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LOWER MISSISSIPPIAN CEPHALOPODS  
OF MICHIGAN  
PART I. ORTHOCONIC NAUTILOIDS

BY

A. K. MILLER and H. F. GARNER



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UNIVERSITY OF MICHIGAN MUSEUM OF PALEONTOLOGY

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PART I. ORTHOCONIC NAUTILOIDS

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INTRODUCTION

**B**ETWEEN 1861 and 1870 Alexander Winchell published a series of paleontologic and stratigraphic studies of the early Mississippian strata in the Lower Peninsula of Michigan. In these reports he discussed a considerable number of cephalopods (as well as other fossils) and established specific names for many of them. Since his descriptions are brief and generalized and not accompanied by illustrations, it has been impossible to interpret his species satisfactorily without restudying the types.

Fortunately, many of Winchell's specimens have been preserved in the Museum of Paleontology of the University of Michigan. These were carefully identified, labeled, and loaned to us by Professor George M. Ehlers and Professor Erwin C. Stumm. Furthermore, with Professor W. A. Kelly, of Michigan State College, they facilitated our work by loaning us additional material that had been secured since Winchell's time and by directing the junior author of the present report to the known outcrops so that he could augment the existing collections. For these favors we are greatly indebted. Acknowledgment is also due Mr. Wayne Nowack of Iowa City, who retouched the accompanying photographs, and to the Graduate College of the State University of Iowa, which made the completion of this report financially possible.

Specimens referred to in this paper are catalogued and deposited in the Museum of Paleontology of the University of Michigan.

There has been considerable difference of opinion as to the proper stratigraphic terminology that should be employed in connection with the Lower Mississippian strata of Michigan. According to Monnett (1948), the Kinderhook group in Michigan is now divided into five formations: the Bedford, Berea, Sunbury, Coldwater, and Marshall, in ascending order. Monnett indicated that the uppermost part of the underlying Antrim shale is probably Mississippian in age, but that most of it belongs in the Devonian. Stratigraphically, the Marshall is overlain by the "Meramec-Osage" Michigan formation, with which it seems to be more or less gradational.

No cephalopods have been found in the Bedford, Berea, Sunbury, or Michigan formations in Michigan, but locally both nautiloids and ammonoids are abundant in the Coldwater and the Marshall. These two formations crop out around the margins of the Michigan Basin in almost complete subcircular bands that are largely covered by Pleistocene debris; their subsurface nature is known from many wells within this basin. In Michigan, the Coldwater and Marshall formations only occur in the Lower Peninsula, but the Coldwater extends south into adjacent parts of Indiana and Ohio.

Monnett (1948) discussed the Coldwater and the Marshall in considerable detail. Therefore, it will suffice here merely to state that the Coldwater consists of something like 500 to 1000 feet of gray shale, with some sandstone, siltstone, red shale, and locally "several calcareous or dolomitic strata"; and that the Marshall is composed predominately of about 160 to 320 feet of red and white sandstone with some shale and siltstone. In the western parts of the outcrop area, the contact between

the two formations is "relatively easy to determine," but to the east it becomes "poorly defined" (Monnett, 1948).

Most of the fossils described by Winchell came from the Marshall sandstone in the southern part of the state, but the Michigan locality at which Mississippian cephalopods are most abundant is a large quarry in the Marshall formation at Burnt Cabin Point, near the tip of the Thumb of the central-eastern part of the Lower Peninsula. A few cephalopods of this age are available from the western part of the Lower Peninsula, but none is known from the northern part, where the Pleistocene deposits completely conceal the Mississippian beds. In both the Coldwater and the Marshall, nautiloids and ammonoids occur in direct association with each other and with a few corals, crinoid columnals, and bryozoans. Many brachiopods, pelecypods, and gastropods, as well as some fish remains, are known from the Marshall and in the lower part of the formation ostracods are locally abundant. The faunas of the Coldwater and the Marshall are predominantly molluscan, but not cephalopodan. Locally, brachiopods are abundant in the older formation, that is, the Coldwater.

The present report is chiefly confined to the straight nautiloids. In the immediate future, however, the authors hope to undertake comparable studies of the coiled nautiloids and the ammonoids, which will almost certainly enable them to suggest world-wide correlations of the containing beds somewhat better than do the forms under consideration.

The following orthoconic nautiloids are now known from the Kinderhook strata of Michigan:

#### COLDWATER SHALE

- Mooreoceras barquianum* (Winchell)
- Mooreoceras ? gracilium* (Winchell)
- ? *Mooreoceras* sp. cf. *M. indianense* (Hall)
- Mooreoceras kellyi* Miller and Garner, sp. nov.
- ? *Mooreoceras ?* sp.
- Cycloceras ehlersi* Miller and Garner, sp. nov.
- ? *Cycloceras ? michiganense* (Miller)

#### MARSHALL SANDSTONE

- Mooreoceras barquianum* (Winchell)
- Mooreoceras* sp. aff. *M. cliftonense* Miller and Furnish
- Mooreoceras clinocameratum* (Winchell)
- Mooreoceras* sp. cf. *M. indianense* (Hall)
- Mooreoceras marshallense* (Winchell)
- Mooreoceras vinchellanum* (Miller)
- Mooreoceras ?* sp.
- Kionoceras bellilineatum* Miller and Garner, sp. nov.

- Cycloceras ? michiganense* (Miller)  
*Spyroceras* sp.  
*Spyroceras ?* sp.  
*Poterioceras ? robustum* (Winchell)  
*Poterioceras ?* sp.

Long straight nautiloids, that is, orthoceraconic forms, are not rare in the Coldwater and the Marshall formations and are quite varied. Almost all of the specimens are fragmentary, and they do not retain the internal structures of the conch. In only a few individuals is it possible to ascertain the shape of the siphuncular segments and the structure of the siphuncle. As a result, it is difficult to determine with certainty the generic affinities of many of the species.

In spite of this, considerable information can be gleaned from available material. First, it is apparent that the Coldwater and the Marshall assemblages of orthoceracones are in general similar to each other and to those known from the Chouteau limestone and the Northview shale of Missouri, the only other American Kinderhook formations that have yielded many nautiloids. A few forms occur in the Rockford limestone of Indiana and the Waverly group of Ohio, and they seem to be rather closely related to those of the Michigan formations under consideration. Second, there is a general similarity with the extensive Lower Carboniferous nautiloid faunas that have been described from Ireland by Foord (1897-1903) and especially those of Belgium made known by de Koninck (1878, 1880). It seems quite likely that if the Michigan specimens were well preserved, they would be found to be similar in detail as well as in general to Missouri and Belgian forms. The resemblance is especially remarkable, because most of the specimens known from Missouri and Belgium are preserved in limestone, whereas those from Michigan are from shale, sandstone, or even conglomerate. In lithology, the cephalopod-bearing parts of the Northview shale of Missouri do not differ greatly from parts of the Coldwater and especially the Marshall formations of Michigan. But Michigan specimens also occur in "peanut conglomerate," and the Northview has yielded relatively few nautiloids.

Comparisons of the Kinderhook orthoceracones of Michigan with those of slightly older and younger beds in the United States are not very satisfactory. Cephalopods are indeed rare in the Osage strata, and in classifying the Devonian forms it is necessary to rely to a great extent on the internal structures of the conch, which are not preserved in most of the Michigan specimens. Altogether, a number of nautiloids are known from the Meramec formations, and some of them are reminiscent of the Michigan Kinderhook forms. Because of the difference in their ages, the similarities, however,

are not striking. Furthermore, no truly gigantic forms are known from the early Mississippian; whereas from the late Mississippian of Arkansas, Miller, Downs, and Youngquist (1949, p. 606, Pl. 98, Fig. 2) described an incomplete phragmocone that is some  $41\frac{1}{2}$  cm. long and attains a diameter of about 19 cm. and, according to Sowerby (1819, p. 83) and Turner (1951, p. 173), congeneric forms "20 feet long" have been found in the Upper Viséan of southern Scotland. These very large carboniferous orthoceracones from both sides of the Atlantic belong in the genus *Rayonoceras* Croneis.

Since breviconic nautiloids are not known to occur in the Coldwater shale and only a few fragmentary specimens have been collected from the Marshall sandstone, it seems hopeless to attempt comparisons with other faunas. Nevertheless, it should be mentioned that, at least superficially, one of the two species known from the Marshall, *Poterioceras? robustum* (Winchell), resembles *P. northviewense* Miller and Furnish of the Northview shale of Missouri, and the other is probably congeneric and appears to be similar to a specimen described from the Chouteau limestone of Missouri.

In regard to paleoecology, certain inferences may be drawn from this study of the fossils and the enclosing matrices. With very few exceptions, the rocks are clastics. Interbedded shales, siltstones, and sandstones are common, and near the tip of the Thumb there are sporadic "peanut conglomerates." Within short distances, the lithology varies markedly. Throughout both formations, fossils are exceedingly abundant in certain narrow zones that do not seem to be of very great lateral extent. Locally, the rocks consist almost exclusively of external molds of a single species of pelecypod, and elsewhere of brachiopods, and in other places small cephalopods are exceedingly abundant. In many cases there are admixtures of various kinds of fossils, and in such instances the specimens are as a rule fragmentary. Plant remains occur in direct association with marine shellfish. All this suggests that the Coldwater and especially the Marshall were deposited in a rather shallow sedimentary basin. The parts of the Marshall that are composed of relatively coarse highly variable clastics, which contain an admixture of fragmentary terrestrial and marine fossils, are believed to have accumulated near the shore, where waves and currents were particularly effective. Most probably, few if any of the organisms were transported far from their habitat.

The close similarity of the Coldwater and Marshall faunas suggests that they represent only a single invasion, which presumably came from the south, for counterparts of most of the species are known from the

Chouteau and the Northview formations of Missouri. The "Meramec-Osage" Michigan formation overlies the Marshall in a more or less gradational sequence and contains beds of gypsum and anhydrite but few fossils; this indicates that the depositing waters were of abnormal salinity and that the climate was arid or semiarid.

#### SYSTEMATIC DESCRIPTIONS

##### *Mooreoceras* Miller, Dunbar, and Condra

In 1933, when this genus was established, its authors designated their species *M. normale* the genotype. The holotype of *M. normale*, came from the mid-Pennsylvanian (Kansas City group) of central-western Missouri. That specimen is a well-preserved internal mold of part of a gradually expanding orthoceraconic conch. It has an essentially smooth surface, moderately short camerae, transverse sutures that are slightly oblique and very slightly sinuous (possibly due to distortion), and a distinctly subcentral siphuncle in which the septal necks are short and somewhat recurved and the connecting rings are subvoid. The deposits in its camerae and siphuncle do not seem to be of organic origin.

Most recent authors who have discussed this genus have allowed it considerable latitude, and quite a variety of specimens have been referred to it. The interpretation here also is broad, although this procedure may be difficult to defend. As now understood, the genus is of widespread occurrence and ranges from the Upper Devonian to the Middle Permian, inclusive (see Flower, 1939, pp. 146-52; Miller and Youngquist, 1949, pp. 23-28).

##### *Mooreoceras barquianum* (Winchell)

(Pl. I, Figs. 8-9)

*Orthoceras Indianense* (part ?) Winchell, 1862, Amer. Journ. Sci. and Arts, 2d Ser., Vol. 33, p. 354.

*Orthoceras Barquianum* Winchell, 1862, Amer. Journ. Sci. and Arts, 2d Ser., Vol. 33, p. 356.

*Orthoceras Indianense* (part ?) Winchell, 1865, Proc. Phila. Acad. Nat. Sci., 1865, p. 132.

*Orthoceras Indianense* (part ?) Winchell, 1870, Proc. Amer. Philos. Soc., Vol. 11, p. 393.

It is impossible to ascertain the number of specimens on which Winchell based this species. The only original type that is now available is the one portrayed (Pl. I, Fig. 8) which was labeled a syntype. This specimen is an internal mold, only moderately well preserved, and appears to have been somewhat distorted during fossilization. Nevertheless, it shows that the conch is rather gradually expanded orad and is elliptical in cross section. Near its mid-length the width and corresponding height of the conch measure



about 14 mm. and 11 mm., respectively. According to Winchell (1862a, p. 356), the phragmocone in this species attains a length of "more than  $4\frac{1}{4}$  inches." No trace of any surface markings of the test is discernable on the specimen under consideration. The length of the camerae is equal to about a fifth their width. The sutures, which are essentially straight, are slightly oblique to the long axis of the conch, probably as a result of distortion. This specimen does not retain its internal structures, but the part of one phragmocone illustrated (Pl. I, Fig. 9) seems to resemble it in all available particulars, and it has a slightly but distinctly eccentric siphuncle that is small, at least at its passage through the septa; at the adapical end of the specimen the diameter of the siphuncle measures only about 1 millimeter or a little less.

*Remarks.*—In the original description of this species, Winchell (1862a p. 356) stated that it "may possibly prove identical" with the form now known as *Mooreoceras vinchellanum* (Miller) and later, when he (Winchell, 1870b, pp. 393–94) listed the Kinderhook cephalopods of Michigan, he did not include this species. Nevertheless, it is worth noting that in the available syntype of *M. vinchellanum* the siphuncle is closer to the venter than is that of specimens which appear to be conspecific with the only known syntype of *M. barquianum*. It may be that this syntype and those of *M. vinchellanum* are conspecific, and that one specimen portrayed (Pl. I, Fig. 9) and others that have a similarly situated siphuncle represent a distinct and presumably unnamed species. Three specimens from the Coldwater shale and two from the overlying Marshall sandstone are here placed in *M. barquianum*. The Marshall specimens were regarded by Winchell as referable to "*Orthoceras Indianense*" Hall, in which species, however, the cross section of the conch is circular.

As mentioned under *M. clinocameratum*, that name may well be a synonym of *M. barquianum*. Both species were established in the same publication; *M. barquianum* was treated first, but clearly the arrangement was not meant to be merely alphabetical.

*Occurrence.*—Coldwater shale at two localities in Michigan: (1) "near the light house at Pt. aux Barques," Huron County, the syntypes, which come from "a hard bluish sandstone" (Winchell, 1862a, p. 356), and (2) near Coldwater, Branch County. One of the two individuals from Coldwater is represented (Pl. I, Fig. 9). Specimens that appear to be conspecific also occur in the Marshall sandstone at two places in Michigan: (1) Hardwood Point, about 1 mile southwest of Flat Rock Point, Pointe au Pain Sucre, on the shore of Saginaw Bay, Huron County; and (2) Germain's quarry at Hillsdale, Hillsdale County.

*Specimens.*—No. 26710, figured syntype; No. 27033, from near Flat Rock Point; No. 27037, from Germain's quarry; No. 30180, from near Coldwater, illustrated Pl. I, Fig. 9; No. 30181, from near Coldwater.

*Mooreoceras* sp. aff. *M. cliftonense* Miller and Furnish

(Pl. III, Fig. 5)

(?) *Orthoceras arcuatellum?* Winchell, 1862, Amer. Journ. Sci and Arts, 2d Ser., Vol. 33, pp. 355–56.

(?) *Orthoceras arcuatellum?* Winchell, 1870, Proc. Amer. Philos. Soc., Vol. 11, p. 393.

The type section of the Marshall sandstone has yielded a specimen that retains a replacement of the test on which there are rather prominent transverse lirae. This specimen is only moderately well preserved and is somewhat crushed. Apparently it was subcylindrical in shape, being very gradually expanded orad and most probably circular, or nearly so, in cross section. It is incomplete both adapically and adorally and has a maximum over-all length of some 25 mm. and a maximum width of a little more than 10 mm.

The most distinctive character of this form seems to be the transverse lirae on its test, of which there are about 20 in a length of 5 mm. Locally, there are minor irregularities in these lirae, presumably due to breakage of the apertural margins during ontogenetic development or possibly to distortion during preservation. The intermediate grooves are rounded and are about twice as wide as the lirae.

Just apicad of the mid-length of the side of the specimen that is not figured, there are two structures that probably represent sutures; and 3 mm. and 5 mm. orad of the adoral one of these there are additional but less distinct structures that may also represent sutures. All of these suggest that the sutures were essentially straight and directly transverse. Another poorly preserved structure on the same portion of the specimen may possibly represent a small eccentric cylindrical siphuncle.

*Remarks.*—The surface lirae of this specimen are reminiscent of those on *M. cliftonense* Miller and Furnish of the Chouteau limestone of central Missouri, in which the conch is more rapidly expanded orad. Another similar form is *Mooreoceras crebriliratum* (Girty) of the Caney shale of Oklahoma and of approximately equivalent formations in Texas, Utah, and probably Arkansas and Nevada.

The specimen which Winchell referred with question to "*Orthoceras arcuatellum?*" Sandberger and Sandberger of the German Devonian most probably should be associated with the above-described individual, which came from the same general horizon and locality. Unfortunately, it has

been misplaced, was never illustrated, and the only published description of it is brief and generalized. It is stated to have been circular in cross section, to have moderately convex transverse septa, to be "nearly smooth externally, with faint, encircling, unequal, irregularly sinuous striae" and to differ from the Sandberger brothers' species particularly in that it "has a much less rapid taper, and the encircling striae are much finer, more unequal, and not regularly reflexed on the anterior and posterior sides" (Winchell, 1870*b*, p. 393).

*Occurrence*.—Lower portion of the upper part of the Marshall sandstone in an abandoned quarry at Marshall, Calhoun County, Michigan.

*Specimen*.—No. 29412.

*Mooreoceras clinocameratum* (Winchell)

(Pl. I, Fig. 1)

*Orthoceras clinocameratum* Winchell, 1862, Amer. Journ. Sci. and Arts, 2d Ser., Vol. 33, pp. 356–57.

*Orthoceras clinocameratum* Winchell, 1870, Proc. Amer. Philos. Soc., Vol. 11, p. 393.

Winchell based this species on a single specimen, one side of which is solidly embedded in a gray fine-grained sandstone matrix. The maximum over-all length of this, the holotype, is about 32 mm., and its width ranges from about 12 mm. near its adapical end to about 16 mm. near its adoral end. The cross section is rather narrowly elliptical. No trace of any test ornamentation can be discerned.

Just apicad of the mid-length of this specimen, there are three distinct sutures, and apicad of them are faint traces of others. On the somewhat narrowly rounded lateral (?) zones of the holotype these sutures are rather strongly oblique, sloping apicad from the figured side. The adapical end of the specimen appears to be an impression of a septum, but it does not retain any recognizable indication of the siphuncle.

*Remarks*.—The general physiognomy of this specimen indicates that it was considerably crushed and distorted during preservation. As a result, its oblique sutures are believed not to be of taxonomic significance. It is quite likely that this specimen is conspecific with those placed here in *M. barquianum* (Winchell), and *M. clinocameratum* probably should be suppressed as a synonym of that name.

*Occurrence*.—Marshall sandstone, about 1 mile southwest of Flat Rock Point (Pointe au Pain Sucre) on the shore of Saginaw Bay, Huron County, Michigan.

*Holotype*.—No. 26774.

*Mooreoceras ? gracilium* (Winchell)

*Orthoceras gracilius* Winchell, 1862, Proc. Phil. Acad. Nat. Sci., 1862, p. 429.

*Michelinoceras? gracilium* Kindle and Miller, 1939, Geol. Soc. Amer., Special Paper, 23, p. 81.

The original description of this species, (Winchell, 1862*b*, p. 429) which is very brief and generalized, reads as follows: "Shell with an apical angle of  $3\frac{1}{2}^{\circ}$ , a circular section and central siphon. Cast smooth; inter-septal space .04 [inches] where the diameter is .9 [inches]."

*Remarks.*—The single specimen on which this description was based was preserved in pyrite or marcasite and was only partly removed from the matrix, a block of gray shale. Most of it has disintegrated. At least in its present condition it does not seem to merit illustration, and the inclination is to doubt that it was ever a very satisfactory study specimen even when Winchell examined it.

Nevertheless, what can be said is that the remaining portion of this specimen is a completely septate internal mold of a small orthoceracone and that it is about 23 mm. long. Within this length its diameter ranges from  $2\frac{1}{2}$  mm. to  $3\frac{1}{2}$  mm. The cross section appears to be circular, or nearly so, the length of the camerae is about average, the sutures are probably straight and directly transverse, the camerae are moderately convex apicad, and the siphuncle is central or subcentral in position and is small at least at its passage through the septa.

So little precise information can be gleaned from this holotype and Winchell's description of it that the affinities of the species are questionable. It is doubtful whether any other specimen can be referred to the species with reasonable certainty.

*Occurrence.*—Coldwater shale at or near Union City, Branch County, Michigan.

*Holotype.*—No. 27032.

*Mooreoceras* sp. cf. *M. indianense* (Hall)

(Pl. I, Fig. 7; Pl. II, Figs. 1–2)

*Orthoceras Indianense* (part ?) Winchell, 1862, Amer. Journ. Sci. and Arts, 2d Ser., Vol. 33, p. 354.

*Orthoceras Indianense* (part ?) Winchell, 1865, Proc. Phila. Acad. Nat. Sci., 1865, p. 132.

*Orthoceras Indianense* (part ?) Winchell, 1870, Proc. Amer. Philos. Soc., Vol. 11, p. 393

Several specimens in the collections studied have rather gradually expanded orthoceraconic conchs that are circular, or nearly so, in cross section and have camerae that are moderate in length, sutures that are essentially straight and directly transverse, and subcentral siphuncles that are small

at their passage through the septa. One of them was sectioned longitudinally and in it the septal necks are short but are distinctly recurved, and the connecting rings are ovoid in shape (see Fig. 1). The maximum diameter of the siphuncular segments is attained slightly orad of their mid-length and is equal to about twice their diameter at the passage through the septa.

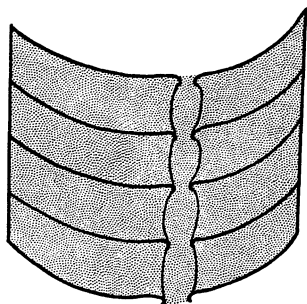


FIG. 1. *Mooreoceras* sp. cf. *M. indianense* (Hall). Diagrammatic longitudinal section of part of a slightly distorted specimen (No. 30182) from the Marshall sandstone at Burnt Cabin Point, near the tip of the Thumb of the Lower Peninsula of Michigan.  $\times 3$ .

*Remarks.*—None of these specimens retains more than faint traces of any surface markings that their tests may have had. They are somewhat variable in cross section, possibly due to distortion during preservation. It is doubtful if all of them are conspecific and most probably none of them belong in Hall's species which was based on specimens from the Rockford limestone of Indiana.

*Occurrence.*—Winchell (1862a, p. 354) stated that "*Orthoceras Indianense* . . . [is] the most abundant *Orthoceras* in the Marshall sandstone," and he listed it from a good many localities in the Lower Peninsula of Michigan. We compare with it specimens from the same formation at the following places in Michigan: (1) an abandoned quarry immediately southeast of Burnt Cabin Point, about 4 miles east of Port Austin, Huron County (specimen illustrated, Pl. II, Fig. 1), and many fragmentary specimens; (2) Napoleon Cut, Jackson County; (3) an abandoned quarry at Marshall, Calhoun County (Pl. I, Fig. 7); (4) 1 mile north of Osseo, Hillsdale County (Pl. II, Fig. 2); and (5) Holland, Ottawa County—the last may be from the Coldwater shale rather than the Marshall sandstone. Also, the glacial drift in a gravel pit about 6 miles southeast of Jackson, Jackson County, Michigan, has yielded some small specimens that may belong here.

*Specimens.*—No. 26871 (Pl. I, Fig. 7); No. 27038, from Napoleon Cut; No. 27050, from Holland; No. 29413 (Pl. II, Fig. 2); No. 29414, from drift near Jackson; No. 30182, from Burnt Cabin Point (Text Fig. 1); No. 30183, Burnt Cabin Point (Pl. II, Fig. 1); No. 30184, from Burnt Cabin Point.

**Mooreoceras kellyi** Miller and Garner, sp. nov.

(Pl. I, Fig. 5)

Among the numerous orthoceracones now known from the Kinderhook strata of Michigan is a fine unique specimen that does not seem referable to any previously described species. The authors propose to name it in honor of its discoverer, Professor W. A. Kelly of Michigan State College.

The holotype of this species is an internal mold about 70 mm. long, which appears to represent three camerae of a phragmocone and the adjacent portion of the body chamber. It is circular, or essentially so, in cross section, is very gradually expanded orad, and attains a maximum diameter of about 32 mm. near its adoral end.

The parts of the test which are preserved reveal that it bears transverse growth lines of unequal prominence and fine longitudinal lirae that are slightly sinuous. The septum that forms the adapical end of the specimen is rather strongly convex apicad. The sutures are simple circles, straight and directly transverse. Each of the two adapical camerae of the holotype is about 15 mm. long. The adoral camera is distinctly shorter, and its length measures only about 12 mm. The siphuncle is slightly but distinctly eccentric, and at least at its passage through the septa it is small. At the adapical end of the holotype its diameter is only about 2 mm.

*Remarks.*—The fact that the adoral camera of the holotype is shorter than the ones which precede it indicates that it is a mature individual. The most distinctive characters of this species are believed to be its subcylindrical shape, long camerae, and reticulate surface ornamentation. A diligent search through the literature has revealed no species that are close enough to this one to merit detailed comparisons.

*Occurrence.*—The label which accompanies this specimen, the only known representative of this species, states that it was secured in 1929 from the Coldwater shale near Coldwater, Branch County, Michigan. It is composed of gray clay-ironstone and came from the abandoned Wolverine Portland Cement Company shale quarry in the NW.  $\frac{1}{4}$  sec. 32, T. 6 S., R. 6 W., about  $1\frac{1}{4}$  miles southwest of Coldwater.

*Holotype.*—No. 30185.

*Mooreoceras marshallense* (Winchell)

(Pl. I, Figs. 2-3; Pl. II, Fig. 4)

*Orthoceras Marshallense* Winchell, 1862, Amer. Journ. Sci. and Arts, 2d Ser., Vol. 33, p. 356.

*Orthoceras Indianense* (part ?) Winchell, 1870, Proc. Amer. Philos. Soc., Vol. 11, p. 258.

*Orthoceras Marshallense* Winchell, 1870, Proc. Amer. Philos. Soc., Vol. 11, p. 393.

Two of Winchell's syntypes of this species are available for study (it is not possible to ascertain how many he may have had). The larger one of these specimens (Pl. I, Fig. 2) is about 67 mm. long, attains a maximum width of about 24 mm., and is very gradually expanded orad. It appears to be septate throughout, but the two adoral sutures are faint and are, therefore, easily overlooked. The complete circumference of the conch is not preserved, but its general physiognomy suggests an elliptical cross section. The camerae are moderately long, averaging about  $8\frac{1}{2}$  mm. in length. The sutures are essentially straight and directly transverse.

The only other available syntype (Pl. II, Fig. 4) is about 50 mm. long. Its width increases from about 12 mm. near its adapical end to about 16 mm. near its adoral end. This specimen has been somewhat crushed and distorted during preservation, but clearly its cross section was elliptical; near its adapical end the height of conch is estimated at some 8 mm. The camerae of this specimen are moderately long in comparison to their other dimensions, the septa are rather strongly convex apicad, the sutures are essentially straight and directly transverse, and the siphuncle is distinctly eccentric and small, at least at its passage through the septa; and at the adapical end of the specimen the diameter of the siphuncle is only about  $1\frac{1}{2}$  mm.

*Remarks.*—No trace of any surface markings the test may have originally possessed can be discerned on either of the syntypes just described or on an illustrated specimen (Pl. I, Fig. 3), which is doubtfully associated with them. This last, like the types, is an internal mold preserved in yellowish brown limonitic sandstone; it has an elliptical cross section, moderately long camerae, straight transverse sutures, and an eccentric siphuncle. This specimen came from the Waverly group at or near Newark, Ohio, where a considerable thickness of Carboniferous strata is exposed. It was identified by Winchell (1870a, p. 258) as "*Orthoceras Indianense*, Hall," but that species is characterized by a circular cross section.

The most distinctive features of this species seem to be its elliptical cross section, rather long camerae, and eccentric siphuncle. These characters are sufficient to differentiate it readily from all similar forms with

which it occurs. It is perhaps closest to *M. vinchellanum* (Miller), in which the camerae are shorter and the siphuncle is nearer the venter.

*Occurrence.*—Marshall sandstone at Marshall, Calhoun County, Michigan. A similar form that may be conspecific is known from some part of the Waverly group at or near Newark, Licking County, Ohio.

*Specimens.*—Nos. 26711a, b, syntypes, and No. 26749, the specimen from Newark, Ohio, doubtfully referred to this species.

*Mooreoceras vinchellanum* (Miller)

(Pl. I, Fig. 6; Pl. II, Fig. 3)

*Orthoceras occidentale* Winchell, 1862, Amer. Journ. Sci. and Arts, 2d Ser., Vol. 33, p. 356.

*Orthoceras occidentale* Winchell, 1870, Proc. Amer. Philos. Soc., Vol 11, p. 393.

*Orthoceras occidentale* Miller, 1877, The American Palaeozoic Fossils . . . , p. 176.

*Orthoceras vinchellanum* Miller, 1883, The American Palaeozoic Fossils . . . , 2d ed., p. 308.

Winchell's name *Orthoceras occidentale* had been used previously by Swallow. S. A. Miller, therefore, proposed to designate this species *O. vinchellanum*. The only specimens here allocated to this species are two of Winchell's syntypes, which may well be segments of the same individual; they represent different parts of the conch, are from the same horizon and locality, and are lithologically very similar. The original description of this species must have been based, in part, on additional material that is no longer available.

The larger of the specimens (Pl. I, Fig. 6) is an internal mold of a body chamber that is complete adapically and appears to be almost complete adorally. It is about 40 mm. long and is expanded orad very gradually. The specimen is somewhat crushed, but the conch is depressed dorso-ventrally and is elliptical in cross section. Near the junction of the phragmocone and the body chamber, the present (distorted) height and width of the conch measure about 10 mm. and 17 mm., respectively. Corresponding measurements near the adoral end of the body chamber are about 12 mm. and 18½ mm. Near the mid-length of the adoral half of this larger specimen, there is a broad shallow rounded constriction that does not appear to be adventitious. The siphuncle is only about 1½ mm. in diameter at its passage through the adoral septum, and its location is approximately half-way between the center of the conch and the venter.

The other available syntype (Pl. II, Fig. 3) is an internal mold of a part of a phragmocone and, like the specimen just described, it retains no indication of any surface markings the test may have possessed. It is more rapidly expanded orad than is the body chamber of the specimen associated



with it, but has a similar cross section. It does not appear to have been appreciably distorted during preservation, and near its adoral end its conch is about 9 mm. high and 12 mm. wide. At this point, the siphuncle at its passage through a septum is about 1 mm. in diameter, and its center is about  $2\frac{1}{2}$  mm. from the venter. The septa are rather strongly convex apicad, the camerae are moderate in length, and the sutures are essentially straight and directly transverse.

*Remarks.*—Winchell (1862a, p. 356) stated that the "septate portion of [the] shell [is] more than  $3\frac{3}{4}$  inches in length" and that the siphuncle is "constricted where it passes through the septa." Verification of these observations from the available material has not been possible, but there seems to be no good reason to doubt their accuracy.

This species can be readily differentiated from similar forms with which it occurs in direct association by means of the ellipticity of its cross section, the marked eccentricity of its siphuncle, and the transverse constriction in the internal mold of its body chamber. This type of constriction is, insofar as has been ascertainable, unique among the Michigan Kinderhook orthoceracones, but it is known to occur in forms from beds of the same general age in Missouri, New Mexico, Ireland, and Belgium.

Winchell compared this species with *Orthoceras muensterianum* de Koninck of the Tournaisian of Belgium. The relationship, however, is not very close, for in that form the conch is more rapidly expanded orad and the siphuncle is more nearly central in position. There seems to be no named species known that is more than superficially similar to *M. vinchellanum*. Nevertheless, Miller and Youngquist (1947, Pl. 27, Fig. 8) have illustrated as "*Mooreoceras* sp." a specimen from the Caballero formation of New Mexico that is reminiscent of the larger of the two syntypes described.

*Occurrence.*—Marshall sandstone at Marshall, Calhoun County, and (according to Winchell, 1862a, p. 356) at Moscow, Hillsdale County, Michigan.

*Syntypes.*—Nos. 26712a, b.

*Mooreoceras* ? sp.

(Pl. III, Figs. 3-4)

*Orthoceras vittatum*? Winchell, 1862, Amer. Journ. Sci. and Arts, 2d Ser., Vol. 33, p. 355.

*Orthoceras vittatum*? Winchell, 1870, Proc. Amer. Philos. Soc., Vol. 11, p. 393.

In 1862 Winchell (1862a, p. 355) described a single small specimen from the "Marshall sandstone" as *Orthoceras vittatum* Sandberger and Sandberger?, and in 1870 he listed this species with question from the

same formation. There is available for study the specimen on which Winchell's description is based as well as two conspecific individuals from the collections of the Museum of Paleontology at the University of Michigan (one of them labeled as having been identified by Winchell). It seems quite clear that these are not referable to the Sandberger brothers' species, the types of which came from the Devonian of western Germany and which have more rapidly expanded conchs marked by relatively fine transverse lines.

The specimen described by Winchell is illustrated (Pl. III, Fig. 3) and Figure 4 on the same plate portrays the better of the other two conspecific individuals now available (the one identified by Winchell). The conch is expanded orad very gradually indeed and is circular, or nearly so, in cross section. The surface of all three of the specimens is marked by rather prominent transverse raised bands that are separated by relatively narrow grooves. For the most part, these are essentially straight and directly transverse, but locally they are oblique, presumably due to distortion.

The camerae are moderate but somewhat variable in length, and the sutures are straight and directly transverse. One individual portrayed (Pl. III, Fig. 3) bears a suggestion of a suture near its mid-length and another near its adoral end. The septa are moderately convex apicad. The siphuncle is slightly but distinctly eccentric and is small, at least at its passage through the septa. Near the adapical end of a specimen shown (Pl. III, Fig. 3) the diameter of the siphuncle measures a little more than half a millimeter and that of the conch about  $5\frac{1}{2}$  mm.

*Remarks.*—The specimen that is not illustrated is labeled as one of the syntypes of "*Orthoceras*" [*Cycloceras*] *michiganense*, but it is doubtful that it is one of the original types of that species. It is only a fragment, some 9 mm. long, of an internal mold of three camerae of a phragmocone which resembles the specimen represented by Figure 4 on Plate III. Both individuals are preserved in yellowish brown limonitic sandstone, whereas the specimen illustrated by Figure 3 on the same plate consists of gray highly calcareous sandstone.

The generic affinities of this form are uncertain. Consequently, it is referred with question to *Mooreoceras* because, as in the type specimens of that genus, its conch is orthoceraconic and its siphuncle at its passage through the septa is small and slightly eccentric. Superficially it seems to resemble *Cycloceras? michiganense* (Miller), but presumably its relationship to that form is much more apparent than real. The general physiognomy and ornamentation are reminiscent of "*Orthoceras*" *indianum* Girty of the Caney shale of Oklahoma, but in that form the siphuncle is stated to be central in position.

*Occurrence.*—Winchell (1862*a*, p. 355) stated that the specimen he described came from the "Marshall sandstone at Battle Creek or Holland," but it is now labeled as from Battle Creek, Calhoun County, Michigan; if it did come from near Holland, it may possibly be from the Coldwater shale. The other two specimens described are from the Marshall sandstone at Marshall, Calhoun County, Michigan.

*Specimens.*—No. 26713 (Pl. III, Fig. 3); No. 27043 (Pl. III, Fig. 4); and No. 29415, unfigured specimen.

#### *Kionoceras* Hyatt

This genus was established by Hyatt (1884, p. 275) for "longicones in which the longitudinal ridges are more prominent than the transverse striae or ridges when these are present and are smooth throughout their entire length." The type species, by original designation, is *Orthoceras doricum* Barrande of the Middle Silurian of Bohemia as figured by its founder in 1868 on his "pl. 269."

In 1928 Foerste (p. 285) pointed out that "several different groups may be recognized among those species usually referred to *Kionoceras*"; and four years later he (1932, p. 89) suggested that "the term *Kionoceras* be restricted to those orthoceracones in which the surface of the shell is vertically ribbed and fluted." In one of his last papers he (1935, p. 23) noted that on Barrande's plate to which Hyatt referred when he designated the genotype, "nine specimens are figured . . . under the name *Orthoceras doricum*. All of these have numerous fine and closely arranged transverse striae. Several of them also have vertical striae, usually only 1 or 2 in number, between each pair of vertical ribs. They are most numerous on the surface of the shell of the specimen here figured first."

Recently "the history of *Kionoceras* in the Ordovician" has been "traced" by Flower (1952, pp. 24, 33–38). He pointed out that in the past "usually no attempt was made to investigate the interior of the shell, . . . [and that] instead, when the group became large and unwieldy as a genus, attempts were made to subdivide it on the basis of the surface features of the shell." Unfortunately, the single Mississippian specimen that is available for study does not reveal a trace of the internal structures of the conch, and one is forced to rely on the surface markings of the test for an indication of the affinities of the species represented.

It seems, therefore, that Barrande allowed the type species of the genus considerable latitude; but, insofar as can be told from the available data, the Kinderhook specimen for which the name *K. bellilineatum* is proposed, is almost certainly congeneric with all of the type specimens of *K. doricum* (Barrande). The genus *Kionoceras*, as now interpreted, ranges from the

Middle (and possibly the Lower) Ordovician to the Upper Carboniferous, inclusive, being most abundant in the Middle Silurian. Geographically it is of very widespread occurrence.

***Kionoceras bellilineatum*** Miller and Garner, sp. nov.

(Pl. I, Fig. 4; Pl. II, Fig. 5)

The Kinderhook strata of Michigan have yielded only a single specimen that is referable to *Kionoceras*. It does not appear to belong in any known species and, because of its general appearance, the authors designate it *K. bellilineatum*.

This holotype is incomplete but is rather well preserved in brown limonitic sandstone. No trace of internal structure can be discerned on it, and presumably, therefore, one is dealing with a portion of a body chamber. The length of the specimen is about 24 mm., and the maximum width approximately  $4\frac{1}{2}$  mm. Not quite half the complete circumference of the conch is represented, but it appears to have been circular, or nearly so, in cross section; the conch was very gradually expanded orad.

The surface ornamentation is presumably distinctive of the species. It consists of both longitudinal and transverse markings, of which the former are much the more prominent. The longitudinal ribs are narrow, and their upper surface appears to be essentially flat. It is estimated that within the complete circumference of the conch there were some 30 of these ribs, and their number is constant in the preserved portion of the holotype. The longitudinal grooves are much wider than the intermediate ridges and are broadly rounded. They bear numerous fine narrowly rounded transverse lirae which do not cross the longitudinal ribs and which are of about the same size as the transverse striae between them; they appear to be less than half as wide as the longitudinal ridges. Near the mid-length of the holotype, there are some 13 transverse lirae to the millimeter.

*Remarks.*—No species are known from the Carboniferous of North America that are similar to this one. Newell (1936, pp. 484–85, Pl. 70, Figs. 2a–2c) has described as "*Kionoceras* sp." two small specimens from the Upper Pennsylvanian of Kansas, but in a reprint of his paper he has written that these individuals "should have been provisionally referred to *Thoracoceras*." The type species of that genus is *T. vestitum* Fischer de Waldheim of a Carboniferous limestone at Karowa (Sergiefsky) in central European Soviet Russia; it is characterized by a laterally compressed orthoceraconic conch with spinose longitudinal ribs, straight transverse sutures, and a marginal siphuncle. Newell's specimens are internal molds representing only a few camerae and the available data in regard to them are not sufficient to enable one to determine their generic affinities with cer-

tainty. Nevertheless, there is no good reason to believe that they are very close to the form here studied, nor does the holotype seem to be more than superficially similar to the genotype of *Thoracoceras*.

*K. bellilineatum* does, however, appear to be closely related to *K. candidum* (de Koninck) and *K. wrightii* (Haughton) of the Lower Carboniferous of Belgium and Ireland, respectively. In all three of these species the surface ornamentation of the conch is strikingly similar. We have not been able to ascertain the exact age of the European forms and, hence, do not know how they compare with ours in that respect.

*Occurrence.*—Lower portion of upper part of Marshall sandstone in an abandoned quarry at Marshall, Calhoun County, Michigan.

*Holotype.*—No. 29416.

#### *Cycloceras* M'Coy

Miller, Dunbar, and Condra (1933, pp. 45–47) have discussed this genus at some length and have shown that its valid type is *Orthocera annularis* Fleming of the Carboniferous (Viséan or Namurian, according to J. Selwyn Turner) of Scotland. That species is very poorly known, but from the original description and illustration of it, one concludes that it is characterized by a gradually expanded orthoceraconic conch, circular or nearly so in cross section, which bears narrowly rounded transverse annulations and intermediate broadly rounded grooves and in which the spacing of the transverse grooves and the septa is not the same. Recently (personal communication, May 16, 1952) J. Selwyn Turner of Leeds wrote that he “had the good fortune to get some specimens [of *Cycloceras*] preserved right down to the pin-point apex, which is curved as in *Pseudorthoceras*.” Presumably, the same species possesses no longitudinal ornamentation and, therefore, Foerste (1932, p. 83) diagnosed the genus as follows: “Annulated conchs, with transverse striae, but without vertical markings of any kind.”

*Cycloceras* was thus interpreted rather broadly by Foerste, and he (1932, pp. 83–89; 1934, pp. 114, 117; 1935, pp. 12, 27) referred to it some Ordovician and Silurian species. Unfortunately, nothing is known about the siphuncle of the genotype and it may differ materially from those of all early Paleozoic forms. Furthermore, the specimens studied do not retain their siphuncles or reveal the nature of the external surface markings of their tests, and therefore one can not be certain about their relationship to the type species of *Cycloceras*. They all are, however, early Carboniferous annulated orthoceracones that are circular or broadly elliptical in cross section. In continental Europe this genus ranges upward at least into the Namurian (see Demanet, 1941).

**Cycloceras ehlersi** Miller and Garner, sp. nov.

(Pl. III, Fig. 7)

From the Coldwater shale, near its type locality, George M. Ehlers secured a fine unique specimen that appears to belong in the genus *Cycloceras*. It is not referable to any known species and the authors propose to name it in honor of its discoverer.

This holotype is a well-preserved internal mold of a body chamber that is complete adapically but probably not adorally. Its maximum overall length measures about 88 mm. The conch, which is essentially circular in cross section, is gradually expanded orad. The diameter of the type specimen increases from about 30 mm. near its adapical end to a maximum of about 35 mm. near its adoral end. The long axis of the holotype is not quite straight, probably due to slight distortion during preservation.

The internal mold bears prominent transverse annulations which are very narrowly rounded and are slightly but distinctly undulatory and which, in the holotype, rise a little more than 1 mm. above the bottoms of the broadly rounded intermediate grooves. There are four annulations in a length equal to the corresponding diameter of the conch. One of the adapical annulations of the holotype is only feebly developed throughout the complete circumference of the specimen and is, presumably, a deformity. The septa are moderately convex apicad, and the sutures are directly transverse and are straight, or essentially so. Unfortunately, the only known representative of this species does not retain its siphuncle.

*Remarks.*—The generic affinities of this specimen are somewhat uncertain for neither the nature of the external ornamentation of its test nor its siphuncle can be determined. It is here referred to *Cycloceras* rather than *Spyroceras*, because no trace of longitudinal markings can be discerned. At one place near the adoral end of the holotype there is, however, a papillose surface which may possibly represent an internal "ornamentation" of the test. No forms are known that are close enough to this one to merit detailed comparisons. The genotype of *Cycloceras*, *C. annulare* (Fleming), is in general similar, but its conch is less rapidly expanded orad.

*Occurrence.*—Coldwater shale in the abandoned Wolverine Portland Cement shale quarry in the NW.¼ sec. 32, T. 6 S., R. 6 W., about 1¼ miles southwest of Coldwater, Branch County, Michigan.

*Holotype.*—No. 29417.

*Cycloceras ? michiganense* (Miller)

(Pl. III, Figs. 1-2)

*Orthoceras multinctum* Winchell, 1862, Proc. Phila. Acad. Nat. Sci., 1862, p. 429.

*Orthoceras multinctum* Winchell, 1870, Proc. Amer. Philos. Soc., Vol. 11, p. 393.

*Orthoceras multinctum* Miller, 1877, The American Palaeozoic Fossils . . . , p. 176.  
*Orthoceras michiganense* Miller, 1883, The American Palaeozoic Fossils . . . , 2d ed., p. 308.

Winchell's name *Orthoceras multinctum* had been used previously by Hall. S. A. Miller (1833, p. 308) therefore, proposed to designate this species of *Orthoceras michiganense*.

The paleontological collections of the Museum of Paleontology at the University of Michigan contain three specimens that are labeled as syntypes of this species. Two of these, which are illustrated, coincide with Winchell's description. The third, which is lithologically identical, is only a small part of a phragmocone. It is quite distinct from the other two, and its affinities seem to be with the form described as *Mooreoceras* ? sp. Furthermore, it is doubtful that it is one of Winchell's syntypes for it shows clearly the shape of the sutures and the length of the camerae, mention of which is conspicuous by its absence in Winchell's description. To clarify the situation, an illustrated specimen (Pl. III, Fig. 1) is hereby designated the holotype of this species.

The holotype is an internal mold, most probably of a body chamber. It is more or less complete adapically but not adorally. Its maximum length measures about  $15\frac{1}{2}$  mm. The specimen is somewhat crushed; but the cross section appears to be elliptical, and near the adoral end of the holotype the two transverse diameters measure about  $4\frac{1}{2}$  mm. and  $5\frac{1}{2}$  mm. The conch is very gradually expanded orad.

The surface of the holotype is marked by numerous small subangular transverse annulations which appear to have about the same size and shape as the grooves between them. There are 38 of these annulations within the length of the holotype. Most of the annulations are essentially straight and directly transverse, but near the mid-part of the holotype some are rather strongly oblique, possibly due to distortion during preservation or to injury during ontogenetic development.

The holotype is bounded adapically by part of an impression of a septum. It shows that the septa are only moderately convex apicad and that the sutures are most probably directly transverse and straight, or nearly so. The paratype (Pl. III, Fig. 2) does not seem to differ materially from the holotype, but it is much less nearly complete. Its maximum length and width measure about 6 mm. and  $5\frac{1}{2}$  mm., respectively, and it bears 15 angular or subangular transverse annulations.

*Remarks.*—On the partial impression of a septum, which forms the adapical end of the holotype of this species, are structures that may possibly represent the siphuncle. Near the mid-length of the holotype are two faint transverse lines that may be sutures.

Winchell (1862*b*, p. 429) stated that this form is a "close analogue of *O. cinctum* de Kon. (An. Foss. 512, xliii. 6, xlv. 5, xlvii. 3), if it is not identical with it." In 1880 de Koninck (pp. 68–69, Pl. 40, Figs. 5–6*b*) recognized that the Belgian (Tournaisian) specimens to which Winchell referred are not identical with typical *Orthoceras cincta* Sowerby of the Carboniferous of England, and he proposed *Orthoceras discrepans* for them. At least their external features are in general similar to those of *C.?* *michiganense*, and all three of these species may be congeneric (though clearly not conspecific).

The only American form that seems to be close to that under consideration is *Orthoceras choctawense* Girty of the Caney shale of Oklahoma. Unfortunately, the nature of its siphuncle is not known, and the generic affinities of these two species are very uncertain. They most probably represent an unnamed genus, but none of the available specimens seem to constitute a satisfactory basis for the erection of a genus. No particular significance should be attached to their being referred here with question to *Cycloceras*. Presumably, the similarity to the form described as *Mooreoceras?* sp. is entirely superficial.

*Occurrence*.—Both the holotype and the figured paratype are preserved in brown ferruginous sandstone; the label which accompanies them indicates that they came from the Marshall sandstone at Marshall, Calhoun County, Michigan. Winchell, however, indicated that one or more of the original type specimens came from Holland in Ottawa County, which is located near the dividing line between the outcrop areas of the Coldwater and the Marshall formations.

*Types*.—Holotype No. 26885*a*; paratype No. 26885*b*.

#### *Spyroceras* Hyatt

Hyatt (1884, p. 276) established this genus for "the longitudinally ridged longicones, which at some stage of their growth are also annulated," and he designated as its type species *Orthoceras crotalum* Hall of the Middle Devonian of New York. Foerste, whose extensive work on Paleozoic nautiloids is well known, applied this generic appellation to a considerable number of Ordovician, Silurian, and Devonian forms, but he (Foerste, 1932, pp. 111–12) segregated as *Metaspyroceras* certain species of which he stated the "tendency toward a more or less distinctly convex ventral outline is their most distinctive feature."

Shimizu and Obata (1935, pp. 3–6) and Flower (1939, pp. 109–11) have proposed to restrict the scope of *Spyroceras* greatly. The former authors attempted a subdivision of the genus on the basis of variations in



the surface markings of the test. Flower based his classification largely on the nature of the siphuncle and the siphuncular and cameral deposits, and fairly recently (1946, pp. 131-39) stated that *Spyroceras* s. s. "is, as far as is known, confined to Middle and Upper Devonian" strata. Nevertheless, he found it desirable to use *Spyroceras* s. l. in connection with Ordovician forms of which "the internal structure of the species is still unknown."

Although we are dealing with specimens that do not reveal the nature of the internal structures of the conch, they differ only slightly in age from the Middle Devonian genotype and closely similar forms from the Upper Devonian. In addition, their surface ornamentation is much like that of certain of the specimens that have been placed in the genotype by the founder of that species (Hall, 1879, pp. 296-98, Pl. 42, Figs. 1-9, 11, 12; Pl. 82, Figs. 1-6; Pl. 113, Figs. 13, 13a). They are most probably referable to *Spyroceras*, regardless of whose interpretation of the genus is accepted. Nevertheless, their affinities can not be established beyond reasonable doubt, because they are only fragments.

*Spyroceras* sp.

(Pl. III, Fig. 6)

*Orthoceras* sp. ? Winchell, 1862, Amer. Journ. Sci. and Arts, 2d Ser., Vol. 33, pp. 357-58.  
*Orthoceras Lathropianum* (*nomen nudum*) Winchell, 1870, Proc. Amer. Philos. Soc., Vol. 11, p. 393.

One of the two specimens from the Kinderhook of Michigan that resembles the genotype of *Spyroceras*, is a small section of an external mold; its maximum length and width measure only about 23 mm. and 14 mm., respectively. The general physiognomy of this specimen suggests that the complete conch was orthoceraconic, rather gradually expanded orad, and circular, or nearly so, in cross section. The maximum diameter of the part represented is estimated to have been of the order of 2 cm.

The most distinctive feature of this specimen is its ornamentation which consists of prominent narrowly rounded transverse annulations and longitudinal lirae. The grooves between the annulations are broadly rounded, and the longitudinal lirae seem to be more prominent in them than on the annulations, possibly as a result of preservation. The spacing of the annulations is elucidated by the accompanying illustration (Pl. III, Fig. 6), but it should be stated that they rise a little more than 1 mm. above the bottoms of the adjacent grooves. The longitudinal lirae appear to be of about the same size and shape as the striae between them and their number is increased adorally by intercalation.

*Remarks.*—An artificial cast made from this mold is strikingly similar

to corresponding parts of certain of the specimens from the Middle Devonian of New York that Hall (1879) illustrated as "*Orthoceras*" *crotalum*, the type species of *Spyroceras*. Therefore, the form is referred to that genus in spite of the fact that no information is available in regard to its sutures or siphuncle.

After Winchell (1862*a*, p. 357-58) published a description of this specimen, he coined a specific name for it which he entered on the label and in a separate of his paper, and which later he (1870*b*, p. 393) published as a *nomen nudum*. It is considered that this fragment is too incomplete to serve satisfactorily as a holotype.

*Occurrence*.—Lower portion of upper part of Marshall sandstone, Marshall, Calhoun County, Michigan.

*Specimen*.—No. 26775.

*Spyroceras* ? sp.

*Orthoceras reticulatum* ? Winchell, 1862, Amer. Journ. Sci. and Arts, 2d Ser., Vol. 33, p. 357.

*Orthoceras reticulatum* Winchell, 1870, Proc. Amer. Philos. Soc., Vol. 11, p. 393.

The specimen that Winchell referred with question to *Orthoceras reticulatum* Phillips of the Lower Carboniferous of England is unique. It is a rather poorly preserved fragment of an orthoceraconic conch that is about 25 mm. long and is estimated to have attained a diameter of at least 20 mm.; its curvature seems to suggest that it was circular, or nearly so, in cross section. There are four prominent rather narrowly rounded annulations on this specimen, separated by broadly rounded grooves that are a little less than 1 mm. deep and about 8 mm. wide. Parts of the test that are retained show that it bore moderately coarse longitudinal lirae, which may have alternated in prominence and which are of about the same size and shape as the striae between them. These striae bear numerous very fine transverse lirae, which are separated by striae of about the same magnitude. Near the adoral end of the specimen, there is a suggestion of rather coarse somewhat irregular transverse lirae. No trace of the septa or the siphuncle is retained. Presumably, the specimen represents part of the wall of the body chamber.

*Remarks*.—This specimen is composed of yellowish brown limonitic micaceous sandstone. Although it is quite distinct from all known Michigan forms, its preservation is such that no illustration of it merits publication. This form is not very close to the English species with which Winchell thought it might be identical. Its rather widely spaced annulations and transverse lirae differentiate it readily from *Spyroceras* sp. of the same general horizon and locality, described above.

*Occurrence.*—Lower portion of upper part of Marshall sandstone in an abandoned quarry at Marshall, Calhoun County, Michigan.

*Specimen.*—No. 26772.

*Poterioceras* M'Coy

The original diagnosis of this genus is very short and reads as follows: "Shell fusiforme, short; mouth contracted; siphuncle dilated between the chambers, excentric" (M'Coy, 1844, p. 10). In 1924 Foerste (p. 254) established *Orthocera fusiformis* Sowerby of the Lower Carboniferous of Ireland and England as the genotype.

From a study of the specimens available and the published data, in regard to the genotype and similar forms, the following generic diagnosis has been drawn up: Conch breviconic, straight or slightly curved exogastrially, body chamber contracted orad, cross section circular or broadly elliptical, sutures (except for the adoral ones at full maturity) essentially straight and directly transverse, and siphuncle subcentral and cyrtochoanitic with subellipsoidal to subspherical segments. As here interpreted, the genus occurs in both Europe and North America, and ranges from near the base of the Mississippian well up into the Pennsylvanian.

J. Selwyn Turner (personal communication, April 8, 1952) of Leeds recently wrote that in one of the typical representatives of the type species which he sectioned (the one illustrated by Foord, 1898, Pl. 15, Figs. 1a-1c) the siphuncular segments are considerably wider than long (the ratio of length to width being about as 2 is to 3). In regard to this specimen he noted: "There seem to be episeptal deposits against the wall of the conch and extending for a very short distance adaxially along the floor of the camerae, but no hyposeptal deposits against the roof. I can distinguish no definite deposits within the siphuncle, but the whole of the interior of camerae and siphuncle is greatly obscured by recrystallised calcitic matrix."

*Poterioceras ? robustum* (Winchell)

(Pl. II, Figs. 8-9)

*Orthoceras robustum* (part) Winchell, 1862, Amer. Journ. Sci. and Arts, 2d Ser., Vol. 33, p. 355.

*Orthoceras robustum* (part) Winchell, 1870, Proc. Amer. Philos. Soc., Vol. 11, p. 393.

*Orthoceras robustum* (part) Miller, 1877, The American Palaeozoic Fossils . . . , p. 177.

Several of the syntypes of this species are available for study. They are not all conspecific, but the one portrayed on (Pl. II, Fig. 8) best coincides with Winchell's concept of the species. It is designated the holotype, although it is incomplete; none of the other available syntypes, however, are any better as study specimens.

Altogether, five specimens are placed in this species. None of them are complete, but collectively they show that the conch is moderately large and attains a maximum width of more than 75 mm. Winchell (1862a, p. 355) who may have had specimens not available to us, stated that one fragment "is so large as to imply a diameter of 4.6 [inches]." The conch appears to be straight and moderately expanded orad (see Pl. II, Fig. 9). The shape of the cross section is not known and no trace of the surface markings of the test can be discerned on any of the specimens under consideration. The camerae are long and the sutures appear to be essentially straight and directly transverse. None of the specimens reveal any trace of the siphuncle.

*Remarks.*—Until better representatives of this species have been collected and studied, its specific affinities will remain uncertain. At least superficially it seems to resemble *Poterioceras northviewense* Miller and Furnish of the Northview shale of southwest Missouri. That species, however, is not very well known and may not be congeneric with the genotype of *Poterioceras*.

*Occurrence.*—Marshall sandstone at (1) Marshall, Calhoun County, and (2) in the SE.  $\frac{1}{4}$  sec. 27, T. 4 S., R. 2 W., Hanover Township, Jackson County, Michigan.

*Types.*—Holotype, No. 26777 (Pl. II, Fig. 8); hypotype, No. 29418 (Pl. II, Fig. 9); three paratypes, No. 26776.

*Poterioceras* ? sp.

(Pl. II, Figs. 6-7)

*Orthoceras robustum* (part) Winchell, 1862, Amer. Journ. Sci. and Arts, 2d Ser., Vol. 33, p. 355.

*Orthoceras robustum* (part) Winchell, 1870, Proc. Amer. Philos. Soc., Vol. 11, p. 393.

*Orthoceras robustum* (part) Miller, 1877, The American Palaeozoic Fossils . . . , p. 177.

The Marshall sandstone has yielded several poorly preserved fragmentary specimens that are superficially similar to the types of *Poterioceras? robustum* (Winchell) but are considerably smaller. Furthermore, in some of them, for example, one of those illustrated (Plate II, Fig. 7), the adoral camera is shorter than the preceding one, which suggests that mature individuals are being dealt with. Several of the specimens retain traces of fine transverse markings, presumably growth lines.

Although Plate II, Figure 6 portrays a slightly crushed individual, it shows that the conch is rather rapidly expanded orad and that the cross section is broadly elliptical. Near the mid-length of this specimen the height and corresponding width of conch measure some 21 mm. and 28 mm., respectively. The camerae are fairly short; the sutures are essentially

straight and directly transverse, or nearly so; the septa are moderately convex apicad; and the siphuncle is small at its passage through the septa and is slightly but distinctly eccentric. One specimen represented (Pl. II, Fig. 6) is bounded adapically by the impression of a septum, and in it the siphuncle is about 2 mm. in diameter and its center is about 7 mm. from the venter and 11 mm. from the dorsum.

*Remarks.*—The largest of the fragments suggests that the conch of this form attains a width of at least 40 mm. None of the available specimens is satisfactory as a holotype. At least superficially they resemble rather closely the individual from the Chouteau limestone of northeastern Missouri that Miller and Furnish (1939, p. 174, Pl. 45, Fig. 3), described and illustrated as *Poterioceras* sp.

*Occurrence.*—Marshall sandstone at the following localities in Michigan: (1) about 1 mile north of Osseo, Hillsdale County; (2) Alan's quarry, Hillsdale County; (3) Moscow, Hillsdale County; (4) Marshall, Calhoun County; and (5) SE.  $\frac{1}{4}$  sec. 27, T. 4 S., R. 2 W., Hanover Township, Jackson County. Also, fragments are known from the glacial drift in a gravel pit about 6 miles southeast of Jackson, Jackson County, Michigan.

*Specimens.*—No. 26773 (1 specimen); No. 27039 (1 specimen, Pl. II, Fig. 6); No. 27044 (2 specimens); No. 29419 (1 specimen); No. 29420 (1 specimen); No. 29421 (Pl. II, Fig. 7); No. 29422 (1 specimen); and No. 29423 (1 specimen). The first, fourth, and fifth of these were syntypes of *Orthoceras robustum*; the second was thought by Winchell to belong in the same species; and those numbered 27044 were referred by Winchell to *Orthoceras indianense* in 1865.

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*Submitted for publication June 20, 1952*



**PLATES**

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PLATE I

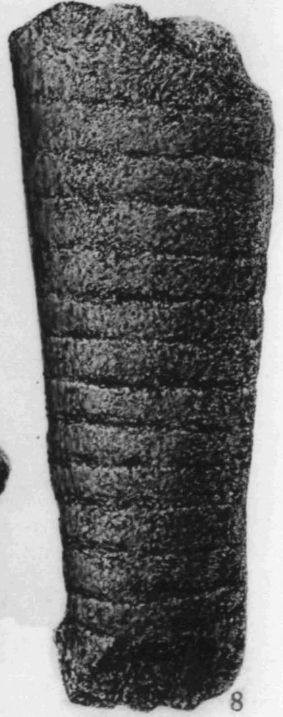
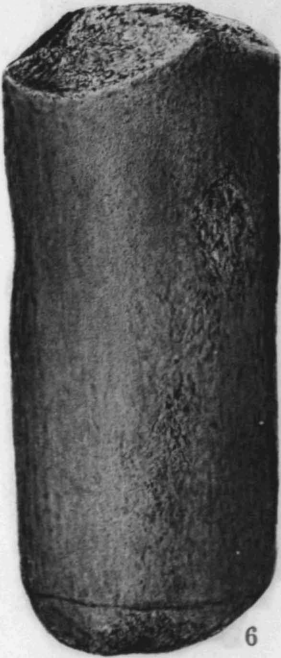
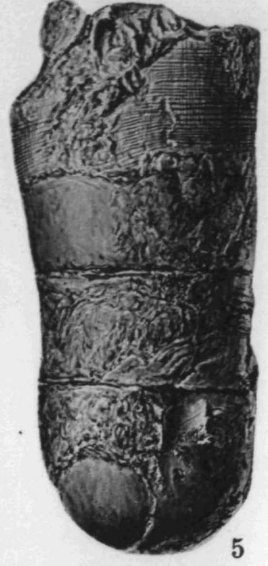
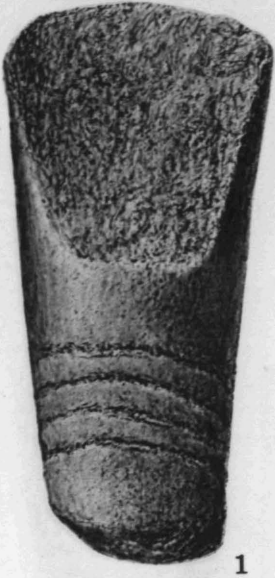


PLATE II



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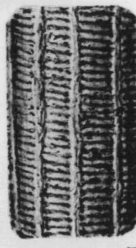
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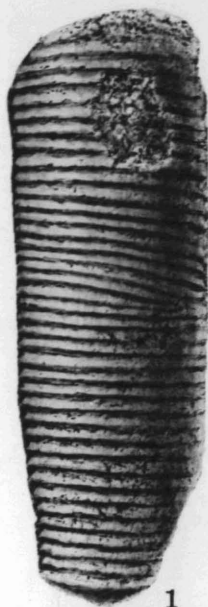
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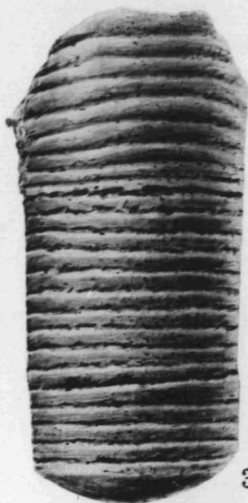
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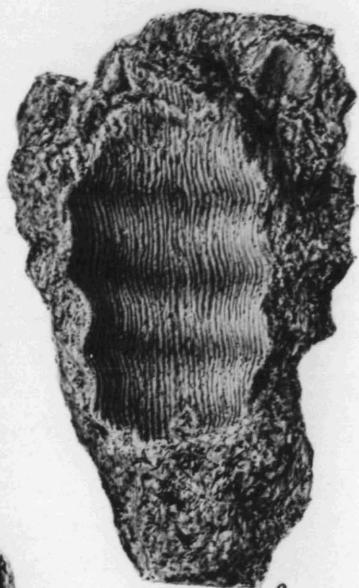
PLATE III



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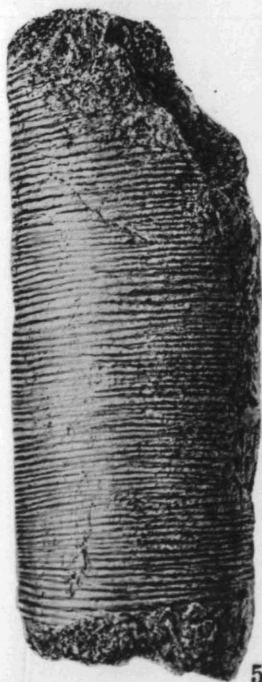
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## VOLUME X

1. Ostracods of the Families Leperditellidae, Drepanellidae, Glyptopleuridae, Kloedenellidae, Bairdiidae, Barychilinidae, and Thlipsuridae from the Genshaw Formation of Michigan, by Robert V. Kesling and John E. Kilgore. Pages 1-19, with 4 plates. Price \$.60.
2. Ostracods of the Families Leperditellidae, Primitiidae, Drepanellidae, Aechminidae, and Kirkbyidae from the Middle Devonian Bell Shale of Michigan, by Robert V. Kesling. Pages 21-44, with 5 plates. Price \$.75.
3. Ostracods of the Family Hollinidae from the Ferron Point Formation of Michigan, by Robert V. Kesling. Pages 45-57, with 2 plates. Price \$.50.
4. Echinoderms of the Middle Devonian Silica Formation of Ohio, by Porter M. Kier. Pages 59-81, with 4 plates. Price \$.70.
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6. Trilobites of the Devonian Traverse Group of Michigan, by Erwin C. Stumm. Pages 101-157, with 12 plates. Price \$1.50.
7. Lower Mississippian Cephalopods of Michigan. Part I, Orthoconic Nautiloids, by A. K. Miller and H. F. Garner. Pages 159-192, with 3 plates. Price \$.85.

