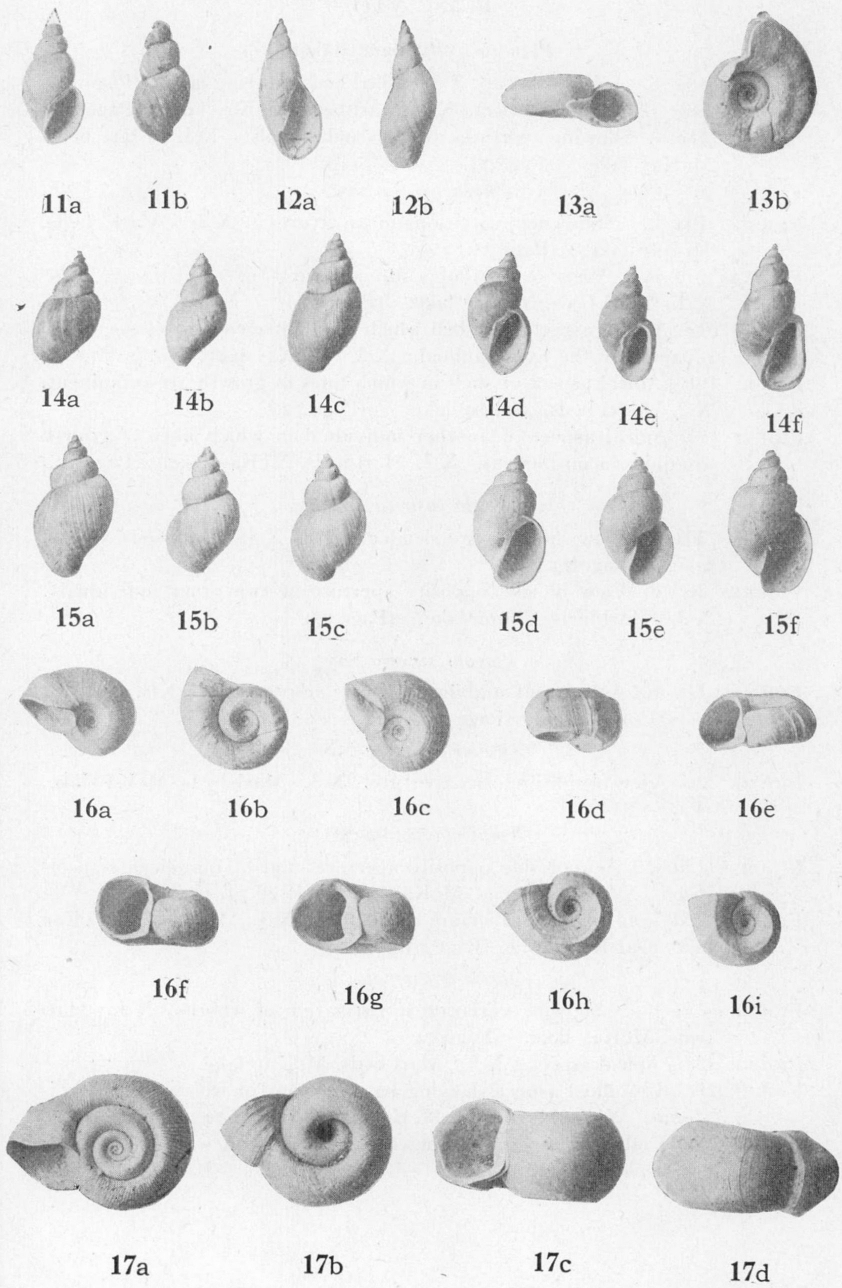
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Plate VIII

Planorbis altissimus Baker

Figures 18a, b. Apical aspect. X 3. Marl beds, McKay lake. (Page 71.)

Figures 18c, d. Umbilical aspect. X 3. Marl beds, McKay lake. (Page 71.)

Figures 18e, f. Showing apertures of two individuals. X 3. Marl beds, McKay lake. (Page 71.)

Physa gyrina Say

Figures 19a, b, c. Showing variation in apertures. X 2. Marl beds, McKay lake. (Page 72.)

Figures 19d, e, f. View of side opposite apertures of three individuals. X 2. Marl beds, McKay lake. (Page 72.)

Figure 19g. Apical aspect of a shell which was damaged and subsequently repaired by the living animal. X 2. McKay lake. (Page 72.)

Figure 19h. Apical aspect of shell in which lines of growth are prominent. X 2. Marl beds, McKay lake. (Page 72.)

Figure 19i. Apical aspect of another individual in which lines of growth are quite inconspicuous. X 2. Marl beds, McKay lake. (Page 72.)

Amnicola lustrica Pilsbry

Figures 20a, b. View showing two slender shells. X 3. Marl beds, Colton lake. (Page 73.)

Figures 20c, d. View of side opposite aperture of two other individuals. X 3. Marl beds, Colton lake. (Page 73.)

Valvata sincera Say

Figures 21a, b. Apical and umbilical aspects respectively. X 3. Marl beds, Colton lake. (Page 73.)

Amnicola limosa Say

Figure 22a. View of side opposite aperture. X 3. Marl beds, McKay lake. (Page 72.)

Amnicola porata Say

Figures 22b, c. View of side opposite aperture, and of umbilicus respectively. X 3. Marl beds, McKay lake. (Page 73.)

Figures 22d, e, f. Showing aperture and spire. X 3. Marl beds, Colton lake, near Renfrew. (Page 73.)

Valvata tricarinata Say

Figures 23a, b, c. Showing variation in carination of whorls. X 3. Marl beds, McKay lake. (Page 74.)

Figure 23d. Apical aspect. X 3. Marl beds, McKay lake. (Page 74.)

Figure 23e. Umbilical aspect showing base of whorl on which the carina is absent. X 3. Marl beds, McKay lake. (Page 74.)

Figure 23f. Umbilical aspect showing base of whorl on which the carina is conspicuous. X 3. Marl beds, McKay lake. (Page 74.)

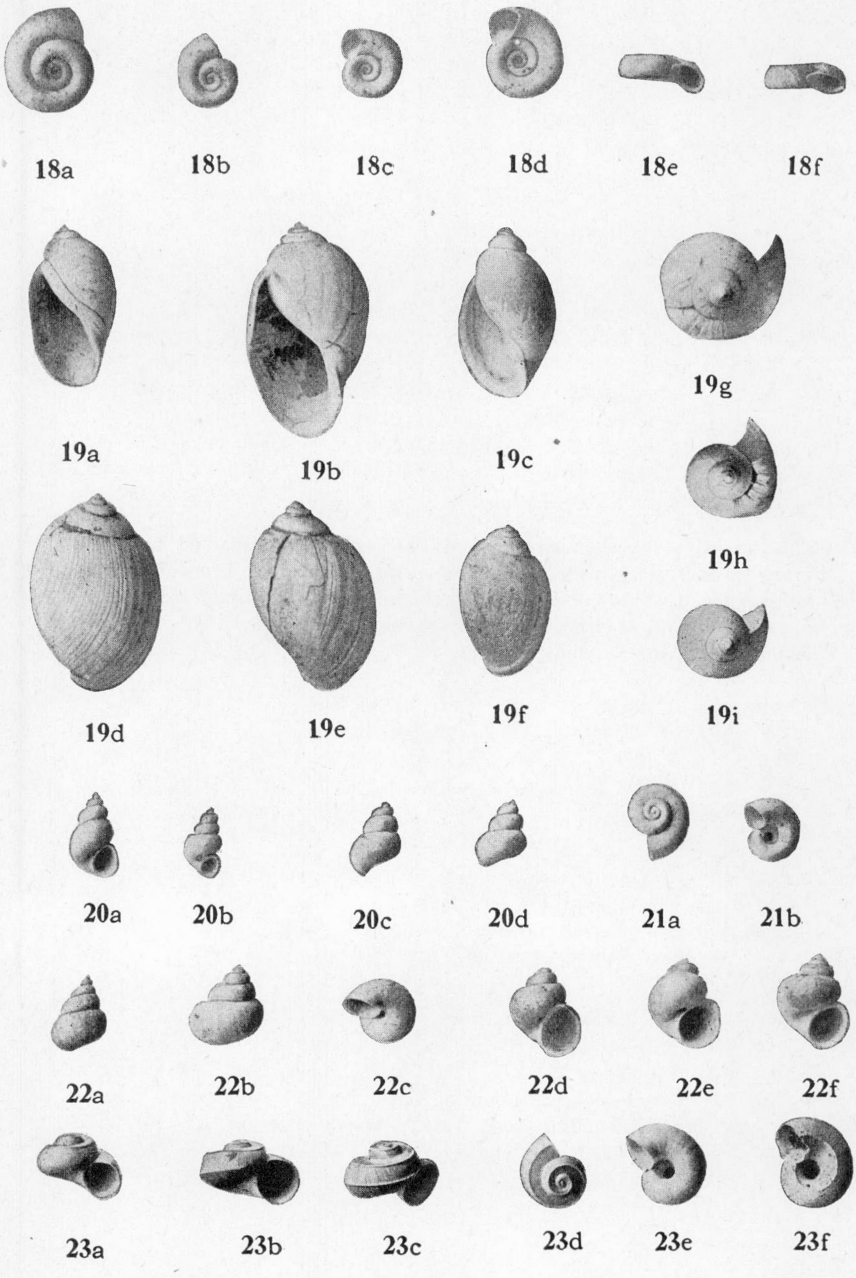
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Plate IX

Cycadeoidea Sternbergii sp. nov.

Lateral view, showing the leaf base spirals undisturbed by axillary branches or fruits, but more or less warped by crushing. The leaf base ends are conspicuously rhombic, although the angles of the spirals to the axis are not determinable as either high or low without the aid of the bundle patterns. Ramentum layers 3 millimetres thick. (Page 81.)

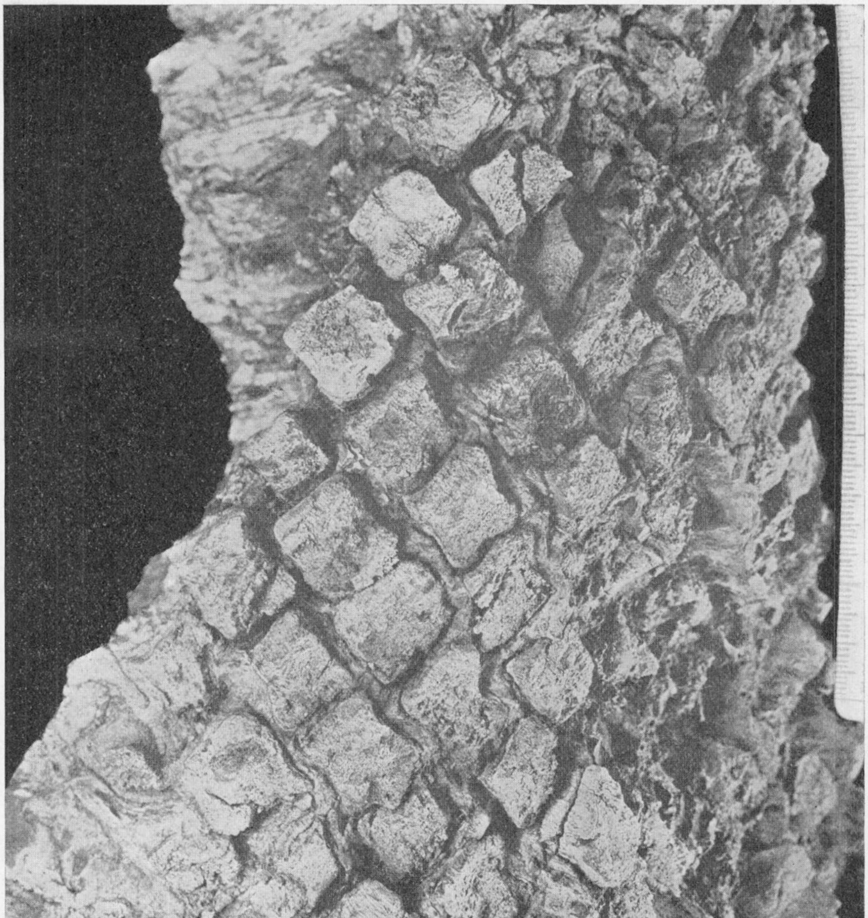

Plate X

Cycadeoidea Sternbergii sp. nov.

Eroded radial surface, showing great thickness of the armour. Only the mass of leaf bases and ramentum is seen, the cortex on which it was inserted failing of conservation entirely. (Page 81.)

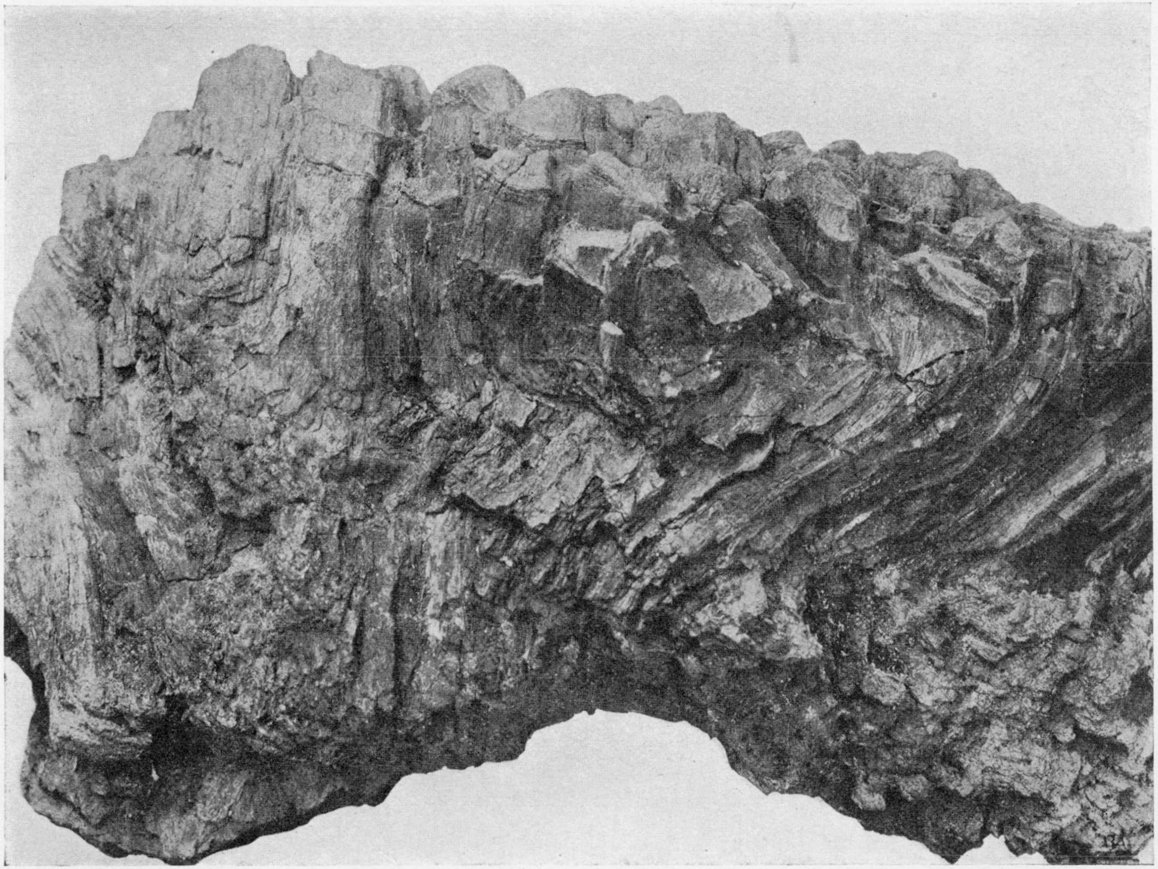

Plate XI

Cycadeoidea Boesiana sp. nov.

Lateral view of trunk, about half natural size, showing base and also the terminal bud somewhat eroded away on the right. Note marked variation in size of leaf bases, the larger of which approach nearly in size and form the bases in *Cycadeoidea marylandica* (See Plate XII). (Page 84.)

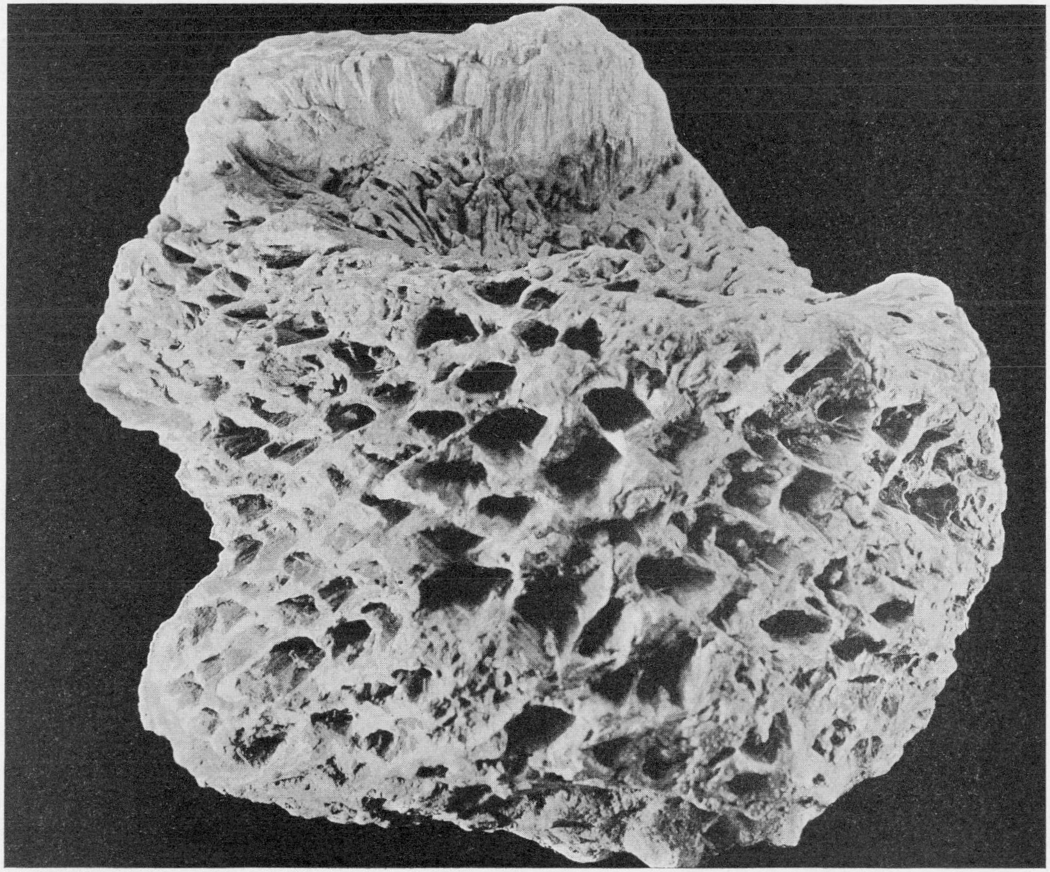

Plate XII

Cycadeoidea Boesiana sp. nov.

Trunk seen from side with the markedly small leaf, or leaf and scale leaf bases. Note the small rhombic scars forming the two low-angled spirals (about 30 degrees, left, and 40 degrees, right). There is some crushing down of the armour, or a slight shear of the trunk obliquely towards the lower right side.

The manner in which the terminal bud is laterally eroded appears more plainly than in Plate XI; but the bud retains its full height, and nearly the original outlines. The heavy ramentum and thickly set scale leaves envelop only young and small foliage leaves, if such are present at all. (The stem is obviously of the large pith type.) (Page 84.)