ORDOVICIAN AND CAMBRIAN FOSSILS FROM A WELL CORE, DELTA COUNTY, MICHIGAN

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ABSTRACT

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by Donald James Moore

A core from a well in Delta County in the Northern Peninsula of Michigan was sampled and examined for megafossils. The core cuts a nearly complete section of the Middle and Lower Ordovician and the Upper Cambrian. The object of the problem was to find and identify fossils from the core and determine stratigraphic succession and ecologic conditions during the depositional interval covered by the core. The latter two objectives to be achieved through the use of the fossils identified.

The core was sampled at six inch intervals. Any fossils found were extracted by mechanical methods and examined with the aid of a binocular microscope. The fossils were identified through the usual means of published material. No new species were found.

The presence of the Trenton, Black River, and Lodi Formations and the position of the Trenton - Black River contact were established. It was determined that during the depositional interval of the core the environment was primarily one of a near shore fluctuating sea.

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by

Donald James Moore

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INTRODUCTION

General

The stratigraphy of the Ordovician system of the Northern Peninsula of Michigan is not fully understood. The discontinuous nature of surface exposures due to the cover of glacial drift and the lack of published work on wells into the Ordovician in the Michigan basin contribute to make the study difficult.

It is hoped that study of a core which cuts a nearly complete section of the Middle and Lower Ordovician of the Northern Peninsula of Michigan may contribute some new lithologic and paleontologic information.

Nature and Scope

This report will cover a paleontologic analysis of a well cored near Cornell, Michigan as an exploratory well by the Cleveland Cliffs Iron Company. The core was given to the Michigan State Geological Survey who turned it over to the Michigan State University Geology Department for detailed study.

The purpose of this report is to identify, when possible, all fossils recovered from the core, to determine the stratigraphic succession based on faunal identification, and to make some determination of paleoecologic conditions.

For practical reasons the scope of investigation of the fauna had to be limited. Brachiopoda were found to give the greatest overall coverage of the core, so the Brachiopoda were used as the prime foundation of this report. Bryozoa, Gastropoda, and other forms were identified as associates, their relative abundance in the core being in that order.

Richard Dixon (1961) in an unpublished Master's thesis at Michigan State University, completed a lithologic analysis of this same core. Therefore, this report will investigate only the paleontologic aspects.

AREAL DESCRIPTION

Location

The exact location of the core which is the subject of this report is SW¼, NE¼, Sec. 5, T.40N., R.23W., Michigan Meridian. This is 2¼ miles southeast of Cornell, Michigan in Delta County, and about 1500 feet south of the Escanaba River (Slaughter, 1960). Delta County is in the south central part of the Northern Peninsula of Michigan and is on the north shore of Lake Michigan.

Regional Structure

This core is located near the north-northwestern flank of the Michigan basin. The Michigan basin is an extensive negative structure that covers all of the Southern Peninsula of Michigan, part of the Northern Peninsula and parts of Wisconsin, Illinois, Indiana, Ohio and Ontario, Canada. Studies have shown that it has been a subsiding structure since Precambrian time (Newcombe, 1933; Pirtle, 1932; Cohee, 1948). The basin today is a relatively restricted area bounded by the Findlay and Kanakee arches on the south, the Wisconsin dome on the west, the Algonquin arch on the east, and the Precambrian rocks of the Canadian shield on the north (Pirtle, 1932). These barriers are breached by the Chatham sag on the east and the Logansport sag on the Kanakee arch to the southwest (Cohee, 1948). Some doubt still exists as to the time of introduction of these major positive elements surrounding the basin. Pirtle (1932) has contoured the top of the Trenton in the Michigan basin and the structural contours clearly show the influence of the positive structural barriers.

Pirtle (1932), Newcombe (1934), Mellhorn (1958), and King (1959)

all give evidence showing that the Kanakee and Findlay arches were present during Ordovician time although perhaps not yet as major positive elements isolating the basin.

Newcombe (1934) points out that complete isolation of the basin did not occur for the first time until late Silurian time.

Results of recent drilling in and around the Michigan basin may provide more information.

On this north-northwestern flank of the Michigan basin, Silurian and Ordovician rocks crop out along stream beds and other places where they are not covered by glacial drift. The regional dip is about 40 feet per mile to the southwest. According to Hussey (1936) the dip is not constant and may change directions locally. This is thought to be a reflection of the Precambrian basement rocks upon which the Paleozoic rocks rest.

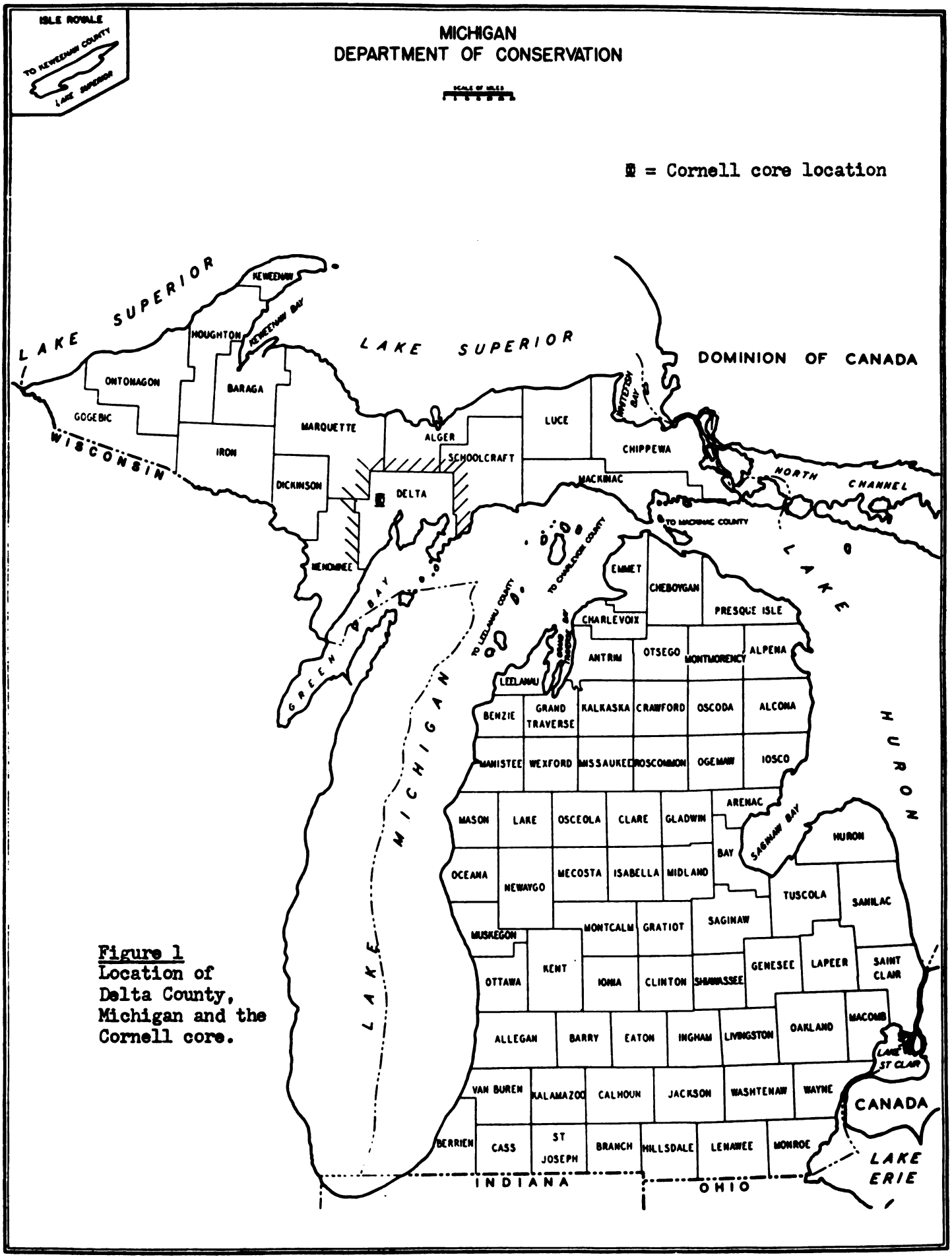

Figure 1
Location of Delta County, Michigan and the Cornell core.

CORE DESCRIPTION

General

The two inch core was drilled at an angle of 45° from the vertical, the direction of the inclination being to the south (Slaughter, 1960). The core has an actual length of 793 feet. It reached a true depth of 561 feet. All depths referred to in this report will be corrected depths, the corrections having been calculated from inclined depths.

The core was not logged prior to its acquisition by Michigan State University. The Cleveland Cliffs Iron Company took three or four inch cuts about every 10 feet for their files. The core was placed in boxes capable of holding 11 feet of core. In many cases, however, the core in these boxes actually cover an interval of anywhere from five to twenty feet. Because of this and the fact that the boxes are inadequately marked to cover situations such as this, it is often difficult to place precisely the depth of any particular sample. The possible margin of error is usually not so great that careful work cannot keep the error down to a maximum range of plus or minus one foot. The exceptions are several boxes, one of which is not labelled at all and another which seems to be mislabelled since the lithology of the rock it contains is quite different from that immediately above and below. The latter box is labelled "to 356?". Two other boxes are marked "to 367?", and "to 378?". Although these two boxes are questionable, if it is assumed the labelling is correct, depths can be worked out.

If these sources of error are kept in mind, however, good accuracy can be obtained. The two-inch diameter of the core provides a relatively small sample to obtain diagnostic results.

For purposes of identification, the Michigan State Geological Survey refers to this core as the Cornell core. That name will be used in this report also.

Lithology

The upper 100 feet or so is primarily limestone with irregular, interbedded shale while the next 375 feet is primarily dolomite with about 36 feet of sandstone and 16 feet of limestone interbedded with the dolomite. The lower 85 feet is primarily sandstone with about five and one-half feet of interbedded dolomite. Conglomerates appear at 117 feet, 247 feet, 485 feet and lowest three feet of core. Thin shaly partings occur throughout the core. Glauconite and pyrite are conspicuous in the dolomite middle section (Dixon, 1961). Figure 3 shows the lithology of the core.

Detailed lithologic descriptions are given in Dixon's report (1961).

STRATIGRAPHIC FRAMEWORK

The fossiliferous portion of the Cornell core starts in the lower part of the Trenton (Slaughter, 1960) and continues through the Black River of the Middle Ordovician (Dixon, 1961). The core continues into the Cambrian but is barren of fossils except for a few scattered specimens. The entire core was examined for fossil content. Figure 2 is a graphic representation of the Ordovician section of the Michigan basin. These formations have been correlated rather well with those of the Upper Mississippi Valley and Ontario, Canada and generally with those of the Appalachian area and the Tennessee - Kentucky area.

Any paleontologic implications of this core as they affect any interpretation regarding presence or absence of any of these units in the core or the presence of formational contacts will be presented in the conclusion of this report.

Dixon (1961), whose work has preceeded the writer's, may be referred to for an excellent summary of the historical development of the stratigraphic nomenclature of the Ordovician as related to the stratigraphy of this core.

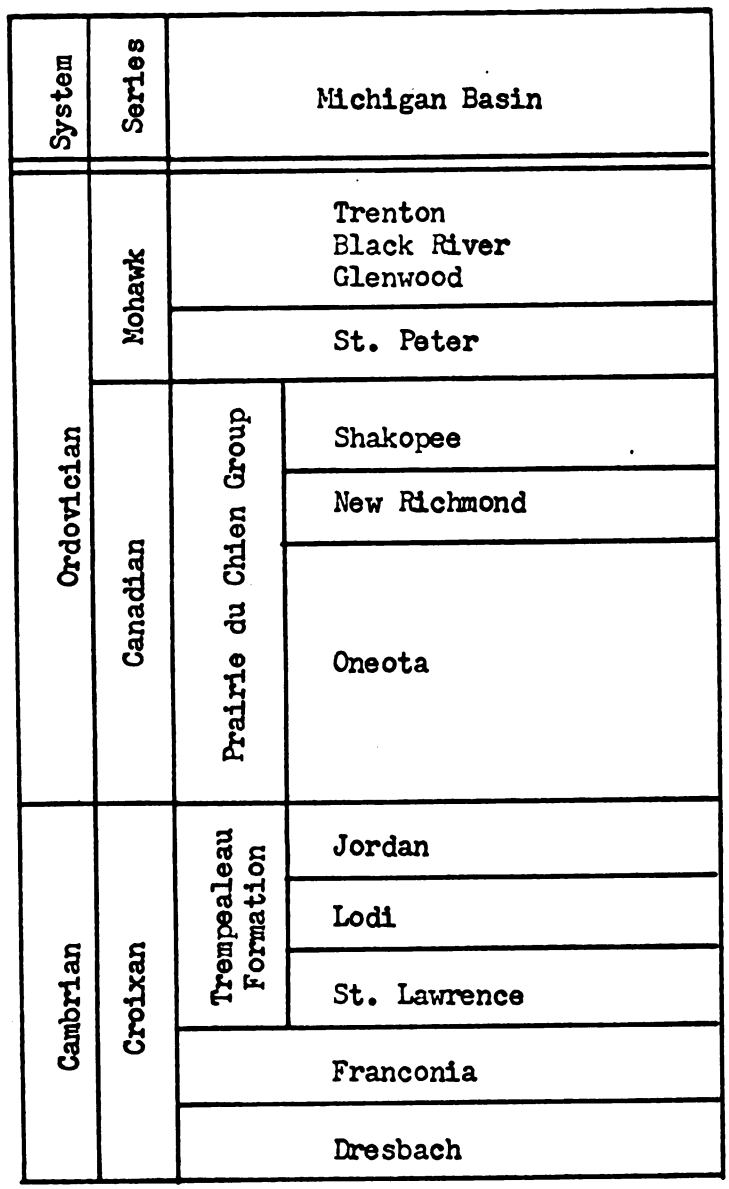

Figure 2 Column showing the Cambrian and Ordovician formations of Michigan as represented in the Cornell core. (After Dixon, 1961)

PREVIOUS WORK

In 1936, Hussey made a study of the Trenton and Black River rocks of Michigan. His approach was both paleontologic and stratigraphic in that he listed the fauna and described the rock type and in this way correlated outcrops over a broad area of the Northern Peninsula. In 1952, Hussey again studied the Ordovician outcrops of the Northern Peninsula, this time concentrating on the Middle and Upper Ordovician rocks. In that report Hussey zoned the Trenton into three zones on a faunal basis, describing and picturing the fossils.

Both of Hussey's papers describe work with outcrops some of which are only two miles from the location of the core described in this report. His works remain as the best available material on the Ordovician of the Northern Peninsula.

In 1946 Alice Wilson began a series of papers for the Canadian Department of Mines and Resources, Mines and Geology Branch, which were planned as a series of reference texts on the paleontology of the Paleozoic formations of the Ottawa - St. Lawrence Lowland. Each of these papers describe a faunal class or, if appropriate, more than one faunal class of the Ottawa Formation. These papers, which are comprehensive and very useful, appeared as numbered bulletins of the Canadian Geological Survey.

E. O. Ulrich and G. Arthur Cooper in 1938 published a study of the Ozarkian and Canadian Brachiopoda in which they described specimens from all of North America except Newfoundland. This work is invaluable for the study of the Lower Ordovician.

In 1953, G. Arthur Cooper's sequel to the latter publication was

released. Although titled Chazyan and Related Brachiopoda, forms from as high as the Trenton or its correlatives are described. This voluminous work is comprehensive in that it describes fossils from all the United States and Canada, but there is a definite emphasis on Appalachian or nearby forms.

The classical works on Ordovician rocks include Hall's 1847 study of the paleontology of New York. This includes descriptions from the type areas of Trenton and Black River rocks.

Another classical work is the 1895 publication of the Geological and Natural History Survey of Minnesota. Winchell, Ulrich, et al. produced in this report on the "Lower Silurian" a long-standing reference to the fauna of the Upper Mississippi Valley. It covers all classes of fossils as does Hall's New York study.

The Treatise on Invertebrate Paleontology sponsored by the Geological Society of America is an authoritative discussion and description of the various classes of animals each of which is taken up in individual volumes. This work is not as yet complete but those sections which are completed are useful, particularly in the early stages of identification.

The works discussed above are the basic ones that must be consulted when working on Ordovician paleontology. They are comprehensive works pertinent to the study of the Ordovician fauna of the Michigan basin.

METHOD OF EXAMINATION

Development of Sampling Technique

The nature of the core which is the subject of this thesis presented several problems. Its length and the dominant lithology made the search for fossil specimens difficult and the two-inch diameter cut down rather drastically on the statistical chance of finding fossils. As a result, much time was spent in developing the best approach to recover the greatest amount of fossil material that would insure good coverage of the core and provide diagnostic results.

In the beginning, it was hoped that microfossils would be found in sufficient quantities to enable a paleontologic analysis based on this type of fossil. Recovery of microfossils proved to be impossible for the most part. The method used in this initial, futile search was as follows. The core was examined for shale breaks or other likely intervals where fossils might be found in identifiable condition and samples from these intervals were removed to the laboratory for disintegration. If natural intervals were not closely spaced an arbitrary choice of a one-foot sample interval was made and samples were removed from these places also and taken to the laboratory for disintegration. A gross examination was made to find any specimens on the broken surfaces. When specimens were found on the broken surfaces they were either removed or cleaned in place depending on matrix material and the condition of the specimen. After the gross examination, the sample was disintegrated by one of or a combination of several methods. These methods are (a) mechanical, (b) boiling in plain water (Layne, 1950), (c) boiling or soaking in potassium hydroxide (Bolli, 1950), (d) alternate heating and water quenching (MacVicar, 1951,

Redmond, 1953), and (e) heating and kerosene quenching (Layne, 1950; Crowley, 1952; Redmond, 1953). These methods all gave varying degrees of success depending on the lithology involved, the more dense rocks being nearly impossible to disintegrate and still produce identifiable specimens. Disintegration complete enough to permit recovery of microfossils was satisfactorily obtained only when shales were boiled in plain water or potassium hydroxide. After subjecting the samples to these disintegration techniques with little recovery, examination for microfossils was for the most part abandoned. Further study was devoted to megafossils using microscopic examination and mechanical extraction of any fossils found which gave results which were as good as could be gained through other methods.

Laboratory Methods

The core was examined at approximately six-inch intervals which gave a coverage of approximately a four-inch interval of true depth. Since the core was cut at an angle of 45° from the vertical, care was taken to insure that all sample cuts were made along bedding planes. When fossils were found, a closer examination of the immediate core section was made to determine if more were present.

The fossils were extracted with the following equipment:

(1) Burgess Vibro Tool

(2) Common Needles

(3) Dissection Needles

(4) Small Chisels

(5) Hydrocholoric Acid

(6) Wax to localize the acid effect

Examination was made with a binocular microscope.

The chisels were used, when necessary, to split the core samples to gain access to specimens imbedded or partially imbedded in the matrix. The common needles and dissection needles were used for chipping matrix and cleaning fossils. The Vibro-Tool was of great value where large amounts of matrix needed to be chipped. Acid was used only where its use would not harm the specimen being cleaned. Dilute acid (HCl) was used to assist in softening up the matrix and occasionally to accomplish final cleaning of the specimen.

SYSTEMATIC DESCRIPTIONS

Phylum PROTOZOA

Class RHIZOPODA

Order CHITINOZOA

Family CONOCHITINIDAE

Genus RHABDOCHITINA Eisenack, 1931

RHABDOCHITINA? MINNESOTENSIS Stauffer, 1933

Rhabdochitina? minnesotensis Stauffer, 1933, G. S. A. Bull., vol. 44, p. 1209, pl. 60, fig. 39; Collinson and Schwalb, 1955, Ill. State Geol. Surv., Rept. of Invest., no. 186, p. 30, fig. 10.

Discussion. - Several specimens of this tiny cylindrical organism were obtained from the Cornell core. Four samples covering an interval of 20 feet contain hundreds of these chitinozoans in jumbled attitudes. The only other fossils found with them were scolecodonts.

Horizon and Locality. - Reported from the bottom five feet of the Decorah Formation in Minnesota by Stauffer (1933). Collinson and Schwalb (1955) mention only Stauffer's report of this species from the Decorah. They report no other horizon or locality. In 1960 Taugourdeau reported an occurrence in the Gothlandien (Silurian) of the Sahara. The specimens from the Cornell core were at depths of 162 ft., 170 ft., 173 ft., and 183 ft. The Specht's Ferry Member of the Decorah Formation is the basal unit of the Decorah (Twenhofel, 1954). According to Kay (1935) the Spechts Ferry is Trenton in age. According to Cooper (1956) the Spechts Ferry is Black River in age.

Specimen Numbers. - 232, 242, 245, 260.

Phylum COELENTERATA

Class SCYPHOZOA

Genus METACONULARIA Foerste, 1928

METACONULARIA CALDERI Sinclair, 1940

Metaconularia calderi Sinclair, 1940, Trans. Roy. Soc., Canada, 3rd Ser. 34, sec. 4, p. 110, pl. 3, figs. 3-5; Wilson, 1951, Canada. Geol. Surv. of Can., Bull. 17, p. 102, pl. XIX, figs. 1-4.

Discussion. - This specimen consists of only a small fragment, but the distinctive ornamentation of the species permits identification.

Horizon and Locality. - This species has been reported doubtfully from the Sherman Falls Beds in Ontario and with certainty from the Coburg Beds in Ontario. This specimen was found at a depth of 17 feet in the Cornell core.

Specimen Number. - 24.

Genus CONULARIA Miller, 1818

CONULARIA cf. C. TRENTONENSIS Hall, 1847

Conularia trentonensis Hall, 1847, Pal. New York, pt. 1, p. 222, pl. 59, figs. 4a-f.

Discussion. - This specimen consists only a part of the entire organism but it is recognizable as Conularia. Its structure most nearly resembles the species C. trentonensis Hall but since not enough of the characters can be seen, it seems advisable to only note the resemblance and not assign a species.

Horizon and Locality. - Reported from the Trenton or its equivalents in Quebec, New York to Virginia, Michigan, and Iowa. This specimen was found at a depth of 58 feet in the Cornell core.

Specimen Number. - 82.

Class ANTHOZOA

Subclass ZOANTHARIA

Genus STREPTELASMA Hall, 1847

STREPTELASMA cf. S. CORNICULUM Hall, 1847

Streptoplasma corniculum Hall, 1847, Paleontology of New York, vol. I, p. 69, pl. 25, figs. 1a-1e.

Streptoplasma crassa Hall, 1847, Paleo. of New York, vol. I, p. 70, pl. 25, figs. 2a-2c.

Streptoplasma multilamellosa Hall, 1847, Paleo. of New York, vol. I, p. 70, pl. 25, figs. 3a-3c.

Streptoplasma parvula Hall, 1847, Paleo. of New York, vol. I, p. 71, pl. 25, figs. 4a-4c.

Streptelasma corniculum Billings, 1856, Canadian Naturalist and Geologist, vol. I, p. 122, figs. 3 & 4 on p. 121; Nicholson, 1875, Paleo. of Ontario, p. 12, (p. 26 partim): Ulrich, in Winchell, Schuchert, et al., 1885, Geol. of Minn., Final Report, vol. III, pt. I, Paleontology, p. 90, pl. G. figs. 20, 21.

Petraia corniculum Billings, in Logan, 1863, Geology of Canada, p. 156, fig. 118, p. 938.

Discussion. - This specimen is the top of a corallum and is broken. On the basis of its size and septal characteristics it was assigned to the genus Streptelasma. Because of its condition a definite specific determination was not made but because of its superficial resemblance to S. corniculum Hall and the fact this species is quite commonly reported

in Black River and Trenton rocks, S. corniculum was recorded as a possible specific name.

Horizon and Locality. - Common in the Black River and Trenton of central and eastern North America. This specimen was found at a depth of 77 feet.

Specimen Number. - 109c.

Phylum BRYOZOA

Subphylum ECTOPROCTA

Order TREPOSTOMATA

Suborder INTEGRATA

Family TREMATOPORIDAE

Genus BATOSTOMA Ulrich, 1882

BATOSTOMA WINCHELLI (Ulrich) 1886

Amplexopora winchelli Ulrich, 1886, 14th Ann. Rept. Geol. Nat. Surv. Minn., p. 91.

Batostma winchelli (Ulrich) Ulrich, in Winchell, Schuchert, et al., 1885, Geol. Minn., Final Report, vol. 3, pt. 1, Paleontology, p. 295, pl. XXVI, figs. 33-37; pl. XXVII, figs. 1-6.

Discussion. - Four specimens found in the Cornell core have been assigned to the species Batostoma winchelli (Ulrich). Sections were made of two of them.

Horizon and Locality. - Reported from the Trenton of Minnesota. These were at depths as follows:

Specimen Number	Depth in Feet
66	46.5
99	70
110	78
118	83.5

Specimen Numbers. - 66, 99, 110, 118.

Family PHYLLOPORINIDAE

Genus PHYLLOPORINA Ulrich, 1887

PHYLLOPORINA sp.

Discussion. - This specimen is very small. It has the appearance of angular ridges on a branching surface. The angular ridges are four to eight in number and could be the zooecial tubes. It resembles Phylloporina though identification is doubtful. No sections were made.

Horizon and Locality. - Reported from the Trenton and Black River rocks of Ontario, New York and Minnesota. This specimen was found at a depth of 76 feet in the Cornell core.

Specimen Number. - 108.

Phylum BRACHIOPODA

Class INARTICULATA

Superfamily OBOLACEA

Family OBOLIDAE

Genus LINGULA Bruguiere, 1789

LINGULA? sp.

Discussion. - This specimen is crushed and broken so that only a general shape and some shell material is still recognizable. For this reason its affinity can only be surmised. The shape is subquadrate and the shell remnants are shiny and show concentric growth lines. In size and shape this specimen resembles L. elderi Whitfield, which is a Trenton form, but due to its condition no positive identification can be made.

Horizon and Locality. - This specimen was found at 87.5 feet in the Cornell core.

Specimen Number. - 124.

Subfamily BICIINAE

Genus DICELLOMUS Hall, 1873

DICELLOMUS POLITUS (Hall) 1861

Obolus appolinus? Owen (not Eichwald), 1852, Rept. Geol. Surv. Wis., Iowa, and Minn., Appendix, p. 501, pl. 1B, figs. 9, 11, 15, 20.

Lingula polita Hall, 1861, Rept. Supt. Geol. Surv. Wisc., p. 24.

Obolella sp. 3 Billings, 1865, Geol. Surv. Can., Paleozoic Fossils, vol. 1, p. 7.

Lingula? polita Hall, 1862, Rept. Geol. Surv. Wisc., vol. 1, p. 435, Fig. 1, p. 21.

Obolella? polita Hall, 1863, Sixteenth Ann. Rept. New York State Cab. Nat. Hist., pp. 133-134, pl. VI, figs. 17-21.

Lingulepis prima Meek and Hayden, 1865, Smithsonian Contributions Knowledge, No. 172, Paleontology Upper Missouri, pt. 1, p. 3, pl. 1, figs. 2a-b.

Dicellomus polita Hall, 1873, 23'd Ann. Rept. New York State Cab. Nat. Hist., p. 246.

Obolella polita (Hall), Whitfield, 1880, U. S. Geog. and Geol. Survey Rocky Mtn. Region, Rept. Geol. and Resources Black Hills of Dakota, by Newton and Jenney, pp. 339-340, pl. II, figs. 12 & 13; Walcott, 1886, Bull. U. S. Geol. Surv., No. 30, p. 111; Hall and Clarke, 1892, Nat. Hist. New York, Paleontology, vol. 8, pt. 1, pp. 72 & 73, pl. II, figs. 37-41.

Dicellomus politus (Hall), Walcott, 1899, Mon. U. S. Geol. Surv., vol. 32, pt. 2, p. 443 & 446, pl. LX, figs., 2 & 4a; Walcott, 1905, Proc. U. S. Nat. Mus., vol. 28, p. 316-318; Grabau and Shimer, 1909, North American Index Fossils, vol. 1, p. 189-190, fig. 224; Walcott, 1912, Mono. U. S. Geol. Surv., vol. 51, pts. 1 & 2, p. 575, text figs. 16A-B, 49A-B, pl. LII, figs. 1, 1a-k, 2, 2a-i, 3, 4, 4a, 5, 5a-b; Shimer and Shrock, 1944, Index Fossils of North America, p. 285, pl. 107, figs. 8-14.

Discussion. - The sample consists of one fairly well-preserved specimen showing all diagnostic characteristics mentioned by Walcott except internal structures. The specimen is a slightly crushed ventral valve. The most posterior part of the beak is missing. There are two other specimens in the same piece of rock that are considerably crushed and broken.

Horizon and Locality. - The species is reported from the Upper Cambrian of the Appalachian area, Wisconsin, Missouri, Black Hills, and the Cordilleran area. This specimen was found at a depth of 415 feet in the Cornell core.

Specimen Number. - 587

Class ARTICULATA

Superfamily ORTHACEA

Family HESPERORTHIDAE

Subfamily HESPERORTHINAE

Genus HESPERORTHIS Schuchert and Cooper, 1931

HESPERORTHIS TRICENARIA (Conrad), 1843

Orthis tricenaria Conrad, 1843, Proc. Acad. Nat. Sci. Philadelphia, v. 1, p. 333; Bassler, 1915, U. S. Nat. Mus. Bull. 92, p. 897.

Orthis disparilis Conrad, 1843, Proc. Acad. Nat. Sci., Philadelphia, v. 1, p. 333.

Hesperorthis tricenaria (Conrad) Schuchert and Cooper, 1932, Mem. Peabody Mus. Nat. Hist., v. 4, pt. 1, p. 86.

Discussion. - This is a small specimen, broken but fairly well-preserved and showing some of the interior. It is probably Hesperorthis disparilis (Conrad) which is thought by Cooper to be a young form of H. tricenaria (Cooper, 1956).

Horizon and Locality. - Reported from the Trenton or its equivalents over a large part of the Middle and Upper Mississippi Valley. Also in Northern Peninsula of Michigan. Found at a depth of 99 feet in the Cornell core.

Specimen Numbers. - 139, 6B.

Superfamily TRIPLESIACEA

Family TRIPLESIIDAE

Genus OXOPLECIA Wilson, 1913

OXOPLECIA? sp.

Discussion. - This specimen has been doubtfully referred to the genus Oxoplecia on the basis of certain external features. It has an approximate width of 13mm. It is costate and has a broad, shallow sulcus with five costae in the sulcus. The general outline is oval, and is gnetly convex. The sulcus apparently starts near the beak and broadens rapidly. The preservation is so poor that nothing else can be determined of this specimen. Although the possibility of sculpturing such as imbrication exists, any hint of it has been destroyed in the process of preservation of this specimen. The exact extent of the beak and portions of the periphery cannot be determined. For these reasons no attempt has been made to identify it as to species and generic determination has been given with a definite question.

Horizon and Locality. - This genus has a long vertical range but the forms most similar to the specimen reported here are Black River in age and are reported from nearly all areas of occurrence. This specimen came from a depth of 166.5 feet in the Cornell core.

Specimen Number. - 237.

Superfamily RHYNCHONELLACEA

Family RHYNCHOTREMATIDAE

Genus ROSTRICELLULA Ulrich and Cooper, 1942

ROSTRICELLULA MINNESOTENSIS (Sardeson) 1891

Rhynchonella minnesotensis Sardeson, 1901, Minn. Acad. Nat. Sci. Bull., vol. 3, p. 333, pl. 4, figs. 21-23.

Rhynchotrema inequavalvis Winchell and Schuchert (part) 1892, Geol. Minn., Final Report, vol. 3, pt. 1, Paleontology, p. 459, pl. 34, figs. 9-11; 15-23.

Rhynchotrema minnesotense (Sardeson) 1922, Fenton and Fenton, Iowa Acad. of Sci. Proc., vol. 22, p. 70, pl. 1, fig. 15-17.

Rostricellula minnesotensis (Sardeson) Cooper, G. A., 1956, Smith. Misc. Coll., vol. 127, pt. 1 & 2, p. 269, pl. 131A, figs. 1-7, pl. 139A, figs. 1-11.

Discussion. - Two specimens were found. One specimen (# 110) is slightly smaller and thinner than that described by Cooper and is probably an immature specimen. Winchell and Schuchert describe one of this nature. It is a complete specimen with no interior showing. Another specimen (# 97) of the same species is a mature form. It is a broken brachial valve showing only the beak characters of the interior. This interior of this specimen is encrusted with a bryozoan (Prasapora).

Horizon and Locality. - Cooper reports this species from the McGregor Member of the Platteville Formation in Wisconsin, Illinois, and Minnesota, and the Spechts Ferry Member of the Decorah in Minnesota. Winchell and Schuchert describe it from the Trenton equivalents of the Upper Mississippi Valley. Specimen No. 110 was found at a depth of 78 feet in the Cornell core while specimen No. 97 was found at a depth of 68.5 feet.

Specimen Numbers. - 110, 97.

Superfamily ATRYPACEA

Family ATRYPIDAE

Subfamily ZYGOSPIRINAE

Genus ZYGOSPIRA Hall, 1862

ZYGOSPIRA RECURVIROSTRIS (Hall) 1847

Atrypa recurvirostris Hall, 1847, Pal. New York, 1, p. 140, pl. XXXIII, fig. 5.

Zygospira recurvirostris (Hall) Chamberlin, 1883, Geol. Wisc., vol. 1, p. 155, fig. 7; Winchell and Schuchert, 1892, Geol. Minn., Final Report, vol. 3, pt. 1, Paleontology, p. 466, pl. XXXIV, figs. 38-41.

Discussion. - Ten well-preserved specimens were found, one of which is broken and another is crushed slightly. All have both valves present. No internal structures were observed.

Horizon and Locality. - This species has been found abundantly in almost all occurrences of the Trenton Formation and less often in Black River rocks. These specimens came from depths as follows:

Specimen # 82a at 57.8 feet
" # 89a at 59.5 "
" # 90 at 63.5 "
" # 99a at 70 "
" # 99b at 70 "
" # 99c at 70 "
" # 99d at 70 "
" # 109a at 77 "
" # 116 at 82 "
" # 118b at 83.5 "

Specimen Numbers. - 82a, 89a, 90, 99a, 99b, 99c, 99d, 109a, 116, 118b.

ZYGOSPIRA cf. Z. ELONGATA Cooper, 1956

Zygospira elongata Cooper, 1956, p. 670, pl. 268G, fig. 29-32.

Discussion. - The specimen is a large Zygospira with 33 costae, a prominent median fold on the pedicle valve with slightly concave flanks posteriorly which accentuate the fold. It is nearly plano-convex with the pedicle valve being moderately convex. The brachial valve has a shallow sulcus beginning near the beak and broadening anteriorly to occupy nearly half the anterior margin. The commissure is sulcate with the flanks slightly swollen. Five costae occupy the sulcus. Measurements are: length, 5.5 mm; width, 5.3 mm; thickness, 3.5 mm.. The specimen is well preserved with both valves complete. Internal structures were not observed. This form is only tentatively assigned to Z. elongata Cooper, because it has a 5 or 6 more costae than his Z. elongata and that species has not been reported as yet from the Upper Mississippi Valley.

Horizon and Locality. - Cooper reports this species from the Lebanon Formation in Tennessee. This specimen was found at a depth of 123 feet in the Cornell core.

Specimen Number. - 175.

ZYGOSPIRA DEFLECTA (Hall) 1847

Atrypa deflecta Hall, 1847, Pal. New York, 1, p. 140, pl. XXXIII, fig. 4.

Zygospira deflecta (Hall), Hall and Clarke, 1894, Pal. New York, 8, pt. 2, p. 157.

Discussion. - This is a small specimen with the typical deflected flanks of Z. deflecta (Hall). It is well-preserved except for the brachial

valve which is partially covered with matrix. The specimen is complete with no interior showing.

Horizon and Locality. - Reported in Trenton and Black River equivalents of Ontario and New York. This specimen was found at a depth of 69 feet.

Specimen Number. - 98.

Subfamily GLASSINAE Schuchert, 1929

Genus IDIOSPIRA Cooper, 1956

IDIOSPIRA PANDERI (Billings) Cooper, 1956

Camerella panderi Billings, 1859, Canadian Nat. Geol., v. 4, p. 302; Logan 1863, Geol. Can., p. 143, fig. 78; Hall and Clarke, 1894, Pal. New York, v. 8, pt. 2, p. 220, pl. 62, figs. 19-23; ? Raymond, 1911, Ann. Carn. Mus., v. 7, p. 250, pl. 36, figs. 31, 32; Wilson, 1946, Geol. Surv. Canada, Bull. 8, p. 118, pl. XI, fig. 2.

Idiospira panderi (Billings), Cooper, 1956, Smithsonian Misc. Coll., v. 127, pts. 1 & 2, p. 691, pl. 108F, figs. 26-32, pl. 195F, figs. 33-37, pl. 195H, figs. 42-46.

Discussion. - A single broken pedicle valve was found. Internal structures were not observed.

Horizon and Locality. - It is widely reported from the basal Trenton or its equivalents in New York, Ontario, Quebec, Kentucky, Missouri, and Iowa. This specimen was found at a depth of 123 feet in the Cornell core.

Specimen Number. - 175a.

Superfamily PLECTAMBONITACEA

Family SOWERBYELLIDAE

Subfamily SOWERBYELLINAE

Genus SOWERBYELLA Jones, 1928

SOWERBYELLA SERICEA (Sowerby) 1839

Leptaena sericea Sowerby, 1839, Murchison's Sil. Sys., pt. 2, p. 636, pl. XIX, figs. 1 & 2.

Plectambonites sericeus (Sowerby) Hall and Clarke, 1892, Pal. New York, 8, pt. 1, pl. XV, figs. 15-19.

Sowerbyella sericea (Sowerby), Jonws, 1928, Geol. Surv., Gr. Brit., Mem. 1, p. 414, pl. XXI, figs. 1-4; Wilson, 1946, Geol. Surv., Can., Bull. No. 8, p. 51, pl. III, fig. 26.

Discussion. - Four pedicle valves with no interiors visible were found. Two of them are fairly well-preserved.

Horizon and Locality. - This species is reported from the Black River and Trenton equivalent in Ontario and the Trenton of Michigan. Specimens were found at the following depths:

Specimen # 66 at 46.5 feet

" # 118a at 83.5 "

" # 118b at 83.5 "

" # 126a at 89.5 "

Specimen Numbers. - 66, 118a, 118b, 126a.

SOWERBYELLA sp.

Discussion. - This specimen is clearly of the genus Sowerbyella but specific determination cannot be made. Both valves are present and

complete and no interior can be seen. The surface sculpturing cannot be seen in enough detail, due to exfoliation, to enable a diagnosis to be made. It is rather large, convavo-convex with the pedicle valve moderately convex and with the greatest convexity just anterior to the umbo. The sides are gently sloping. The interarea is flat, and the pedicle opening sub-triangular with deltidial plates. The beak projects slightly over the posterior margin and the outline is suboval. There is a prominent concentric rugosity midway of the brachial valve, with a fainter corresponding one on the pedicle valve. There are very faint wrinkles on the posterior margin.

Width	-	13.5 mm.
Length	-	9.0 mm.
Midwidth	-	13.0 mm.
Brachial Length	-	8.5 mm.
Height	-	3.0 mm.
Thickness	-	2.0 mm.

Horizon and Locality. - The genus has been reported in all Middle Ordovician rocks. This specimen was found at a depth of 45 feet in the Cornell core.

Specimen Number. - 64a.

Superfamily STROPHOMENACEA

Family STROPHOMENIDAE

Genus STROPHOMENA Blainville, 1825

STROPHOMENA cf. S. FILITEXTA (Hall), 1847

Leptaena filitexta Hall, 1847, Pal. New York, v. 1, p. 111, pl. 31B, fig. 3.

Strophomena filitexta Hall and Clarke, 1892, Pal. New York, v. 8, pt. 1, p. 251, pl. 9, fig. 6; Fenton, 1929, Amer. Midland Nat., v. 11, no. 9, pp. 500-503, pl. 38, figs. 1-5.

Discussion. - Two samples found in the Cornell core came from within three feet of each other and contain brachiopods that could be referred to Strophomena filitexta (Hall). One sample consists of one large, incomplete pedicle valve with external features only while the other sample consists of many large, broken, intermingled valves. The size and external characteristics of the valves strongly suggest S. filitexta.

Horizon and Locality. - This species has been found in the Trenton and Black River equivalents in the Middle and Upper Mississippi Valley, Michigan, the Appalachians, and Ontario. These specimens were found at depths in the Cornell core as follows:

Specimen # 176 at 124.5 feet

" # 180 at 127 "

Specimen Numbers. - 176, 180.

STROPHOMENA sp.

Discussion. - Two specimens found in the Cornell core at depths of 60.5 feet and 77 feet cannot be identified beyond genus. Both are resup-

inate, reticulate, and have costellae of varying size. For these reasons they have been placed in the genus Strophomena. No internal characters are available and in both cases, poor preservation prevents measurements.

Horizon and Locality. - These specimens were found at the following depths:

Specimen # 86 at 60.5 feet

" # 109b at 77 "

Specimen Numbers. - 86, 109b.

Genus RAFINESQUINA Hall and Clarke, 1892

RAFINESQUINA NORMALIS Wilson, 1932

Rafinesquina normalis Wilson, 1932, Royal Soc. Can. Trans., ser. 3, v. 26, sec. 4, p. 395, pl. 5, figs. 5-7; Salmon, 1942, J. of Paleo., v. 16, No. 5, p. 585, pl. 86, figs. 21-24; Wilson, 1946, Canada. Geol. Surv. Bull. No. 8, p. 79, pl. 8, figs. 10, 11, text fig. 6, No. 6.

Discussion. - The specimen referred to here as R. normalis is a complete specimen except that the cardinal extremities are broken. No interior is visible but the beak was washed with acid (Cooper, 1956) and faint outlines of interior structures are visible. Acidizing was not satisfactory due to the partial silicification of the specimen as evidenced by Beekite structures. The exterior of the specimen is in good enough condition to recognize all diagnostic characteristics. Salmon (1942) in her paper on Mohawkian Rafinesquinae, defined the essential identifying characteristics as follows:

> "The most important characters are those of the interior (especially the brachial) and the shell structure (character of the pseudopunctae). These are considered fundamental and are here used as generic distinctions. This usage is in accord with recent research in other groups of brachiopods, notably the work of Schuchert and Cooper on the Orthoidea."

She further states in regard to specific determination:

> "_____convexity and outline - are here considered the basic criteria for distinguishing species."

With regard to the generic distinctions, the character of the pseudopuncta, the shape of the cardinalia and the sum of other minor characters indicates that the specimen discussed herein is of the genus Rafinesquina. Specific determination was made through careful measurements and the ratios of these measurements. Wilson (1946) says that the average measurements of the type specimens of R. normalis are: width, 29mm.; length, 22mm.; thickness, 6mm.. She relates these measurements by dividing each of them by the thickness. This expresses the dimension of thickness as one, which she calls convexity, and each of the other two dimensions as a multiple of the thickness. These values are compiled in a table that shows the relationship of convexity to length and to width and points out that decreasing length and width accompany increasing thickness. Her values for R. normalis are: convexity = 1, length = 3.6, width = 4.8. The measurements of the specimen found in the Cornell core are: width, 30mm.; length, 21.5mm.; and thickness, 6.3mm.. The reduced values for the specimen are: convexity = 1, length = 3.4, and width = 4.5. An examination of Wilson's tables show that these values approximate those of R. normalis more nearly than those of other Rafinesquina species. Salmon (1942) states that the length/width ratio of R. normalis is high, ranging from 1:1.40 to 1:1.53.

The length/width ratio of this specimen is 1:1.40.

Horizon and Locality. - This species, found at a depth of 56 feet in the Cornell core, has a reported range of Upper Sherman Falls to Upper Coburg in New York and Ontario.

Specimen Number. - 79.

Superfamily DALMANELLACEA

Family DALMANELLIDAE

(= WATTSELLIDAE)

Genus DALMANELLA Hall and Clarke, 1892

DALMANELLA WINCHELLI Cooper, 1956

Orthis (Dalmanella) hamburgensis? Winchell and Schuchert, 1885 (not Walcott, 1884), Geol. Minn., Final Report, v. 3, pt. 1, Paleontology, p. 440, pl. 33, figs. 14-16.

Dalmanella winchelli Cooper, 1956, Smithsonian Misc. Coll., v. 127, pts. 1 & 2, p. 953, pl. 158D, figs. 15, 16.

Discussion. - This specimen is poorly preserved and no interior can be seen. Enough external characteristics are available to warrant placing this specimen with D. winchelli Cooper. Size and configuration are similar and while only an estimate can be made, the number of costellae seem to exceed 32 which agrees with Winchell and Schuchert's description.

Horizon and Locality. - This species is reported from the Decorah Formation, Guttenburg Member, in Minnesota. This specimen came from a depth of 20.5 feet in the Cornell core.

Specimen Number. - 29.

Family ONNIELLIDAE

Genus PAUCICRURA Cooper, 1956

PAUCICRURA ROGATA (Sardeson), 1897

Orthis rogata Sardeson, 1901, Minn. Acad. Nat. Sci., Bull. 3, p. 331, pl. 5, figs. 1-4; 1896, Amer. Geol., v. 19, p. 95, pl. 4, figs. 1-10.

Orthis (Dalmanella) testudinaria (Winchell and Schuchert, not Dalman) Winchell and Schuchert, 1885, Geol. Minn., Final Report, pt. 1, Paleontology, v. 3, p. 491, pl. 33, figs. 17-22; Hall and Clarke, 1893, Pal. New York, v. 8, pt. 1, pl. 5B, figs. 27-31.

Dalmanella rogata (Sardeson) Schuchert and Cooper, 1932, Mem. Peabody Mus. Nat. Hist., v. 4, pt. 1, p. 120, pl. 17, figs. 2-5, 7, 13, 31.

Paucicrura rogata (Sardeson), Cooper, 1956, Smithsonian Misc. Coll., v. 127, pts. 1 & 2, p. 957, pl. 157F, figs. 18-24.

Discussion. - This specimen is imperfectly preserved and no interior may be observed. The external characteristics, however, are sufficient to warrant placing this specimen with P. rogata.

Horizon and Locality. - This species has been reported from the Upper Decorah (Ion Member) and the Lower Prosser in Minnesota and Wisconsin and from the Aubern Chert in Missouri. The specimen reported here was found at a depth of 45.3 feet in the Cornell core.

Specimen Number. - 64b.

Phylum MOLLUSCA

Class PELECYPODA

Order TAXODONTA

Superfamily NUCULACEA

Genus CTENODONTA Salter, 1851

CTENODONTA OBLIQUA (Hall), 1845

Nucula obliqua Hall, 1845, Amer. Jour. Sci. and Arts, vol. XLVIII, p. 292.

Tellinovuya? obliqua Meek, 1873, Pal. Ohio, vol. 1, p. 139.

Paleoconcha obliqua and P. faberi Miller, 1889, North America Geol. and Pal., p. 498.

Ctenodonta obliqua (Hall), Ulrich, in Winchell and Ulrich, 1896, Geol. Minn., vol. 3, pt. 2, p. 604, pl. XLII, figs. 83-87.

Discussion. - The specimen is a very small inner mold. Its size, shape and other characteristics enable assignment to C. obliqua Hall.

Horizon and Locality. - Found in Trenton and Richmond rocks in Ohio, Indiana, Kentucky, Tennessee, Illinois, and Iowa. This specimen was found at a depth of 29 feet in the Cornell core.

Specimen Number. - 41.

Class GASTROPODA

Subclass EUGASTROPODA

Superorder PROSOBRANCHIA

Order ARCHEOGASTROPODA

Genus HORMOTOMA Salter, 1859

HORMOTOMA? sp.

Discussion. - The specimen consists only of two coils which are pyritized. It is referred to Hormotoma because it is rather loosely coiled, high-spired, and has slightly flattened whorls.

Horizon and Locality. - This specimen was found at a depth of 25.4 feet in the Cornell core.

Specimen Number. - 36.

Genus ECCYLIOMPHALUS Portlock, 1843

ECCYLIOMPHALUS? sp.

Discussion. - This specimen is poorly preserved with the entire surface covered with euhedral calcite crystals. It is a discoidal species with the last whorl flaring out. Its general appearance permits a questionable assignment to the genus Eccyliomphalus.

Horizon and Locality. - This specimen was found at a depth of 45.6 feet in the Cornell core.

Specimen Number. - 64.

Genus TROPIDODISCUS Meek and Worthan, 1866

TROPIDODISCUS sp.

Discussion. - The specimen is a nearly complete small inner mold showing no ornamentation. It is assigned to Tropidodiscus on the basis of its size and angular cross section.

Horizon and Locality. - Found in the Trenton of Eastern United States and Mississippi Valley. This specimen was found at a depth of 98 feet in the Cornell core.

Specimen Number. - 131.

Phylum ARTHROPODA

Class TRILOBITA

Order PTYCHOPARIIDA

Suborder ASAPHINA

Superfamily ASAPHACEA

Family ASAPHIDAE

Subfamily ISOTELINAE

Genus ISOTELUS DeKay, 1824

ISOTELUS GIGAS DeKay, 1824

Isotelus gigas DeKay, 1824, Ann. Lyc. Nat. Hist., New York, vol. 1, p. 176, pl. 13, figs. 1 & 2.

Discussion. - Two specimens that consist of only parts of hypostomata were found. The characteristic imbrication of this structure serves to identify the species.

Horizon and Locality. - Reported from Middle and Upper Ordovician of North America, Siberia, Northern Europe, and Greenland. The species is common in the Trenton of Michigan and Ontario. These specimen were found at depths of 58 feet (# 82c) and 88 feet (# 126).

Specimen Numbers. - 82c, 126.

Order PHACOPIDA

Suborder PHACOPINA

Superfamily DALMANITACEA

Family PTERYGOMETOPIDAE

Subfamily PTERYGOMETOPINAE

Genus CALYPTAULAX

Subgenus C. (Calliops) Delo, 1935

CALYPTAULAX (Calliops) cf. C. CALLICEPHALUS (Hall) 1847

Phacops callicephalus Hall, 1847, Pal. New York, pt. 1, p. 247, pl. 65, figs. 3a-31; Billings, in Logan, 1863, Geol. Surv., Can., Geol. Canada, p. 187, fig. 184.

Pterygometopus callicephalus (Hall), Clarke, in Winchell and Ulrich, 1896, Geol. Minn., Final Report, 3, pt. 2, Paleontology, p. 731, figs. 51, 52, p. 732.

Calliops callicephalus (Hall), 1935, Delo, Journ. Paleon., vol. 9, p. 402-420, figs. 1-45.

Calyptaulax (Calliops) callicephalus (Hall), 1959, Harrington et al., Treatise on Invertebrate Paleontology, pt. O, Arthropoda 1, p. 492, fig. 389, nos. 3a-c.

Discussion. - Two specimens, one a pygidium, the other a cephalon, are doubtfully referred to as C. callicephalus (Hall) on the bases of their gross appearance and the common occurrence of this species in Trenton

and Black River rocks of Minnesota, Michigan, and Ontario. Both specimens are in poor condition.

Horizon and Locality. - Found in Trenton and Black River rocks of Minnesota, Michigan, and Ontario. These specimens were found at depths of 88 feet (# 127) and 207 feet (# 295).

Specimen Numbers. - 127, 295.

SUMMARY AND CONCLUSIONS

Summary

Though many of the fossils recovered from the core are poorly preserved and others not diagnostic, some stratigraphic correlation can be made and some conclusions as to ecologic conditions at the time of deposition of the core can be drawn. In strong contrast to the highly fossiliferous upper hundred feet of the core, below 100 feet fossils are very scarce, a condition which Hussey (1936) noted in the outcrop of the Black River. The rock types of the core below 100 feet are dense limestone, dolomite, and sandstone none of which are usually very productive of fossils, but even in shaly partings fossils are lacking.

Conclusions

Stratigraphic Implications of the Cornell Core

An attempt has been made with Figure 3 and Figure 4 to summarize the paleontologic findings of this investigation.

One of the objectives was to establish the Trenton - Black River contact in the core with paleontologic evidence. Between the depths of 123 and 127 feet three diagnostic brachiopod species occur. Idiospira panderi (Billings) was found at a depth of 123 feet. This species has been reported only from the Trenton over a wide area including New York, Ontario, Quebec, Kentucky, Missouri, and Iowa. Strophomena filitexta (Hall) was found at 123.5 and 127 feet. Wilson (1946) has reported this species from the Leray Beds in Ontario but Cooper (1956) states that this species has never been found in Chaumont equivalents except for Wilson's report so feels that perhaps the identification was incorrect. Zygospira

cf. Z. ELONGATA (Cooper) was found at a depth of 124 feet. Z. elongata has been found only in the Lebanon Formation (Black River) in Tennessee. The depth at which it was found in the Cornell core lies between the two occurrences of S. filitexta but, since the referral to Z. elongata was doubtful, little significance can be attached to its presence. Hussey (1952) reports S. filitexta very common in the beds that he calls the base of the Trenton. At 127 feet in the Cornell core S. filitexta occurs in a relatively thin bed with many other fossils in random attitudes. On the basis of the above evidence this writer would place the Trenton - Black River contact at 127 feet. A review of the work of Hussey (1952) and Dixon (1961) will supply further evidence.

Dixon (1961) places the Trenton - Black River contact at 117 feet because of a conglomeratic bed found at that depth. The first unit below his contact is a limestone - shale unit, 15.6 feet thick, which is fossiliferous and more like the majority of the Trenton above it than the Black River below. Hussey (1952) states that at the Chandler Falls area, which is the type area for his basal Trenton Member, zone 2, "may be the base of Trenton." Zone 2 at Chandler Falls is three feet thick and the conglomerate above it (zone 3) is five feet thick, the top of which marks a disconformity. According to this, the base of the Trenton could be as much as eight feet below the contact established by Dixon. Hussey (1936) also says that:

> "the most fossiliferous part of the Trenton is the first three or four feet immediately below the conglomerate."

The writer regards the entire Trenton section (0 - 127 feet) as the Chandler Falls Member.

The most significant thing paleontologically about the rocks below

127 feet is the scarcity of fossils. They are virtually non-existent. There were only two species found between 127 feet and 415 feet that are of any significance. A possible Oxyoplecia sp. was found at 162 feet. If the identification is correct then that may mean that the zone where it was found at least is Black River. Its preservation is so poor that little importance can be attached to it. Rhabdochitina? minnesotensis Stauffer was found at depths of 162 feet, 170 feet, 173 feet and 183 feet. Stauffer (1933) reported this species from the bottom five feet of the Decorah Formation in Minnesota. This would be the Specht's Ferry Member which Kay (1935) says is basal Trenton in age while Cooper (1956) says it is Black River in age. In 1933, when Stauffer first reported this species, the lower part of the Decorah was considered to Black River in age. As late as 1955 (Collinson, 1955) no one had reported any other occurrence of this species in North America. In 1960, Taugourdeau reported this same species from the Silurian of the Sahara. If this is correct then any stratigraphic value of R.? minnesotensis is in doubt though the North American occurrence of this form may be vertically more restricted.

The lowermost fossil found in this core was Dicellomus politus an inarticulate brachiopod of Upper Cambrian age which was discovered at a depth of 415 feet. This supports Dixon's conclusion that the top of the Lodi is found at that depth.

Ecologic Implications of the Cornell Core

Hussey (1952) and Dixon (1961) have both suggested that the Cornell area in Trenton - Black River time was a shallow sea with a fluctuating water level that sometimes left the sediments near shore uncovered. Hussey has reported ripple marks and many intraformational conglomerates.

Dixon also reports many intraformational conglomerates. This writer believes that the paleontologic evidence of the Cornell core supports this theory.

There are many highly fossiliferous zones such as those at 56 feet, 68 feet, 77 feet, and 78 feet, 100 feet, and 127 feet. Some zones have partially silicified fossils. The fossils which belong to many classes of invertebrates, are in attitudes suggesting a thanatacoenosic situation. This would seem to indicate that the sea level was subject to rather sudden shallowing as might occur in a near-shore environment.

An investigation of the paleoecology of the fossils found may prove helpful at this point. All of the specimens recovered are of neritic benthos habit and all but the conularids are sessile forms. The Cambrian oboloid brachiopod found at 415 feet was probably an inhabitant of the shallow neritic zone, even perhaps stagnant water (Cooper, 1936). The Rhabdochitina of the 180 foot zone is considered to be an inhabitant of the reducing environment (Collinson, 1955). The carbonaceous character of the rock at this core depth supports this interpretation. The strophomenid brachopods (Rafinesquina, Strophomena, etc.) are adapted for living on a muddy bottom--their structure allows them to extract more oxygen from the water (Cooper, 1936). Bryozoa need clear water and a hard substratum to survive (Elias, 1949). The more streamlined and the more rotund forms of Brachiopoda (i.e. Zygospira and Rostricellula) would indicate an environment of clear, moving water (Cooper, 1936).

Using the above particulars and the core lithology one can erect an ecological sequence for the Cornell core. The sediments of the core from the bottom to the 80 foot level were deposited in near-shore, fluctuating seas. This is evident by the Dicellomus, by the Rhabdochitina, by the

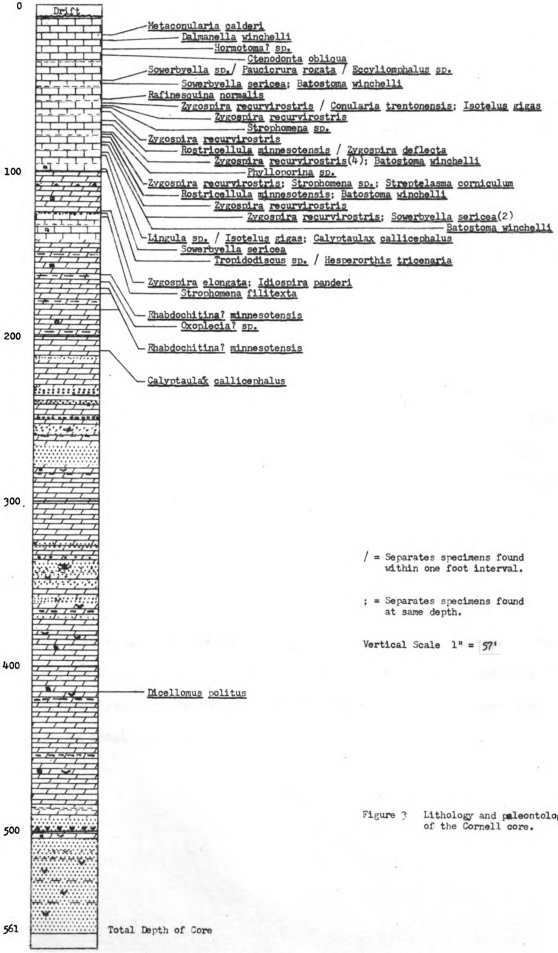

Figure 3 Lithology and paleontology of the Cornell core.

strophomenid-type brachiopods, by the oolitic zones, the intraformational conglomerates, the pyritic and glauconitic zones and the zones of clean sandstone. Between 80 feet and 60 feet the depositional environment was probably one of moving water over at least a partially hard substratum. The environment was probably near-shore since there are zones of macerated shells at intervals. The fact that bryozoans and zygospirid brachiopods were in abundance in this zone is also evidence for this. Above 60 feet the environment was again one of fluctuating sea level. The bryozoans are not abundant and the brachiopod population is similar to the type found below the 80 foot level.

Regional Correlations

The evidence produced by this core indicates that Middle Ordovician fauna of the Northern Peninsula of Michigan is closely related to that of the Upper Mississippi Valley and the Ontario- St. Lawrence Lowland. Affinities with other areas exist to a lesser extent. Figure 4 summarizes the relationships in a graphic manner.

Further Work

Further work with the Ordovician subsurface of the Northern Peninsula of Michigan will depend upon future drilling. It would appear that paleontologic evidence concerning the Middle Ordovician of Michigan will not be easy to obtain.

Species \ Area	Mich. Basin	Upper Miss. Valley	Ont., Can.	Appal. Area	Tenn. & Ky. Area	Okla. Area
Rhabdochitina? minnesotensis		Obr?				
Metaconularia calderi			Ot			
Conularia trentonensis	Ot	Ot		Ot		
Streptelasma corniculum	Om	Om	Om	Om	Om	
Batostoma winchelli		Ot				
Phylloporina sp.		Om	Om	Om		
Lingula? sp.	Om	Om	Om	Om	Om	Om
Hesperorthis tricenaria	Ot	Ot			Ot	
Oxoplecia? sp.	Om	Om	Om	Om	Om	Om
Rostricellula minnesotensis		Om				
Zygospira recurvirostris	Om	Om	Om	Om	Om	Ot
Zygospira elongata					Obr	
Zygospira deflecta			Om	Om		
Idiospira panderi		Ot	Ot	Ot	Ot	
Sowerbyella sericea	Om		Om			Obr
Strophomena filitexta	Om	Om	Om	Om	Om	Ot
Strophomena sp.	Om	Om	Om	Om	Om	Om
Rafinesquina normalis			Ot	Ot		
Dalmanella winchelli		Ot				
Paucicrura rogata		Ot				
Ctenodonta obliqua	Ot	Ot			Ot	
Tropidodiscus sp.		Ot		Ot		
Isotelus gigas	Om	Om	Om	Om	Om	Om
Calyptaulax callicephalus	Om	Om	Om			

Trenton - Ot **Trenton and Black River - Om**
Black River - Obr

Figure 4 **Geographic and geologic ranges of Middle Ordovician species from the Cornell core.**

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