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LOWER MISSISSIPPIAN CEPHALOPODS OF MICHIGAN
PART II. COILED NAUTILOIDS

BY

A. K. MILLER and H. F. GARNER

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CONTENTS

INTRODUCTION

THIS study, which is a comprehensive treatment of the coiled nautiloids, is Part II of a trilogy on the Lower Mississippian cephalopods of Michigan. Part I (Miller and Garner, 1953) presented a detailed account of the orthoconic forms and, in addition, it included a résumé of the pertinent data regarding the previous work, collections, and stratigraphy involved in the entire study. Part III will be devoted to the ammonoids and will contain a summary of the findings in regard to all the cephalopods known from the Lower Mississippian of this state.

In Michigan, the coiled forms occur in direct association with the orthoconic nautiloids and the ammonoids. In distribution and number of genera

they are comparable to the orthocones, but specimens are rarer and represent fewer species. The ammonoids are more numerous than the nautiloids but tend to be localized. These statements apply equally well to both the Coldwater shale and the overlying Marshall sandstone, the two formations which have yielded all the Michigan cephalopods in the collections being studied.

The great bulk of the material is fragmentary and is preserved in siltstone and sandstone, so that it was not practical to make longitudinal sections that would reveal the nature of the siphuncle and related internal features of the conch. Since the siphuncle is of uniform structure in this particular group of nautiloids, and siphuncular and cameral deposits do not appear to exist, lack of median longitudinal sections was no particular handicap. Diagrammatic transverse sections could be readily prepared and proved to be significant from a taxonomic standpoint.

Previously, students of Lower Carboniferous nautiloids have held divergent views as to the scope of the genera involved. During the latter part of the nineteenth century, classical studies of this group of fossils were published by de Koninck, Foord, Hyatt, Tzwetaev, and others. Since that time, however, no major reports have appeared, with the exception of Schmidt's "Nautiliden aus deutschem Unterkarbon." There have been few recent attempts to synthesize the available data and to classify the established species in accordance with present-day concepts of genera. Difficulties of classification have been increased, because there has been little uniformity of opinion as to which generic names should be employed, but it is more significant, from a taxonomic point of view, that the type species of some genera were based on immature specimens and that those of others were never illustrated.

Most of the original types of previously described Lower Carboniferous nautiloids were of European origin, and they need to be restudied in accordance with modern paleontological methods. This task should be undertaken by workers thoroughly familiar with the stratigraphy involved and ones who have ready access to the existing collections as well as to supplementary material from the type localities. Fortunately, Mr. J. Selwyn Turner of the University of Leeds is now engaged in this work. Meanwhile, we of necessity can only rely on the existing literature and the collections available to us, most of which consist of American specimens.

From a study of such monumental works as those of de Koninck and Foord, it is apparent that there is great diversity in the Lower Carboniferous nautiloids. They show many variations, the majority of which appear to be more or less gradational and some of which represent different onto-

genetic stages of the same species. In certain cases there even seems to be more variation within a group than between separate groups. This variation readily explains why the taxonomy employed by previous workers differs greatly as, indeed, does that used by the same author from time to time.

We decided to place all of the Michigan coiled nautiloids under consideration in five genera and to group these, with three genera from other regions, into one family. We have attempted to indicate, moreover, the affinities of most of the American Lower Carboniferous forms as well as those of many related ones from Eurasia.

The following coiled nautiloids occur in the Lower Mississippian strata of Michigan:

COLDWATER SHALE

Chouteauoceras? sp.
Vestinautilus altidorsalis (Winchell)

MARSHALL SANDSTONE

Chouteauoceras? ingenitor (Winchell)
C? sp. aff. *C.? tessellatum* (de Koninck)
C.? spp.
Rineceras meekianum (Winchell)
R. strigatum (Winchell)
R.? striatulum (Winchell)
Vestinautilus altidorsalis (Winchell)
Stroboceras intermedium Miller and Garner, sp. nov.
S. planidorsale (Winchell)
Maccoyoceras discoidale (Winchell).

Nautiloids of all kinds are relatively rare in the Coldwater shale, and so far only six coiled specimens have been obtained from it. These represent two generically distinct species, at least one of which, *Vestinautilus altidorsalis,* occurs also in the overlying Marshall sandstone. It is likely that the differences between the nautiloids of the Coldwater and the Marshall are not primarly a matter of the age of the formations but rather a result of ecological controls. The Coldwater formation consists largely of shale through which numerous clay ironstones are dispersed. All of the Coldwater specimens are from the clay-ironstone nodules, whereas the Marshall cephalopods are largely from sandstones that are locally calcareous and/or ferruginous. Coiled nautiloids are extremely scarce in the conglomeratic beds which occur in the Marshall, although at one locality (Burnt Cabin Point) such beds contain goniatites in abundance. Presumably, the shells of the nautiloids yielded more readily than those of the goniatites to the eroding effects of the strong waves and currents, a statement which does not apply in as great a degree to the orthoconic nautiloids.

The great majority of the coiled nautiloids from the Marshall sandstone came from its type section, which is in a small abandoned quarry in the city of Marshall. The type beds there represent only a small part of the formation, but they carry an abundant fauna that is predominantly molluscan and consists of a variety of nautiloids and ammonoids as well as pelecypods, gastropods, and other fossils, including plants. Marshall and Burnt Cabin Point, both in Michigan, are now the best places in America at which to collect Mississippian nautiloids. The beds of Rockford limestone at Rockford, Indiana, which contain cephalopods in some abundance, are now under water. Besides these, the only other strata in the western hemisphere that have yielded a considerable variety of Mississippian nautiloids are the Chouteau limestone and the Northview shale of Missouri, which are believed by some to be parts of one formation.

We regard the coiled nautiloids of the Coldwater and the Marshall formations as belonging to a single fauna. It possesses only one, or possibly two, generic elements (*Rineceras* and *Chouteauoceras?*) in common with the Chouteau, which indicates that the two faunas are not contemporaneous, as has heretofore been believed. Nor is this fauna contemporaneous with those of the Caballero formation of New Mexico, the Redwall limestone of Arizona, or the approximately equivalent strata in Sonora, all three of which have yielded a representative of *Rineceras* that is conspecific with that of the Chouteau. The species of *Rineceras* that is characteristic of these last formations, *R. digonum* (Meek and Worthen), was originally described from the Rockford limestone of Indiana, which is also of about the same age as the Chouteau but has yielded only a few coiled nautiloids. The Waverly group of Ohio contains a related cephalopod fauna that needs to be restudied.

Comparison of the Coldwater-Marshall coiled-nautiloid fauna with European assemblages has revealed no striking similarities. Most of the genera represented in the Michigan fauna, however, occur in various parts of the Lower Carboniferous in Ireland, England, Belgium, Germany, and central European Soviet Russia. Apparently, during Lower Carboniferous time intercontinental migration was not particularly difficult, at least in the northern hemisphere, nor were the life spans of most of the nautiloid genera represented very limited.

Acknowledgment is due to Professor George M. Ehlers of the University of Michigan, who made this study possible and who facilitated our work in many ways, and to Dr. Erwin C. Stumm of the same institution, who labeled and catalogued all the specimens in the Winchell collections. Professor W. A. Kelly of the Michigan State College kindly donated to the

University of Michigan the material he had collected, and he and Professor Ehlers directed the junior author to the exposures from which additional specimens were collected. The photographs on Plates I and IV were retouched by Mr. Howard Webster of Iowa City, Iowa, and those on Plates II and III by Mr. Len Everett of Kirkwood, Illinois.

All of the specimens are deposited at the University of Michigan. The catalogue numbers cited refer to the paleontological collections there.

SYSTEMATIC DESCRIPTIONS

Family Rineceratidae Hyatt

The coiled nautiloids of the Michigan Lower Mississippian show considerable variation, most of which seems to be more or less gradational. Because of this gradation, we are convinced that these forms are so closely related that they should be grouped together in a single family. Since we are suppressing the genus *Triboloceras,* the only valid name for this family is Rineceratidae, which was proposed by Hyatt (1893, p. 424). We offer, to be sure, a far different interpretation of the family from its author (1893 and 1900), although as recently as 1951 Schmidt accepted Hyatt's views in regard to the essential content of the family.

In representatives of this group, during early growth stages, the conch is subcircular in cross section and rather loosely coiled. At maturity the shape of the volutions is modified and the whorls are in contact, though not deeply impressed, and at late maturity many of the forms are known to have become evolute. The surface of the test bears prominent longitudinal ridges, some (rarely all) of which may become obsolete during ontogenetic development. Transverse lirae are present in most cases during some stage of growth. Typically the sutures are slightly sinuous, largely as a result of variations in the shape of the conch, though in a few examples there is a deep ventral lobe formed by a prominent flexure of the septa. The siphuncle is small, subcentral, and orthochoantic.

Chouteauoceras is thought to be the most primitive member of the family, because the conch is very loosely coiled, the cross section of its whorls is only slightly modified during ontogenetic development, and the longitudinal ridges are retained throughout all stages of growth. If representatives of this genus did not become evolute during late maturity, they could easily be mistaken for immature portions of large and more advanced members of the family.

The early volutions of at least some species of *Rineceras* are loosely coiled, suggesting that it also is fairly primitive, an interpretation which

is substantiated by the fact that representatives of the genus retain longitudinal ridges throughout ontogenetic development, as in *Chouteauoceras*. It seems likely, therefore, that *Rineceras* arose from *Chouteauoceras* and in turn gave rise to *Vestinautilus,* in which the early growth stages resemble certain mature representatives of the intermediate genus. During late ontogenetic development, typical *Vestinautilus* loses most of its longitudinal ornamentation in favor of prominent transverse markings, as in *Maccoyoceras*. The general physiognomy in *Maccoyoceras* suggests that it probably arose from *Discitoceras,* another presumed descendant of *Chouteauoceras,* in which, however, the conch seems to have become slightly impressed during very early growth stages. *Discitoceras* most probably also gave rise to *Stroboceras* by certain of its longitudinal ridges becoming very large at the expense of others. *Stroboceras,* which seems to us to be close to *Discitoceras,* was not included in the family Rineceratidae by Hyatt or Schmidt. See Text Figure 1.

In addition to the genera mentioned, Hyatt and/or Schmidt included in this family *Lispoceras, Thrincoceras, Phloioceras, Leuroceras,* and *Phacoceras,* all of Hyatt, and *Subclymenia* of d'Orbigny. The genotype of the first of these is *L. trivolve* Hyatt of the Viséan of Belgium, a species which has never been illustrated and which is so poorly known that its affinities can not be determined until the original specimens are restudied. *Thrincoceras,* as exemplified by its type species, *T. depressum* Hyatt of the "Carboniferous" of Kentucky, has a thickly subdiscoidal conch that is subrectangular in cross section (being depressed dorsoventrally) and is prominently lirate throughout ontogenetic development. The highly ornamented *Phloioceras* of the Triassic most probably belongs in the Tainoceratidae and is only superficially similar to some of the Rineceratidae. Although Schmidt (1951, p. 24) stated to the contrary, the type species of *Leuroceras* is, by original designation, *L. aplanatum* Hyatt of the "Carboniferous," presumably of Belgium. It has never been illustrated, but there seems to be no good reason to believe that it belongs in the Rineceratidae. The genotype of *Phacoceras, P. oxystomum* (Phillips) of the Lower Carboniferous of Europe, has a sublenticular deeply involute conch with strongly compressed volutions and a rather sharply acute periphery. In our opinion it does not belong in the Rineceratidae. *Subclymenia* d'Orbigny, however, as exemplified by *S. evoluta* Phillips of the Viséan of England and Belgium, is probably to be regarded as an aberrant member of this family which presumably evolved from *Maccoyoceras*. It is characterized by sutures that form prominent angular ventral lobes and by similar ventrolateral saddles, which are rare indeed in nautiloids. In 1894 Hyatt (p. 544)

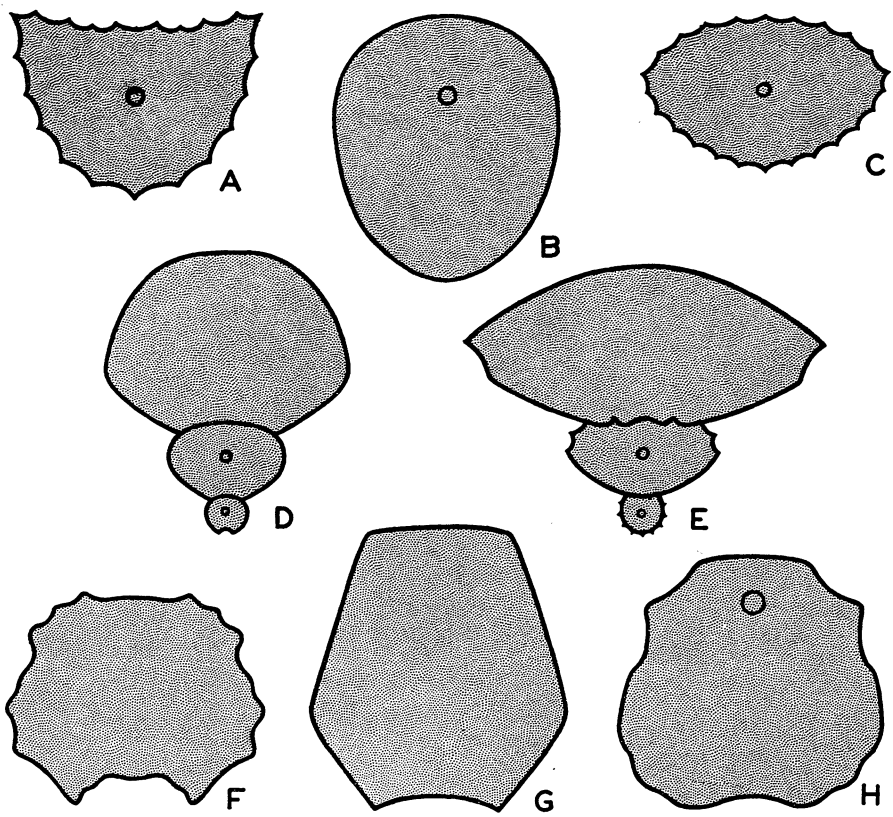

FIG. 1. Cross sections of the type species of *"Triboloceras," Chouteauoceras, Rineceras, Discitoceras, Vestinautilus, "Coelonautilus," Maccoyoceras,* and *Stroboceras.*

A—Figured syntype of *Rineceras* [=*"Triboloceras"*] *serratum* (de Koninck), from Tournaisian of Belgium, × 2. After de Koninck.

B—Figured syntypes of *Chouteauoceras americanum* (Miller and Furnish), from Chouteau limestone of Missouri, × 2½.

C—Figured syntype of *Rineceras propinquum* (de Koninck), from Lower Carboniferous of Belgium, × 1¼. After de Koninck.

D—Holotype of *Discitoceras costellatum* (M'Coy), from Lower Carboniferous of Ireland, × 2. Adapted from M'Coy.

E—Type specimen of *Vestinautilus koninckii* (d'Orbigny), from Tournaisian of Belgium, × 1. After de Koninck.

F—Figured syntype of *Stroboceras* [=*"Coelonautilus"*] *stygiale* (de Koninck), from Namurian of Belgium, × 1. Adapted from de Koninck.

G—Figured syntype of *Maccoyoceras discors* (M'Coy), from Lower Carboniferous of Ireland, × 1½. After M'Coy.

H—Mid-part of holotype of *Stroboceras harttii* (Dawson), from Upper Mississippian Windsor limestone of Nova Scotia, × 5.

expressed the opinion that his Permian genus *Pselioceras* may belong in this family, but its affinities seem rather to be with the Domatoceratidae.

Hyatt and/or Schmidt included in the Triboloceratidae several genera which should be considered here, for presumably they thought them to be close to *Triboloceras,* which we are suppressing as a synonym of *Vestinautilus,* which is a valid representative of the Rineceratidae. These are *Planetoceras, Stearoceras, Knightoceras,* and *Liroceras* [=*? Coloceras* Hyatt, which was preoccupied]. No representative of the genotype of *Planetoceras* Hyatt has ever been illustrated and the affinities of the genus are therefore difficult to ascertain. It may be related to *Stearoceras* Hyatt, which belongs in the Domatoceratidae, or to *Liroceras* Teichert, now the type of a family. *Knightoceras* Miller and Owen, though superficially similar to some of the Rineceratidae, probably evolved independently and should be retained in the Koninckioceratidae.

In summary, it seems to us that the family Rineceratidae contains the following valid genera: *Chouteauoceras, Rineceras, Vestinautilus, Discitoceras, Thrincoceras, Stroboceras, Maccoyoceras,* and *Subclymenia.* Geographically, the family is of widespread occurrence at least in North America and Eurasia; stratigraphically, it ranges through the Lower Carboniferous and extends into at least the early part of the Upper Carboniferous.

Chouteauoceras Miller and Garner, gen. nov.

The various coiled Lower Mississippian nautiloids of Michigan probably evolved from a common ancestral stock, for the early growth stages of their conchs are similar. The Chouteau limestone of Missouri, which is slightly but distinctly older than the beds yielding these Michigan cephalopods, contains a species which at maturity closely resembles the immature parts of typical representatives of the Rineceratidae. This form was illustrated and described by Miller and Furnish (1939, pp. 156–57, Pl. 48, Figs. 4–6), who coined for it the name *Rineceras americanum.* This species seems to be considerably more primitive than typical *Rineceras,* and is here regarded as the type of a distinct genus that we are naming for the formation in which it occurs. Because we attach great significance to this genus and because Miller and Furnish's study was published in a rather obscure serial, we are refiguring the species. In order to avoid precise duplication, a restoration (Text Fig. 2) has been prepared which is, in certain respects, superior to the previously published illustrations.

From a study of the type specimens of this species, we have drawn up the following diagnosis of the genus: Conch rather loosely coiled, with

volutions not in contact during early and late growth stages and only slightly (or not at all) in contact during typical maturity. Whorls ovate in cross section, somewhat higher than wide, more narrowly rounded dorsally than ventrally, and not impressed dorsally (Text Fig. 1B). Surface of internal mold, and presumably also of test, with numerous small but prominent longitudinal ridges and relatively fine transverse growth lines; the latter form broadly rounded lateral salients and corresponding dorsal

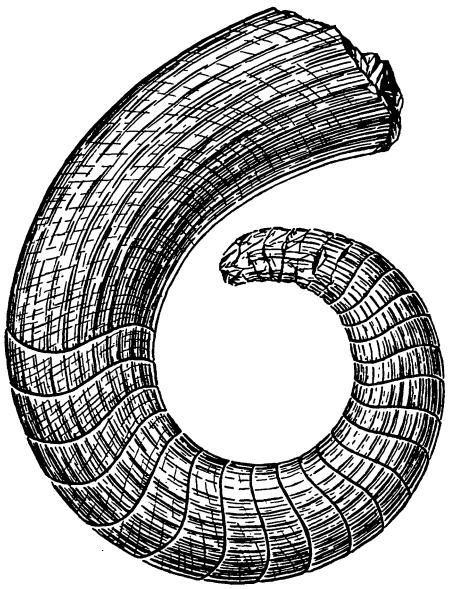

FIG. 2. *Chouteauoceras americanum* (Miller and Furnish).

Restoration, based on two figured syntypes, from Chouteau limestone of Missouri, × 1½. For cross section of conch see Text Figure 1B. Drawn by Howard Webster.

and ventral sinuses, of which the ventral are the deeper. Camerae short. Sutures form broad rounded lateral lobes and dorsal and ventral saddles, of which the ventral are the more pronounced. Siphuncle appears to be small and subcentral.

The most important characters of *Chouteauoceras* are the loose coiling of the conch, which becomes distinctly evolute during late maturity; the relatively unmodified shape of the whorl cross section; and the retention of the longitudinal ridges throughout ontogenetic development. These characters lead us to believe that this genus is primitive and to regard it as representing the ancestral stock of the Rineceratidae.

All seven of the known representatives of the genotype came from the

Chouteau limestone in central Missouri. This genus may also include *Cyrtoceras tessellatum* de Koninck of the Viséan of Belgium and Ireland, in which, however, the conch is distinctly depressed dorsoventrally. We are doubtfully referring to the genus certain specimens from both the Coldwater and the Marshall formations of Michigan.

Chouteauoceras? ingenitor (Winchell)

(Pl. IV, Fig. 6)

Nautilus ingenitor Winchell, 1862*a*, Amer. Journ. Sci. and Arts, 2d Ser., Vol. 33, pp. 361–62.

Nautilus (*Trematodiscus*) *ingenitor* Winchell, 1870, Amer. Philos. Soc., Proc., Vol. 11, p. 393.

Winchell based this species on several fragments, of which only two can be recognized. We collected an additional small fragment that is both a homeotype and a topotype. The better of the original types is labeled "holotype," and we here designate it as such (see Pl. IV, Fig. 6). The paratype is comparable in size, shape, and preservation, but it is considerably crushed and does not merit illustration.

Little of descriptive worth can be ascertained from the available specimens. The conch seems to have attained a diameter of at least 12 cm. The whorls are rounded laterally and dorsolaterally. The shape of their dorsal and ventral zones is unknown, but, Winchell's statement to the contrary, both primary types suggest that there was a dorsal impressed zone. The surface of the internal mold is largely devoid of markings other than the sutures, but on the paratype there are suggestions of sinuous transverse growth lines. The camerae are moderately short and at least the dorsolateral and lateral portions of the sutures are almost directly transverse and slightly sinuous and form broad shallow rounded lateral lobes. None of the types retains a trace of the siphuncle.

Remarks.—Winchell stated that this species "recalls *N. ingens* Martin" (1809, Pl. 41) of the Lower Carboniferous of Great Britain, and it is possible that these two forms are congeneric. We are uncertain in regard to the affinities of *Chouteauoceras? ingenitor;* we doubt that it is closely related to any of the others in the collections under study or that it should be included in the Rineceratidae; and we place it with question in *Chouteauoceras* merely as a matter of expediency.

Occurrence.—Marshall sandstone at Marshall, Calhoun County, Michigan.

Types.—Holotype No. 23551 (Pl. IV, Fig. 6); also, not figured, paratype No. 23552 and homeotype No. 27045.

Chouteauoceras? sp. aff. *C.? tessellatum* (de Koninck)

Cyrtoceras tesselatum? Winchell, 1862*a*, Amer. Journ. Sci. and Arts, 2d Ser., Vol. 33, p. 362.

Under the heading "*Cyrtoceras tesselatum?* de Kon. (An. Foss., p. 529; Pl. xlvii, 5)" Winchell stated that "A mere impression, undistinguishable from the above, seems to possess sufficient interest to deserve mention. It is one inch long and four-tenths broad, and could not have been made by any body which has heretofore come under my observation from the Marshall sandstone."

Remarks.—This specimen is not in the collections available and is doubtless lost. It is impossible to determine the affinities of Winchell's specimen from his brief remarks in regard to it, but *Cyrtoceras tessellatum* de Koninck of the Viséan of Belgium is most probably referable to *Chouteauoceras*. S. A. Miller (1877, p. 167), who may possibly have seen Winchell's specimen, stated unqualifiedly that de Koninck's species is "Not American."

Occurrence.—Marshall sandstone at some unspecified locality in Michigan.

Chouteauoceras? spp.

(Pl. II, Fig. 4)

The collections we are studying contain three specimens of uncertain affinities that we are doubtfully associating with *Chouteauoceras*. The first specimen, which is illustrated (Pl. II, Fig. 4), is small and probably immature. Its adapical part represents a camera of the phragmocone, but the

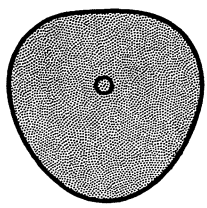

FIG. 3. *Chouteauoceras?* sp.

Cross section of the small specimen (No. 30423) from the Marshall sandstone at Marshall, Michigan, that is represented by Figure 4 on Plate II, × 5.

adoral part is covered by a replacement of the test. The coiled conch is gradually expanded orad. The cross section is reminiscent of that of the genotype of *Chouteauoceras,* for it is ovate, flattened ventrally, and narrowly rounded dorsally, and attains its maximum width distinctly ventrad of the center (cf. Text Figs. 1B and 3). The surface of the test bears

prominent longitudinal lirae and less pronounced transverse lirae. The transverse lirae, which probably represent growth lines, are more numerous and more closely spaced than the longitudinal, and they form broad deep rounded ventral sinuses. On the internal mold there is a subdued replica of the test ornamentation. The sutures are essentially straight and directly transverse and the septa are only moderately convex apicad. The camera which forms the adapical part of the figured specimen is about 1½ mm. long and 6 mm. wide. The siphuncle is small and subcentral but is distinctly nearer to the venter and to the dorsum.

The second of the three specimens is very similar in size and general shape to the first; but it is a little more rapidly expanded orad, the longitudinal lirae on its test are somewhat coarser and more widely spaced, and the growth lines are essentially straight and directly transverse. This specimen is completely septate and represents four camerae of the phragmocone. It may well prove to be the adolescent portion of the conch of some species such as *Vestinautilus altidorsalis* (Winchell).

The third specimen is a rather poorly preserved internal mold of part of two whorls of a coiled conch that was well over 10 cm. in diameter. The volutions do not appear to have been quite in contact. The cross section seems to have been subcircular. No trace of ornamentation can be discerned on the internal mold. The body chamber is at least a third of a volution in length. The adoral camera, the only one recognizable, is about 6 mm. long. The sutures appear to be essentially straight and directly transverse. Although the condition of this specimen leaves much to be desired, the general configuration indicates that it may belong in the genus *Chouteauoceras*.

Occurrence.—Marshall sandstone at Marshall, Calhoun County, Michigan (2 small specimens); Coldwater shale south of Coldwater, Branch County, Michigan (1 large specimen).

Specimens.—No. 30423 (Pl. II, Fig. 4; Text Fig. 3); also, not figured, No. 30424 (Marshall) and No. 30425 (Coldwater).

Genus *Rineceras* Hyatt

When Hyatt (1893, pp. 425–26) established the genus *Rineceras,* he based it on several species, including *Gyroceras propinquum* de Koninck of the Lower Carboniferous of Belgium, which Foord (1900, p. 102) subsequently selected as the type. In 1894 Hyatt (p. 543, Pl. 9 legend, Figs. 20, 21) used this generic name as he had originally spelled it, but in 1900 (p. 523), without explanation, he changed to *Rhineceras.* In no instance did he give the etymology. Except in the last of these publications, the name is used more than once and presumably, therefore, does not contain

a typographical error. Furthermore, in the 1900 report the derived family name also is spelled with an "h." Although Foord (1903, p. 216) apparently accepted the emended spelling, Schmidt (1951) and others have not. We believe that the name should be retained in its original form.

The first description and illustrations of the type species of *Rineceras* were published by de Koninck (1878, p. 12, Pl. 33, Figs. 5, 5*a*). They indicate that its most distinctive characters are: (1) a conch which is so loosely coiled that at least its first two volutions are not in contact and the cross section of which is unequally biconvex (see Text Fig. 1C); (2) a test that bears longitudinal ridges which may be spinose and which are expressed on the internal mold; and (3) short camerae, slightly sinuous sutures, and a siphuncle that is small, subcentral, and presumably orthochoanitic.

The figured syntype of this species consists of only two volutions and there seems to be no good reason to believe that it represents the mature portion of the conch. In general physiognomy it is quite reminiscent of the inner whorls of a late mature individual from the Chouteau limestone of Missouri which Miller, Downs, and Youngquist (1949, p. 603, Pl. 97, Figs. 6, 7) illustrated and described as *Triboloceras digonum pentagonum* Miller and Furnish.

If, as we are inclined to believe, this Chouteau specimen and similar forms are congeneric with the type species of *Rineceras,* the genus may be diagnosed as follows: Conch serpenticonic; volutions very loosely coiled during adolescence, making contact (but not becoming deeply impressed) with maturity, and becoming evolute during late maturity. Cross section, though subcircular during early adolescence, is typically a modified gibbous figure at maturity, but in some cases the ventral and/or dorsal zones are flattened or even slightly concave. Surface of test bears a number of prominent longitudinal ridges which are expressed on the internal mold; the ridges, which may be spinose, are present throughout ontogenetic development. Camerae are short; sutures are slightly sinuous, being modified by the shape of the conch. Siphuncle is small, subcentral, and orthochoanitic.

As we interpret *Rineceras,* it includes the majority of the forms previously referred to *Triboloceras;* for example, all of those from the many widely separated localities in the United States and Mexico that have been placed in the several varieties of *T. digonum* (Meek and Worthen)—see Miller and Furnish, 1939; Miller and Youngquist, 1947; Miller, Downs, and Youngquist, 1949; and Miller and Collinson, 1952. But it does not include *T. kentuckiense* Miller, Downs, and Youngquist nor *Gyro-*

ceras serratum de Koninck, the genotype of *Triboloceras*. Several representatives of *Rineceras* from the Lower Mississippian of Michigan are described in the present report. In addition to the genotype, at least the following Eurasian nautiloids belong to *Rineceras:* (1) possibly *Nautilus luidii Fleming* (Turner, 1953, p. 690) of the Lower Carboniferous limestone of England; (2) *Gyroceras consobrinum* and *G. intermedium,* both of de Koninck and both from the Lower Carboniferous of Belgium; (3) probably *Nautilus Meyerianus* de Koninck and *N. multicarinatus* de Koninck (1878, pp. 139–40, Pl. 29, Figs. 4*a*–4*c*) [not *N. multicarinatus* Sowerby], both from the Lower Carboniferous of Belgium; (4) probably *Nautilus rhenanus* Holzapfel of the Lower Carboniferous of Germany; (5) *Triboloceras patteiskyi* Schmidt of the Viséan of Germany and Czechoslovakia; and (6) *Nautilus canaliculatus* and *N. carinatus,* both of Eichwald and both from the Lower Carboniferous of northwestern European Soviet Russia.

Edaphoceras Hyatt and *Nautiloceras* d'Orbigny are somewhat similar to *Rineceras*. The type species of *Edaphoceras, Nautilus* (*Temnocheilus*) *Niotensis* Meek and Worthen, from the Osage (Keokuk) of Illinois, has the surface at least of the internal mold without any longitudinal ridges. Insofar as we have been able to ascertain no one has designated a type species for *Nautiloceras* d'Orbigny, 1847 [fide d'Orbigny, 1850, p. 112] or 1849 [fide Neave], but probably *Cyrtocera Aigokeros* Münster (1843, pp. 56–57, Pl. 1, Figs. 7*a,* 7*b;* Pl. 2, Fig. 1) from the Tournaisian of Belgium can be taken as typical of the genus. The figured type specimen of that species appears to be the adapical part of one volution of a loosely coiled gyrocone; it most probably represents only the immature portion of the conch. It is characterized particularly by the possession of tranverse lateral ribs. Neither it nor the type species of *Edaphoceras* appears to be more than superficially similar to *Rineceras*.

Rineceras meekianum (Winchell)

(Pl. III, Figs. 4–5)

Nautilus (*Trematodiscus*) *Meekianus* Winchell, 1862*a,* Amer. Journ. Sci. and Arts, 2d Ser., Vol. 33, p. 360.

Trematodiscus meekanus Miller, 1877, The American Palaeozoic fossils . . . , p. 179.

Trematoceras meekianus Weller, 1898, U.S. Geol. Surv. Bull. 153, p. 634.

Winchell based this species on a single fragment which represents only a lateral "half" of a third of one volution of a phragmocone that was at least 3 cm. in diameter (Pl. III, Figs. 4–5). We now have available for study this holotype and six topotypes, all of which are fragments of internal molds and some of which bear remnants of the test.

From this material, especially the holotype, it can be said that the coiled conch is only very slightly involute and that it is gradually expanded orad. The holotype is the largest of the available specimens. Its cross section, which is elucidated by Text Figure 4B, is more or less semicircular, for the conch is flattened ventrally and rounded laterally and dorsally, except for the slight impressed zone. The ventrolateral zones are rounded, and the dorsolateral ones are very broadly so. The dorsum is much narrower than the venter, and the broad median zone of the venter is distinctly depressed but at the same time very slightly convex externally.

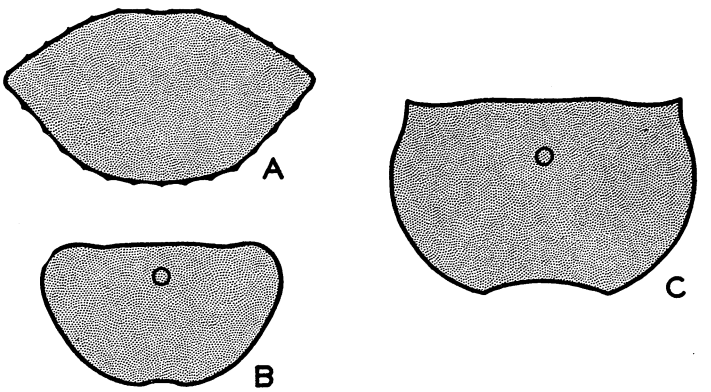

FIG. 4. Cross sections of the holotypes of three species of *Rineceras*.

A—*R. ohioense* Miller and Garner, sp. nov., (No. 27046)) of the Waverly group of Ohio, × 1.

B—*R. meekianum* (Winchell) (No. 23734) of the Marshall sandstone of Michigan, × 2.

C—*R. strigatum* (Winchell) (No. 23760) of the Marshall sandstone of Michigan, × 2.

As Winchell noted, there are coarse longitudinal ridges on the lateral zones of the holotype (an internal mold) and obscure longitudinal ridges on the venter. Several of the topotypes show that the relative prominence of the longitudinal markings on the lateral and ventral zones of the conch is largely a matter of preservation. On some specimens which retain small portions of the test, it may be seen that the external surface bears numerous fine transverse lirae (as well as longitudinal ones) that are slightly sinuous.

The camerae are moderate in length, and the sutures form broad rounded ventral, lateral, and probably dorsal lobes, of which the ventral ones are deep. One of the topotypes bears a structure that may represent the siphuncle; it is small and subcentral but closer to the venter than the dorsum.

Remarks.—In general physiognomy, this form resembles typical *Rineceras digonum* (Meek and Worthen). It appears to be especially similar to specimens of that species from the Rockford limestone of Indiana and the Northview shale of Missouri. In contrast to *R. digonum,* however, its dorsum is distinctly narrower, its ventral side is more nearly flat, and the longtiudinal markings on the conch are less pronounced.

Occurrence.—Marshall sandstone at Marshall, Calhoun County, Michigan.

Types.—Holotype No. 23734 (Pl. III, Figs. 4–5; Text Fig. 4B); also, not figured, two homeotypes No. 23736, three topotypes No. 23763, and one topotype No. 30426.

Rineceras ohioense Miller and Garner, sp. nov.

(Pl. I, Figs. 6–7)

This species is based on a single specimen which is an internal mold of the adapical portion of a body chamber and much of the adjacent camerae of the phragmocone. Although it represents only a small part of the conch, the holotype is rather well preserved in brown fine-grained limonitic micaceous sandstone and appears to be essentially free from distortion. Its maximum over-all length, width, and height, measure about 34 mm., 42 mm., and 24 mm., respectively. The conch is sublenticular in cross section, distinctly flattened ventrally, almost subangular laterally, and somewhat more highly arched dorsally than ventrally (Text Fig. 4A).

The surface of the internal mold bears low but rather prominent widely spaced longitudinal ridges which are not nearly as broad as the flat interspaces. There are very distinct traces of numerous growth lines which are essentially straight and directly transverse on the dorsal side of the holotype but which form deep rather narrow ventral sinuses. The holotype also bears a single transverse constriction which is parallel to the growth lines. The only suture that is preserved is directly transverse on the ventral side but forms a low broad rounded dorsal saddle. No trace of the siphuncle can be discerned on the sole known representative of this species.

Remarks.—This form is similar to *Rineceras digonum dyeri* (Miller and Furnish) of the Chouteau limestone of northeastern Missouri. But in that variety the conch is more strongly depressed, it is not flattened ventrally, and the longitudinal ridges are finer and more numerous.

Occurrence.—Waverly group (probably Cuyahoga formation) at or near Richfield, Summit County, Ohio.

Holotype.—No. 27046 (Pl. I, Figs. 6–7; Text Fig. 4A).

Rineceras strigatum (Winchell)

(Pl. II, Figs. 8–9)

Nautilus (*Trematodiscus*) *strigatus* Winchell, 1862*b*, Phila. Acad. Nat. Sci., Proc., 1862, pp. 428–29.

Trematodiscus strigatus Miller, 1877, The American Palaeozoic fossils . . . , p. 179.

Trematoceras strigatus Weller, 1898, U.S. Geol. Surv. Bull. 153, p. 634.

The original description of this species appears to have been based on two specimens. Since the smaller can no longer be recognized in the original collections, the larger of the two is designated the holotype (Pl. II, Figs. 8–9). This type is a fragment which elucidates the nature of the lateral and the ventral portions of part of one whorl of a coiled conch that is estimated to have been at least 4 cm. in diameter. The cross section can be reconstructed, see Text Figure 4C. Measurements more nearly precise than those that can readily be secured from our illustrations would be of little significance.

Winchell noted that the surface markings of the test consist primarily of prominent longitudinal lirae and relatively fine transverse lirae. On the lateral zones of the conch, the longitudinal are particularly prominent and few; and the relatively broad interspaces are concave and each bears several very fine longitudinal lirae. In the same area the transverse lirae are sharply defined and are somewhat sinuous; they form broad shallow rounded lateral sinuses. On the flat ventral side of the conch, the lateral zones (each about a fourth of the over-all width) bear both longitudinal and transverse lirae, and there are suggestions of two or three fine longitudinal lirae in the flat interspaces between the coarse longitudinal lirae. The coarse longitudinal lirae become progressively closer together and less prominent mediad and then end abruptly, so that the median half of the ventral side is devoid of them. But the transverse lirae (growth lines) are continuous across the ventral side and form deep rather narrowly rounded ventral sinuses. Since no trace of the septa, the sutures, or the siphuncle, can be discerned on the holotype, it presumably represents part of the body chamber.

According to Winchell the 'young shell [is] less angular in transverse section." We have not been able to verify this statement, but there seems to be no good reason to doubt it.

Remarks.—In all available particulars, this form is typical of *Rineceras*, as we interpret that genus, but it is not particularly close to any species with which we are familiar. Its most distinctive characteristic is the external markings of its test, particularly the presence on the ventral side of the conch of a median zone that does not bear longitudinal lirae. In

addition to the described specimen, the collections under consideration contain two small fragments that are homeotypes. Their general physiognomy and the details of the surface markings of their tests indicate that they are conspecific with the holotype. They do not reveal any characters that add materially to the existing knowledge of the species.

Occurrence.—Marshall sandstone at Marshall, Calhoun County, Michigan.

Types.—Holotype No. 23760 (Pl. II, Figs. 8–9; Text Fig. 4C); also, not figured, two homeotypes No. 23761.

Rineceras? striatulum (Winchell)

Nautilus (*Trematodiscus*) *striatulus* Winchell, 1862*a*, Amer. Journ. Sci. and Arts, 2d Ser., Vol. 33, pp. 359–60.

Trematodiscus striatulus Miller, 1877, The American Palaeozoic fossils . . . , p. 179.

Trematoceras striatulus Weller, 1898, U.S. Geol. Surv. Bull. 153, p. 634.

All the available data in regard to this species are included in Winchell's description of it, which reads as follows:

Shell small, rapidly enlarging, whorls not impressed, flattened on the dorsum [venter] on each side of the peripheral line, and thence rounded regularly into the umbilical expanse; transverse section somewhat elliptic, with the major axis corresponding to the transverse diameter of the shell. Septa slightly sinuous, one broad shallow sinus extending across the side and another across the dorsum. Surface finely and elegantly fluted longitudinally.

The largest fragment of this species is about half a volution, wholly septate, and about 1.18 [inches] (100) across; dorso-ventral diameter at larger end .41 [inches] (34); at smaller end .34 [inches] (29); transverse diameter at smaller end .38 [inches] (32); interseptal space on the dorsum .16 [inches] (14); distance of striae .025 [inches], giving 4 in one-tenth of an inch.

Locality. Marshall.

The above species agrees with Hall's brief description of *Gyroceras gracile* (13th Rep. N.Y. Reg., p. 105), except in the abrupt undulation of the septa upon the dorsum. Though the position of the siphon is not satisfactorily ascertained, there are some indications that it is excentric though not marginal. The striately fluted surface recalls some species of *Gyroceras* figured by de Koninck.

Remarks.—The paleontological collections at the University of Michigan contain a specimen (Pl. IV, Figs. 1, 2; and Text Fig. 9A) which is labeled as being the holotype of this species. As is readily apparent from the illustrations, this specimen is not one of the syntypes upon which Winchell based his species, nor is it conspecific with them. After a careful review of all of Winchell's publications, we are convinced that at no time did he publish a description of this "holotype," for his descriptions are remarkably accurate and establish clearly that he was a thorough competent observer and recorder. We feel sure that we do not have the original

type specimen of *Nautilus* (*Trematodiscus*) *striatulus* and we are, furthermore, uncertain in regard to its affinities. Since the species was based on specimens from a locality from which we have a wealth of material, it seems likely that the types, which presumably are no longer extant, were conspecific with one of the forms in our collections. The specific name may well prove to be a synonym of *R. meekianum* (Winchell), which was established in the same publication and was based on specimens from the same locality.

Occurrence.—Marshall sandstone at Marshall, Calhoun County, Michigan.

Genus *Vestinautilus* Ryckholt

There has been considerable difference of opinion in regard to this genus, which was proposed by Ryckholt in 1852. It now seems clear that Hyatt (1884, p. 295) established as the genotype, *Nautilus Koninckii* d'Orbigny (1847, Pl. 95, Figs. 1–6) of the Tournaisian of Belgium. This species was well described and illustrated by de Koninck (1878, pp. 137–39, Pl. 30, Figs. 1*a*–5), who appears to have allowed it a considerable amount of latitude.

The published data in regard to the genotype and related European forms and a study of the American specimens now available lead to the following diagnosis: Conch serpenticonic and volutions in contact except during very early and very late ontogenetic stages. Umbilicus perforate and large, as whorls not deeply impressed dorsally. Cross section variable but typically semicircular during late adolescence (being flattened ventrally), though sublenticular at full maturity (see Text Fig. 1E). Test with longitudinal ridges, most of which become obsolete at maturity. Camerae short; sutures sinuous, tending to form ventral and, in some cases, dorsal and lateral lobes. Siphuncle small, subcentral, and orthochoanitic.

Hyatt (1893, p. 418; 1894, p. 540) thought that typical *Vestinautilus* evolved from his genus *Triboloceras* and that these two genera are gradational. The type species of *Triboloceras, Gyroceras serratum* de Koninck, known only from small fragments representing little more than the innermost volution of a conch, is indeed reminiscent of the corresponding volution of the type species of *Vestinautilus*. Previously, these two genotypes have been separated generically because it was believed that in *G. serratum* the conch (1) is more loosely coiled, (2) bears more longitudinal ridges, and (3) consists of whorls that are subcircular rather than sublenticular in cross section (see Text Fig. 1A). But every one of these characters is revealed by the genotype of *Vestinautilus,* at a comparable stage of onto-

genetic development, and de Koninck's figures of the type species of *Triboloceras* indicate clearly that in the adapical part of the second volution of the conch the whorls make contact just as they do in the genotype of *Vestinautilus* (cf. de Koninck, 1878, Pl. 30, Fig. 2C; 1880, Pl. 32, Fig. 5). Furthermore, the original type specimens of the genotypes of *Triboloceras* and *Vestinautilus* came from the same horizon and locality. The types of these two genera are so closely similar that they should not be separated generically, and *Triboloceras* should be suppressed in favor of *Vestinautilus,* which has priority.

Vestinautilus is very close to *Rineceras* Hyatt, which is probably a little more primitive, for the earlier volutions of typical representatives of the latter are so loosely coiled that they are not in contact and the longitudinal ridges tend to be retained at maturity. The type species of *Rineceras* Hyatt attains a lenticular cross section during relatively early ontogenetic development. *Stroboceras* and *Discitoceras,* both of Hyatt, are also related, but in neither is the conch sublenticular in cross section. The mature parts of *Edaphoceras* Hyatt and *Knightoceras* Miller and Owen of the Osage and the Pennsylvanian-Permian, respectively, are superficially similar to those of *Vestinautilus,* being lenticular in cross section, but in those genera there are no prominent longitudinal ridges.

Representatives of *Vestinautilus* occur in both the Tournaisian and the Viséan of Europe. In North America they are known for certain from only the Coldwater and Marshall formations of Michigan; but the Mississippian system of the western hemisphere has yielded very few nautiloids, and the rather poorly known *Nautilus ellipticus* Strong of the Point au Gres limestone at Grand Rapids, Michigan, may belong in this genus—see Ehlers and Humphrey, 1944, pp. 126–27, Pl. 2, Figs. 5–6. Kruglov (1928, pp. 84–87, 179, 190) has doubtfully referred to *Vestinautilus* a specimen from the Lower Permian of the Ural region but its affinities seem to us to be very uncertain.

Vestinautilus altidorsalis (Winchell)

(Pl. I, Figs. 1–4; Pl. II, Figs. 5–7; Pl. III, Fig. 6; Pl. IV, Figs. 3–4)

Nautilus (*Trematodiscus*) *altidorsalis* Winchell, 1862*b,* Phila. Acad. Nat. Sci., Proc., 1862, p. 429.

Trematodiscus altidorsalis Miller, 1877, The American Palaeozoic fossils . . . , p. 179.

Trematoceras altidorsalis Weller, 1898, U.S. Geol. Surv. Bull. 153, p. 634.

From the original description of this species it seems clear that Winchell based it on a single specimen. We have studied his specimen and nine more that we believe to be conspecific. Most of them are fragments and

some are considerably distorted. The holotype, which appears to have been distorted during preservation, is an internal mold of part of a single volution and it represents considerably less than half the complete circumference of a whorl (Pl. II, Fig. 5). Winchell's account of this specimen leads use to believe that he did not orient it correctly and did not recognize that it was distorted. His description of the species differs materially from ours, which is based on several specimens, some of which are larger and much more nearly complete than the holotype.

At full maturity the coiled conch consists of four or more volutions and attains an over-all maximum measurement of at least 11 cm. The largest specimen that we are referring to the species is represented by Figures 3 and 4 on Plate IV. Near its adoral end the height and corresponding width of conch of this large individual are about 4 cm. and 6 cm., respectively. The impressed zone in this and all other representatives of

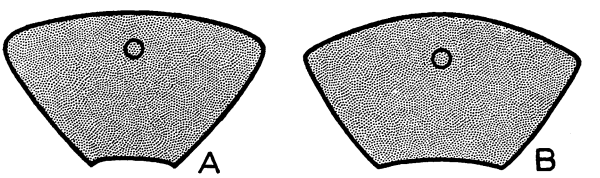

FIG. 5. *Vestinautilus altidorsalis* (Winchell).

Cross sections of the conch during early (A) and typical (B) maturity, × 2 and × 1, respectively. (A) is based on the specimen portrayed by Figures 1 and 2 on Plate I and (B) on that illustrated by Figures 3 and 4 on the same plate.

the species is very shallow. The shape of the cross section during adolescence and at maturity is elucidated by Text Figures 5A and 5B, respectively. The umbilical walls are broad and the umbilicus is very large, open, and perforate. The perforation is very broadly oval in shape and its "diameter" measures some 8 mm. The test is thick, and in late mature individuals it measures as much as 2½ mm. along the venter. Certain specimens, for example that illustrated by Figures 3 and 4 on Plate I, retain both the internal and the external markings of the test, as well as expressions of these markings on one another, on intermediate layers, and on the internal mold.

On the early volutions of the conch, the external surface of the test bears coarse longitudinal lirae and fine transverse ones. The transverse lirae form deep narrowly rounded ventral sinuses, but are essentially straight and directly transverse on the umbilical walls. As full maturity is

attained the longitudinal markings become relatively faint in the median portion of the venter and just outside the umbilical seams and eventually become obsolete or nearly so. Nevertheless, small parts of the test that adhere to the dorsolateral zones of one of the large unfigured specimens show that at least in these areas there are fine longitudinal and transverse lirae and that the former do not cross the latter, which are slightly but distinctly coarser.

The inner surface of the test appears to have been papillose, for well-preserved internal molds bear many small pits (see Pl. II, Fig. 7). These pits are asymmetrical, as the adoral side is steeper than the adapical. For the most part the pits are rounded, but in the vicinity of the ventrolateral shoulders of the conch they become progressively very much elongated in an oral-aboral direction, so that on those shoulders the surface of the internal mold is irregularly striate. In some specimens this striate pattern continues across the umbilical walls, though in most the markings on these walls resemble those on the venter. In the large specimen represented by Figures 3 and 4 on Plate IV and in another large but unfigured individual, the arrangement of the pits coincides with the sinuous increments of growth. These growth lines form a deep rounded ventral sinus and on either side of it a similar salient and an asymmetrically rounded lateral sinus which extends to a deep very broad medianly flattened dorsal salient. Expressions of both the external and the internal markings of the test are present on intermediate layers of it.

The camerae are moderately short and in the fully mature portion of the phragmocone there are some 23 to a whorl. Each structure forms a prominent rounded medianly deepened ventral lobe and on each side of it a narrowly rounded lateral saddle which centers on the ventrolateral shoulder of the conch, a shallow rounded lobe on the umbilical wall, and a low narrowly rounded saddle which centers on the umbilical seam and which extends to a moderately shallow dorsal lobe. In the dorsal lobe there is a small angular median lobe, that is, an annular lobe. The siphuncle is small and subcentral, being distinctly nearer the venter than the dorsum.

Remarks.—Although the specimens that we are placing in *Vestinautilus altidorsalis* show considerable variation, a careful study has convinced us that all are conspecific and that the differences are more apparent than real and largely a matter of the growth stage represented, preservation, etc. It should be emphasized that the markings of the test vary from one layer to another and also from adolescence to late maturity. The roughening of the inner surface of the test increased its area and presumably facilitated the attachment of the soft parts of the animal to the shell walls.

This species is the only definite representative of the genus *Vestinautilus* known from North America. Superficially, it is reminiscent of some of the varieties of *Rineceras digonum* (Meek and Worthen), which is widespread in the North American Kinderhook; but in that species the early volutions of the conch are loosely coiled, and the prominent longitudinal markings of the test are retained throughout ontogenetic development. The form under consideration seems to be much closer to the genotype of *Vestinaultilus* and especially to *V. cariniferus triplicatus* Foord of the Lower Carboniferous of Ireland. In regard to the latter species, Foord (1900, p. 113) stated: "The body chamber, where it is bare of the test, is very distinctly marked on the peripheral part by the 'Runzelschicht' . . . which consists, as usual, of minute pits, lineally arranged, the lines conforming exactly with the contour of the aperture." Similar markings are illustrated by Tzwetaev (1898, Pl. 2, Fig. 5) on a representative of *Vestinautilus, V. hesperis* (Eichwald), from the Lower Carboniferous of central European Soviet Russia.

Occurrence.—Coldwater shale near Coldwater, Branch County, Michigan (5 specimens); Marshall sandstone at Marshall, Calhoun County, of the same state (5 specimens, including the holotype).

Types.—Holotype No. 27035 (Pl. II, Fig. 5); hypotypes Nos. 30427 (Pl. III, Fig. 6), 30428 (Pl. I, Figs. 1–2), 30429 (Pl. I, Figs. 3–4; Pl. II, Fig. 7), 30430 (Pl. II, Fig. 6), 30431 (Pl. IV, Figs. 3–4); also, not figured, hypotypes Nos. 3631, 30433 (Coldwater shale, collected by Winchell) and two specimens No. 30434 (Marshall, collected by Garner).

Genus *Discitoceras* Hyatt

There has been difference of opinion as to just which species should be regarded as the type of *Discitoceras* Hyatt, which was established to replace *Discites* M'Coy, as that generic name was preoccupied. In the original publication of his genus Hyatt (1884, p. 292) designated as the type *Nautilus costellatus* M'Coy of the Lower Carboniferous of Ireland, and "this species shall be accepted as type, regardless of any other considerations."

The published data in regard to M'Coy's species indicate that its most distinctive characters are a subdiscoidal coiled conch in which the volutions are in contact but not deeply impressed dorsally, are rounded ventrally and laterally, and are about as high as wide with their maximum width attained at the rather abrupt umbilical shoulders (see Text Fig. 1D). The umbilicus is large and a perforation, if present, is small. The test bears prominent

longitudinal ridges. The sutures appear to be nearly straight, and the siphuncle is small and subcentral.

To this genus should be referred such species as *Thrincoceras Hyatti* and *Gyroceras Hibernicum,* both of Foord and both from the Lower Carboniferous of Ireland, and *Nautilus rhenanus* Holzapfel from the Viséan of Germany. The genotype of *Thrincoceras* Hyatt, *T. depressum* Hyatt, is at least superficially similar to typical *Discitoceras*. We have not been able to locate and restudy the figured type specimen of *T. depressum* and its source is vague. All that is known about its derivation is that it came from Bullitt County, Kentucky, presumably from the Carboniferous. Quite possibly these two generic names should be regarded as synonyms, with *Discitoceras* having priority.

Genus *Stroboceras* Hyatt

When he proposed this genus, Hyatt (1884, p. 291) referred to it by name only the genotype, *Gyroceras Hartii* Dawson (1868, p. 311) of the Upper Mississippian Windsor limestone of Nova Scotia. Through the courtesy of Professor Thomas H. Clark of McGill University, we have been able to study the single specimen on which this species was based (see Pl. I, Fig. 5; and Text Figs. 1H and 6A). It consists of two contiguous pieces of an internal mold and a small part of the external mold of the same portion of the conch. When the species was established, only the larger piece of the internal mold was illustrated.

The holotype is slightly crushed but moderately well preserved, and it retains much of the apertural margins. It shows that the conch is coiled and is very slightly involute; though at full maturity the adoral portion of the body chamber straightens and loses contact with the preceding whorl but retains, however, the slight impressed zone. The internal mold is almost as high as wide and bears a number of prominent longitudinal ridges and grooves. It retains traces of strongly sinuous growth lines, which parallel the apertural margins. Each growth line forms a deep rounded more or less U-shaped ventral sinus and on each side of it a similar but asymmetrical ventrolateral salient and a somewhat shallower and more narrowly rounded dorsolateral sinus which extends to a low broad rounded dorsal salient. Slight undulations in the growth lines result from the longitudinal ridges and grooves of the conch. The ventrolateral lappets of the apertural margins are not appreciably converged, though they coincide in position with concave zones of the conch. A fragment of test which adheres to the external mold indicates that the outer surface

bears fine longitudinal and coarse transverse lirae. The body chamber is approximately three-fifths of a volution in length.

The camerae are moderately short and the adoral one of the holotype is especially so, suggesting that this particular individual had attained full maturity. The sutures form broad shallow rounded lateral lobes that are bounded by small but fairly prominent subangular saddles which result chiefly from the presence of dorsolateral and ventrolateral longitudinal ridges. The siphuncle is small and is located about halfway between the center and the venter.

The holotype came from the Upper Mississippian Windsor limestone of Brookfield, Nova Scotia. Specimens from the same formation at other localities in that province have been referred to this species by Dawson (1883, p. 411) and Bell (1929, pp. 182–83, Pl. 33, Figs. 3–3*b*; Pl. 34, Figs. 1, 2). Dawson did not illustrate or describe his additional material, so we cannot express an opinion as to its affinities. We have not studied Bell's specimens, but the published data in regard to them indicate that they are almost certainly referable to *S. hartii.*

The most distinctive characters of the genus *Stroboceras* are: (1) A coiled conch in which, except in the adoral part of fully mature individuals, the volutions are in contact but are only slightly impressed dorsally. (2) Whorls which are never greatly depressed but may be considerably compressed (see Text Fig. 6); they are flattened ventrally and their lateral zones are slightly but distinctly converged ventrad. (3) Prominent longitudinal ridges and grooves on the conch; two of the grooves coincide in position with the lateral lappets of the apertural margins. To these perhaps should be added the presence of slightly sinuous sutures and a small siphuncle, ventrad of the center of the conch.

Forms having all or most of these characters have been described under several other generic appellations, for example, *Coelonautilus*. That generic name was first used in print by Foord and Crick (1889, pp. 494–98), who stated that it was "proposed by one" of them "in substitution for *Trematodiscus,* Meek and Worthen," which was preoccupied. Two years later Foord (1891, p. 105) made it clear that it was he who had proposed the name; he stated that the type is *Nautilus stygialis* de Koninck of the Namurian of Belgium and possibly England and gave a footnote reference to "p. 547, pl. xlv. ff. 11, *a, b*" of de Koninck's well-known 1842–1844 volume. When they established *Trematodiscus,* Meek and Worthen (1861, pp. 147–48) cited *Nautilus stygialis* as a representative; later Meek (1876, p. 491) listed it as the typical or type species. Since the species was indirectly included under the substitute name *Coelonautilus,* when that

was originally published, it seems clear that we must regard de Koninck's species *N. stygialis* as the type of that genus. This form resembles the genotype of *Stroboceras* so closely (cf. Text Figs. 6A and 6B) that the two should be regarded as congeneric, though it is possible that at full maturity the conch of *N. stygialis* does not become evolute. Therefore,

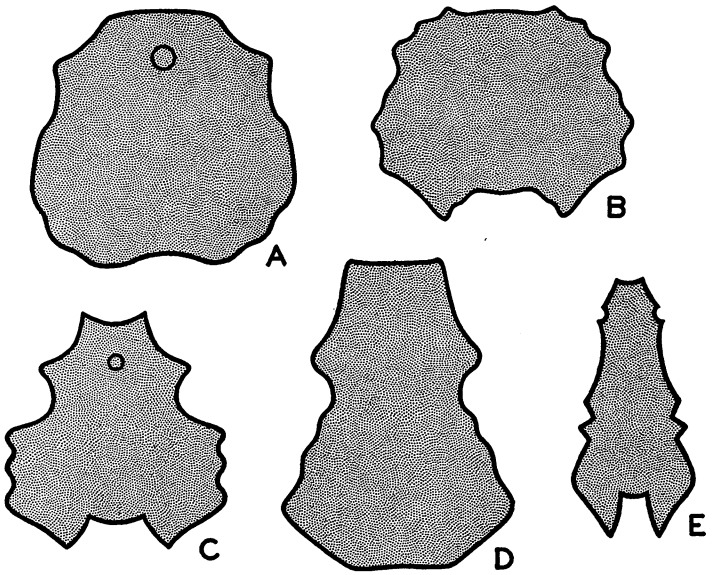

FIG. 6. Cross sections of five representatives of *Stroboceras,* illustrating variations within the genus.

A—Mid-part of holotype of *Stroboceras hartii* (Dawson), from Upper Mississippian Windsor limestone of Nova Scotia, × 5.

B—Figured syntype of *Stroboceras stygiale* (de Koninck), from Namurian of Belgium, × 1. Adapted from de Koninck.

C—Specimen identified by Miller and Furnish (1940, p. 359, Text Fig. 3, Pl. 45, Figs. 8, 9) as "*Discitoceras sulcatum* (Sowerby)," from Upper Mississippian of Kentucky, × 3. After Miller and Furnish.

D—Specimen identified by M'Coy (1844, p. 19, Pl. 3, 14 figs.) as "*Nautilus* (*Discites*) *sulcatus* Sowerby," from Lower Carboniferous of Ireland, × 2⅔. After M'Coy.

E—Specimen identified by Demanet (1941, p. 124) as "*Stroboceras bisulcatum* (De Koninck) non (Mac Coy)," from the Viséan of Belgium, × 1¾. Adapted from de Koninck.

we propose to suppress *Coelonautilus* as a subjective synonym of *Stroboceras,* which has priority. Furthermore, *Trematoceras* Hyatt (1884, p. 291) [not Eichwald, 1851; nor Whitfield, 1882] and *Streptodiscus* Miller (1892, p. 11) are both objective synonyms of *Coelonautilus* Foord and presumably

so is *Coelonatilus* Fredericks [Frédérix] (1915, p. 112—not pp. 40, 41, 85, Pl. 3 legend), which is merely a misprint.

Miller, Dunbar, and Condra (1933, p. 226) expressed the opinion that *Coelonautilus* should be regarded as a subjective synonym of *Vestinautilus* Ryckholt. In the type species of *Vestinautilus*, however, the conch is relatively wide, and its mature cross section is sublenticular rather than subquadrate (cf. Text Figs. 1E and 1F). Nevertheless, Ryckholt's genus is related to it and more or less intermediate forms are known.

Demanet, de Koninck, Foord, Hyatt, Kruglov, Schmidt, Weigner, Weller, and others have referred to *Stroboceras* and its synonyms a considerable number of European and American late Paleozoic species. Some of these are so poorly known that their affinities can not be determined with a reasonable degree of certainty; for example, the specimens from the Permian of the Ural region, which Kruglov (1928) doubtfully placed in *Coelonautilus* and *Stroboceras*. Restudy of the type species of *Stroboceras* has convinced us that it is congeneric with at least the following American species: *Discitoceras texanum* Miller and Youngquist from the White Pine and Barnett shales of Nevada and Texas, respectively (and possibly the Viséan of the Isle of Man); *Stroboceras* sp. of Weller (1916, p. 263, Pl. 19, Fig. 16) from the Ste. Genevieve limestone in Illinois; *Nautilus* (*Discus*) *trisulcatus* Meek and Worthen (1860, p. 470; 1866, pp. 162–63, Pl. 14, Figs. 10*a*–10*c*) of the Rockford limestone of Indiana; the form from the "Meramec" of Kentucky (Text Fig. 6C), which Miller and Furnish (1940, p. 359, Pl. 45, Figs. 8, 9) illustrated as *Discitoceras sulcatum* (Sowerby); and *Triboloceras kentuckiense* Miller, Downs, and Youngquist of the Mississippian of Kentucky.

Similar and presumably related forms from the Carboniferous of Europe are illustrated and described in Foord's well-known reports published near the turn of the last century, de Koninck's and Demanet's volumes of 1878 and 1941, respectively; and Schmidt's 1951 report. In addition, *Stroboceras* should most probably contain *Nautilus* (*Stroboceras*) *varsoviensis* Weigner from near the Lower Upper Carboniferous boundary at Gołonóg, central southern Poland, and probably the form from the same general horizon and locality which Weigner (1938, pp. 5, 50, 68, 72, Pl. 3, Fig. 4) identified as "*Coelonautilus subsulcatus* Phillips." From the published data in regard to *Coelonautilus sargaensis* Fredericks, we are unable to ascertain its generic affinities. However, inasmuch as the type specimen came from the Permian of the Ural region, there seems to be little reason to believe that it belongs in *Stroboceras* (of which we are suppressing *Coelonautilus* as a synonym).

Stroboceras intermedium Miller and Garner, sp. nov.

(Pl. I, Fig. 8; Pl. II, Figs. 1–2; Pl. IV, Fig. 5)

Six specimens from one locality in the Marshall sandstone represent a previously unrecognized species which appears to be an aberrant member of the genus *Stroboceras*. This form is reminiscent of certain of the varieties of *Rineceras digonum* (Meek and Worthen), but it seems to be somewhat intermediate between typical *Stroboceras* and typical *Rineceras*.

Four of the six types are small fragments that do not merit illustration. The better and larger of the other two (Pl. I, Fig. 8; Pl. IV, Fig. 5) is here designated the holotype. The illustrated portion of it represents much of the adapical part of the body chamber and the adoral camera of the phragmocone—portions of two adjacent camerae are imbedded in unfigured matrix. This specimen suggests that the maximum over-all measurement of

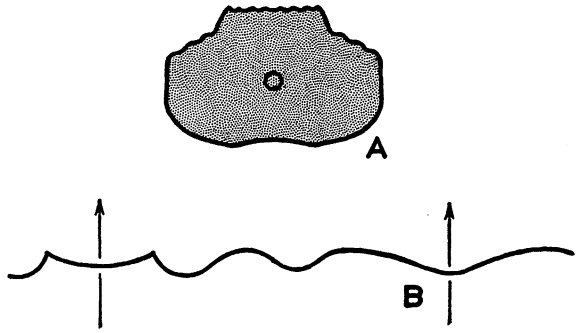

FIG. 7. *Stroboceras intermedium* Miller and Garner, sp. nov.

Diagrammatic cross section (A) and representation of a suture (B), both based on the holotype (No. 30435), × 1½ and × 2, respectively.

the coiled phragmocone was at least 5 cm. The shape of the whorl cross section is elucidated by Text Figure 7A, which also makes it clear that the dorsum is slightly but distinctly impressed. The impressed zone of the holotype is shallower than that of the relatively small figured paratype (Pl. II, Figs. 1–2) and the conch may well have been evolute at full maturity. Two of the small paratypes (fragments) indicate that the adolescent portion of the conch was more strongly depressed dorsoventrally than is the holotype.

The internal mold bears longitudinal ribs on its dorsolateral, ventrolateral, and flattened ventral zones, and there is a single rib on the lateral zone of the holotype that is free of matrix. The ribs are coarsest and most prominent on the ventrolateral zones.

In all of the types the camerae are moderate in length. The sutures are similar and are affected by the shape of the conch. The illustrations, especially Text Figure 7B, elucidate their nature much better than it can be expressed by words. The siphuncle is small, is located slightly ventrad of the center of the conch, and is composed of cylindrical segments.

Remarks.—At least superficially this species resembles *Rineceras digonum semicirculare* (Miller and Furnish), *Stroboceras trisulcatum* (Meek and Worthen), and *S. kentuckiense* (Miller, Downs, and Youngquist). It seems to be somewhat closer to the last two than to the first.

Occurrence.—Marshall sandstone at Burnt Cabin Point, Huron County, Michigan.

Types.—Holotype No. 30435 (Pl. I. Fig. 8; Pl. IV, Fig. 5), paratype No. 30436 (Pl. II, Figs. 1–2); also, not figured, four paratypes No. 30437.

Stroboceras planidorsale (Winchell)

(Pl. II, Figs. 10–11; Pl. III, Figs. 7–12)

Nautilus (*Trematodiscus*) *planidorsalis* Winchell, 1862*a*, Amer. Journ. Sci. and Arts, 2d Ser., Vol. 33, pp. 358–59.

Nautilus (*Trematodiscus*) *trigonus* Winchell, 1862*a*, Amer. Journ. Sci. and Arts, 2d Ser., Vol. 33, p. 359.

Trematodiscus planidorsalis Miller, 1877, The American Palaeozoic fossils . . . , p. 179.

Trematodiscus trigonus Miller, 1877, The American Palaeozoic fossils . . . , p. 179.

Stroboceras (*Naut.*) *trigonus* Hyatt, 1893, Texas Geol. Surv., Ann. Rept. 4, p. 412.

Stroboceras trigonus Weller, 1898, U.S. Geol. Surv. Bull. 153, p. 612.

Trematoceras planidorsalis Weller, 1898, U.S. Geol. Surv. Bull. 153, p. 634.

Although Winchell based this species on more than one specimen, his description deals almost exclusively with his "best" individual, which we here designate the holotype (Pl. III, Figs. 9–10). It is an internal mold which represents almost half a volution of a phragmocone and to which parts of the test adhere on the umbilical wall. The specimen is fairly well preserved, but especially its adapical portion has been slightly crushed dorsoventrally so as to accentuate the subangular aspect of its lateral zones (umbilical shoulders); apparently these zones are subangular during late adolescence and very early maturity but become rounded during later growth stages (cf. Text Figs. 8A–C). The maximum over-all measurement of the holotype is about 18 mm.; and near its adoral end the height of its conch measures approximately 7 mm. and the corresponding width about 10 mm. Presumably this specimen represents the early mature portion of the conch. It is subhexagonal in cross section, being flattened ventrally, subangular ventrolaterally, laterally, and dorsolaterally, and apparently somewhat impressed dorsally.

On the internal mold the flat venter bears two laterally situated longitudinal grooves. Essentially all external surfaces of the test exhibit prominent longitudinal lirae, traces of which can be discerned on the internal mold. On the dorsolateral and to a less extent on the ventrolateral zones these lirae are crossed by fine transverse lirae, which results in spinose processes at the points of juncture of the two sets. The camerae are moderate in length. The sutures are sinuous, forming rather deep narrowly rounded ventral lobes, similar ventrolateral saddles, relatively shallow broadly rounded lateral lobes, and very slight dorsolateral saddles.

The collections contain ten specimens which appear to be conspecific with the holotype just described. All are fragments, some of which repre-

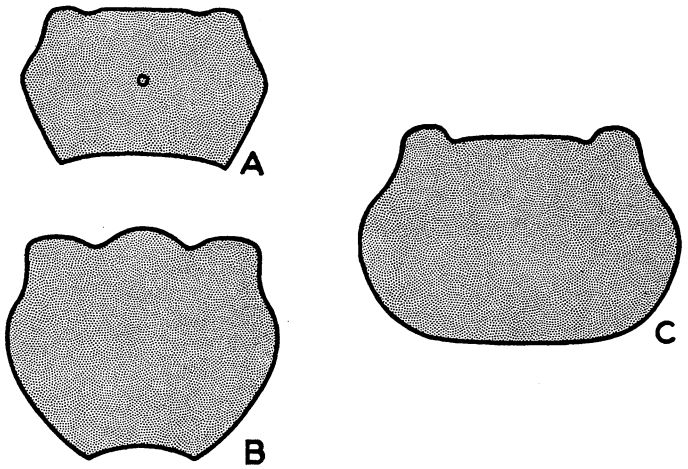

FIG. 8. *Stroboceras planidorsale* (Winchell).

Cross sections of the conch during late adolescence, early maturity, and full maturity (A-C, respectively), × 4 (A) and × 3 (B, C). The first is based on the specimen (No. 23735) portrayed by Figure 11 on Plate II, the second (No. 23732) by Figures 7 and 8 on Plate III, and the last (No. 30439) by Figures 11 and 12 on Plate III. All specimens are from the Marshall sandstone at Marshall, Michigan.

sent larger and, therefore, presumably later whorls than does the holotype. These show that at full maturity the dorsum is not appreciably impressed, the dorsolateral zones are broadly rounded, and on the venter there is a broad flat slightly depressed median zone that bears relatively coarse longitudinal lirae between each pair of which there are four or five very fine parallel lirae. Text Figure 8 elucidates the shape of the cross section of the conch during late adolescence, typical maturity, and late maturity. The

specimen portrayed by Figure 11 on Plate II shows that the siphuncle is small and subcentral, at least during late adolescence.

Remarks—Winchell apparently based his species *"Nautilus (Trematodiscus) trigonus"* on a single fragment (Pl. III, Figs. 7–8), which represents a later stage of ontogenetic development of the conch than does the holotype of *Stroboceras planidorsale* (Pl. III, Figs. 9–10), but which is conspecific with it and is from the same horizon and locality. Both of these specific names were established in the same publication (see synonymy), and we retain the one that has page precedence (and has the better type specimen). The affinities of this species with *Stroboceras* were first recognized by Hyatt. Winchell compared it with *Rineceras digonum* (Meek and Worthen), but the similarity is more apparent than real and the two species are not close enough to be placed in the same genus.

Occurrence.—Marshall sandstone at three localities in Michigan: (1) Marshall, Calhoun County [8 specimens including the holotype and the type of *"Nautilus (Trematodiscus) trigonus,"* which we are suppressing]; (2) Battle Creek, Calhoun County (1 specimen); (3) Burnt Cabin Point, Huron County (1 specimen).

Types.—Holotype No. 23733 (Pl. III, Figs. 9–10), hypotypes No. 23732 (Pl. III, Figs. 7–8), the holotype of *"Nautilus (Trematodiscus) trigonus";* No. 23735 (Pl. II, Fig. 11), collected by Winchell; No. 27041, Battle Creek, by Winchell; three, No. 27052, by Winchell; Nos. 30438 (Pl. II, Fig. 10) and 30439 (Pl. III, Figs. 11–12), collected by Garner; No. 30440, by Winchell; No. 30541, from Burnt Cabin Point.

Genus *Maccoyoceras* Miller, Dunbar, and Condra

Miller, Dunbar, and Condra (1933, pp. 50–52), in an attempt to clarify the generic appellation of the group of nautiloids typified by *Nautilus (Discites) discors* M'Coy (1844, pp. 17–18, Pl. 3, Fig. 5), established *Maccoyoceras* and designated as the genotype the species just cited. It occurs in the Lower Carboniferous of Ireland and probably Belgium, where the containing strata are upper Tournaisian or Lower Viséan. Its chief characteristics seem to be a thickly subdiscoidal coiled conch in which the volutions are unequally hexagonal in cross section (see Text Fig. 1G) and are only very slightly impressed dorsally. The umbilicus is large and open, and its shoulders are very narrowly rounded. The test bears prominent transverse lirae and also, during adolescence, longitudinal lirae; the transverse ones form rather shallow narrowly rounded lateral and ventral sinuses (with the former centering on the umbilical shoulders). The sutures are

sinuous, forming moderately shallow ventral and lateral lobes, of which at least the ventral are rather narrowly rounded. The siphuncle is small and is ventrad of the center of the conch.

This form is quite reminiscent of the Upper Carboniferous and Permian genus *Domatoceras,* in which, however, the test (but not necessarily the internal mold) commonly bears ventrolateral keels and/or nodes and in some cases dorsolateral nodes. It is difficult to differentiate between internal molds of representatives of *Domatoceras* and *Maccoyoceras,* one of which genera may well have arisen from the other.

Planetoceras Hyatt, 1893, may well be related to *Maccoyoceras,* but its type species, by original designation, is *P. retardatum* Hyatt of the Viséan of Belgium, which has never been illustrated and is very poorly known. Although Schmidt (1951, p. 24) indicates that *Nautilus globatus* (Sowerby) is the genotype, Hyatt's designation will presumably have to stand. The type species of *Mesochasmoceras* Foord, 1900, (a monotypical genus) is *Nautilus latidorsatus* M'Coy of the Viséan of Ireland, in which the conch, though similar in shape to that of *Maccoyoceras,* lacks the prominent transverse lirae. According to Foord (1900, p. 74) *Nautilus planidorsatus* Portlock of the Carboniferous of England, the type species of *Diorugoceras* Hyatt, 1893, (another monotypical genus) is a "very problematical form," and its relationship to typical *Maccoyoceras* can not be satisfactorily determined from the literature.

When he established the genus *Aphelaeceras,* Hyatt (1884, p. 293) referred to it only two species, *Nautilus difficilis* de Koninck of the Viséan of Belgium and *N. (Discites) disciformis* Meek and Worthen of the Kinderhook of Illinois. In order to anchor the genus, we hereby designate the latter as its type species. Schmidt (1951, p. 24) indicates that the genotype is *N. (Discites) mutabilis* M'Coy of the Carboniferous of Ireland, but according to the International Rules of Zoological Nomenclature, that species has to be "excluded from consideration" in determining the type of the genus because it was "not included under the generic name at the time of its original publication." In the valid genotype the conch is somewhat similar to that of typical *Maccoyoceras,* but its lateral zones are broadly rounded, nothing is known as to the nature of the surface markings of the test, and the sutures form a prominent subangular ventral lobe. In our opinion *Aphelaeceras* should include the two species referred to it by Hyatt, but not those regarded as congeneric by Hind (1911, pp. 102–3) and Yin (1933, pp. 7–12).

In addition to its type species and the congeneric form from Michigan, the genus *Maccoyoceras,* should include at least *Nautilus Leveillanus* de

Koninck and *N.* (*Discites*) *planotergatus* M'Coy, both of the Viséan of Belgium and Ireland, and possibly *Discites hibernicus* Foord and Crick of the Viséan of Ireland.

Maccoyoceras discoidale (Winchell)

(Pl. II, Fig. 3; Pl. III, Figs. 1–3; Pl. IV, Figs. 1–2)

Nautilus (*Trematodiscus*) *discoidalis* Winchell, 1862*a*, Amer. Journ. Sci. and Arts, 2d Ser., Vol. 33, pp. 360–61.

Nautilus subsulcatus? Winchell [not Phillips], 1862*a*, Amer. Journ. Sci. and Arts, 2d Ser., Vol. 33, p. 361.

Trematodiscus discoidalis Miller, 1877, The American Palaeozoic fossils . . . , p. 179.

Trematoceras discoidalis Weller, 1898, U.S. Geol. Surv. Bull. 153, p. 634.

All of the syntypes of this species are fragments, each of which represents only a small portion of the conch. The best is portrayed by Figure 1 on Plate III. These original type specimens seem to be conspecific with the topotypes we are illustrating, which are much more satisfactory study specimens.

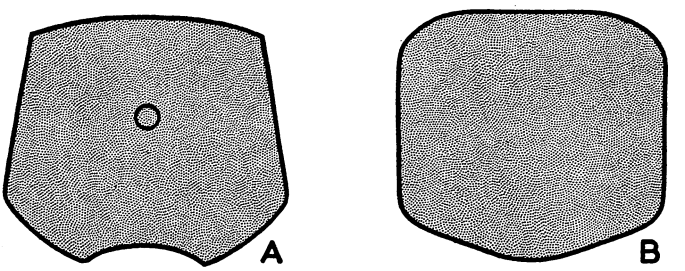

FIG. 9. *Maccoyoceras discoidale* (Winchell).

Cross sections during typical (A) and late (B) maturity, × 2 and × 1½, respectively. The first is based on the specimen (No. 23762) represented by Figures 1 and 2 on Plate IV and the second (No. 26709*a*) by Figure 2 on Plate III.

The material now available makes it clear that the species should be diagnosed about as follows: Conch coiled, subdiscoidal, and moderately large; phragmocone attaining a diameter of more than 8 cm. During adolescence whorls distinctly wider than high, subelliptical in cross section, and not impressed dorsally. At typical maturity cross section irregularly subhexagonal, but during late maturity, when the dorsal impressed zone is lost, becoming subrectangular or subpentagonal (cf. Text Figs. 9A and 9B).

Surface of test bears prominent longitudinal lirae which are fairly coarse on the umbilical walls and the lateral zones of the conch, relatively fine

on the ventral zone, and inconspicuous on the median portion of the venter. During typical maturity these lirae are expressed on the internal mold, but the largest of our specimens, which are internal molds, reveal only suggestions of them. During adolescence and early maturity, there are fine transverse growth lines on at least the umbilical walls, but not more than faint traces of such markings can be discerned on internal molds of fully mature individuals.

The camerae are moderate in length. Each mature suture forms a broad rounded ventral lobe and on either side of it a narrowly rounded ventrolateral saddle, a broad rounded somewhat asymmetrical lateral lobe, and on the umbilical wall a low saddle which presumably extends to a shallow dorsal lobe. During late maturity, with the loss of the impressed zone, the dorsal lobe most probably became obsolete. The siphuncle is small and is subcentral but is slightly closer to the venter than the dorsum.

Remarks.—This species is the only representative of the genus *Maccoyoceras* known from America. It resembles the genotype, *Maccoyoceras discors* (M'Coy), rather closely and is particularly similar to certain specimens from the Lower Carboniferous of Belgium which have been referred to that species.

A detailed study of the five specimens which Winchell (1862*a*, p. 361) referred with question to *Nautilus subsulcatus* Phillips has convinced us that they belong to *Maccoyoceras discoidale* (Winchell), the syntypes of which came from the same horizon and locality. Two of the five are portrayed by Figures 2 and 3 on Plate III.

The paleontological collections of the University of Michigan contain a fragment, No. 26763, from the Rockford limestone at Rockford, Indiana, that is labeled as having been referred to this species by Winchell. It represents only a very small part of an umbilical shoulder, and we are unable to determine even its generic affinities.

Occurrence.—Marshall sandstone at Marshall, Calhoun County, Michigan (13 specimens). In the original description of *M. discoidale*, Winchell cited Battle Creek, Michigan, as an additional locality for it, but the collections now available for study contain no specimens of this species from there, although the beds exposed at Battle Creek are part of the Marshall sandstone.

Types.—Topotypes No. 23762 (Pl. IV, Figs. 1–2); two, Nos. 26709*a* and 26709*b* (Pl. III, Figs. 2–3), collected by Winchell; syntypes, four, Nos. 27031*a* to 27031*d* (27031*a* figured, Pl. III, Fig. 1); four, not figured, No. 30542, collected by Winchell; hypotypes (and topotypes), No. 30543 (Pl. II, Fig. 3) and 30544 (not figured), collected by Garner.

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EXPLANATION OF PLATE I

PAGE

Vestinautilus altidorsalis (Winchell) 130

FIGS. 1–2. Lateral and ventral views of hyptotype, No. 30428. Coldwater shale, 1¼ miles southwest of Coldwater, Michigan. × 2.

FIGS. 3–4. Ventral and lateral views of hypotype, No. 30429. Same formation and locality as specimen in Figures 1–2. × 1.

See also Plates II–IV.

Stroboceras hartii (Dawson) 134

FIG. 5. Lateral view of the holotype. Windsor limestone at or near Brookfield, Nova Scotia. × 2.

Rineceras ohioense Miller and Garner, sp. nov. 126

FIGS. 6–7. Dorsal and ventral views of holotype, No. 27046. Waverly group at or near Richfield, Ohio. × 1.

Stroboceras intermedium Miller and Garner, sp. nov. 138

FIG. 8. Lateral view of holotype, No. 30435. Marshall sandstone at Burnt Cabin Point, Michigan. × 2. Same specimen as Figure 5, Plate IV.

See also Plate II.

PLATE I

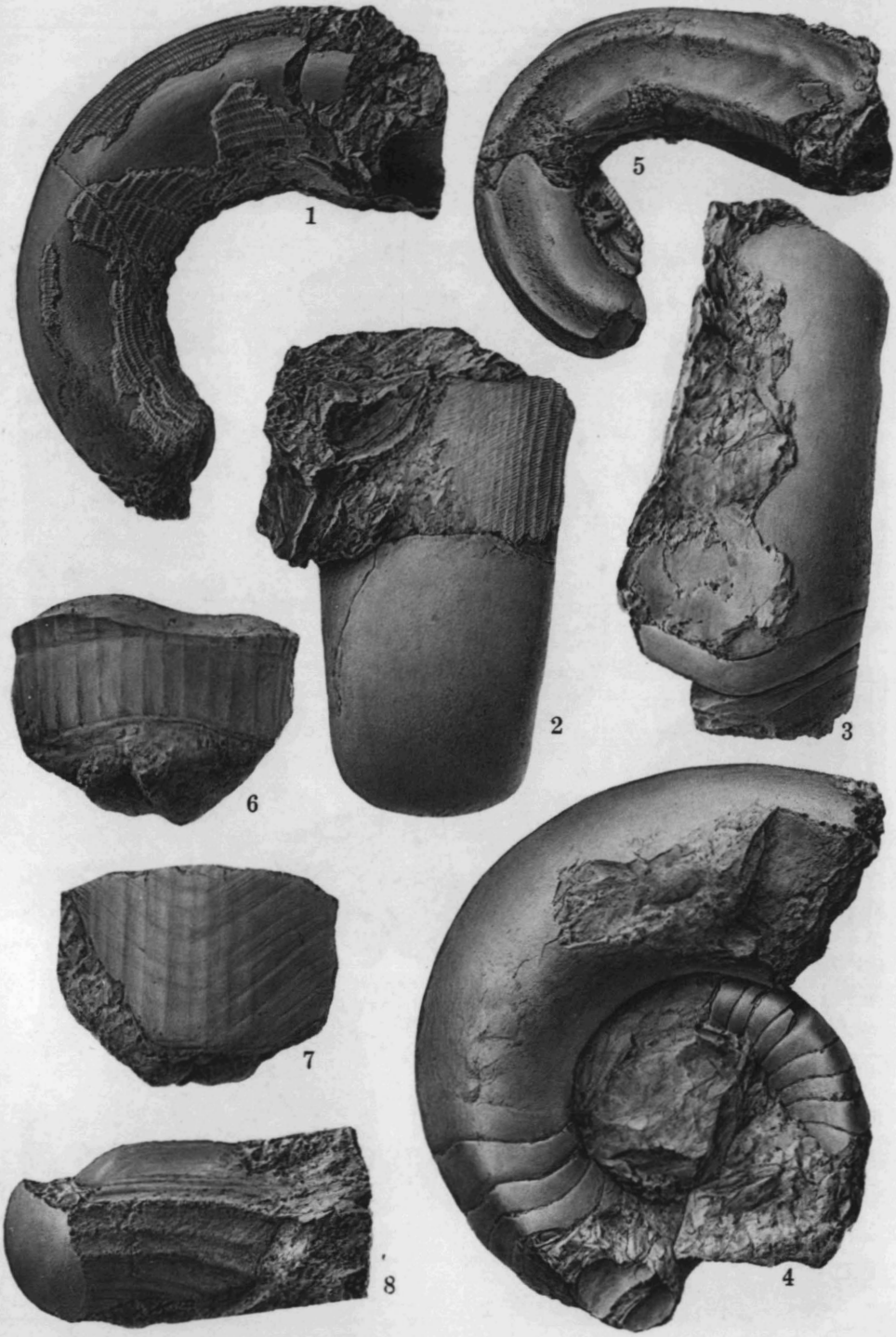
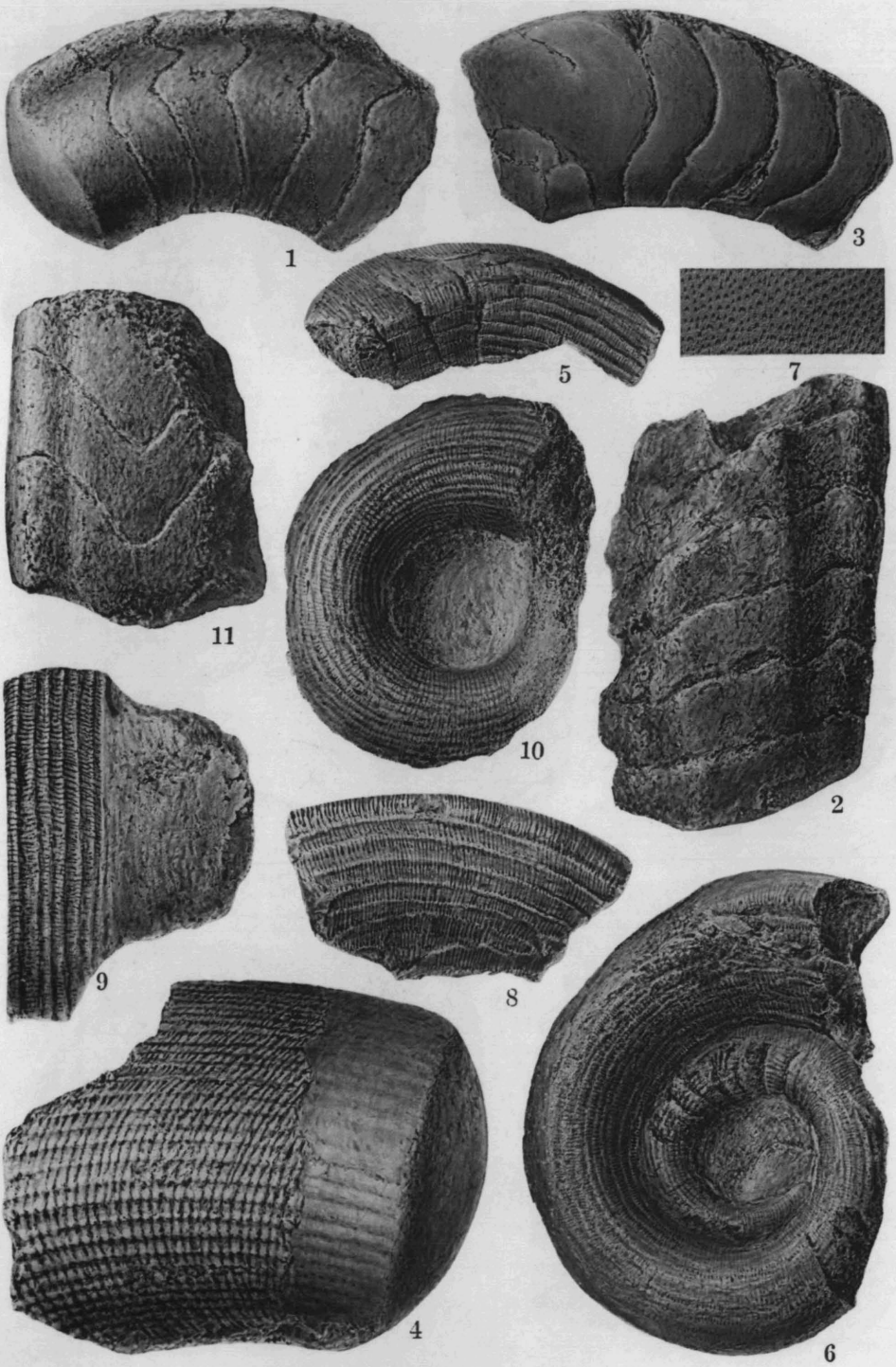


PLATE II



EXPLANATION OF PLATE II

PAGE

Stroboceras intermedium Miller and Garner, sp. nov. 138

FIGS. 1–2. Lateral and ventral views of paratype, No. 30436. Marshall sandstone at Burnt Cabin Point, Michigan. × 3.

See also Plates I and IV.

Maccoyoceras discoidale (Winchell) 143

FIG. 3. Lateral view of hypotype, No. 30543. Marshall sandstone at Marshall, Michigan. × 1.

See also Plates III and IV.

Chouteauoceras? sp. 121

FIG. 4. Lateral view of small specimen of uncertain affinities, No. 30423. Marshall sandstone at Marshall, Michigan. × 10.

Vestinautilus altidorsalis (Winchell) 130

FIG. 5. Lateral view of holotype, No. 27035. Marshall sandstone at Marshall, Michigan. × 1.

FIG. 6. Lateral view of hypotype, No. 30430; adoral part of specimen is much more narrowly rounded ventrolaterally than illustration suggests. Coldwater shale; abandoned shale quarry of Wolverine Portland Cement Co., NW. ¼ sec. 32, T. 6 S., R. 6 W., 1¼ miles southwest of Coldwater, Michigan. × 2.

FIG. 7. Small part of ventrolateral surface of fully mature individual; hypotype, No. 30429. Unretouched photograph taken near mid-length of outer volution of internal mold shown in Plate I, Figures 3–4. Coldwater shale, 1¼ miles southeast of Coldwater, Michigan. × 10.

See also Plates I, III–IV.

Rhineceras strigatum (Winchell) 127

FIGS. 8–9. Lateral and ventral views of holotype, No. 23760. Marshall sandstone at Marshall, Michigan. × 2.

Stroboceras planidorsale (Winchell) 139

FIG. 10. Lateral view of hypotype, No. 30438. Marshall sandstone at Marshall, Michigan. × 1.

FIG. 11. Ventral view of hypotype, No. 23735. Same formation and locality as Figure 10. × 5.

See also Plate III.

EXPLANATION OF PLATE III

All specimens from the Marshall sandstone at Marshall, Michigan

PAGE

Maccoyoceras discoidale (Winchell) 143

FIG. 1. Lateral view of syntype, No. 27031*a*. × 2.
FIG. 2. Lateral view of hypotype, No. 26709*a*. × 1.
FIG. 3. Lateral vew of hypotype, No. 26709*b*. × 2.
See also Plates II and IV.

Rineceras meekianum (Winchell) 124

FIGS. 4–5. Ventral and lateral views of holotype, No. 23734. × 2.

Vestinautilus altidorsalis (Winchell) 130

FIG. 6. Ventrolateral view of hypotype, No. 30427. × 1½.
See also Plates I, II, and IV.

Stroboceras planidorsale (Winchell) 139

FIGS. 7–8. Ventral and lateral views of hypotype, No. 23732 [holotype of *Nautilus* (*Trematodiscus*) *trigonus* Winchell]. × 3.
FIGS. 9–10. Lateral and ventral views of holotype, No. 23733. × 3.
FIGS. 11–12. Ventrolateral and ventral views of hypotype, No. 30439. × 2.
See also Plate II.

PLATE III

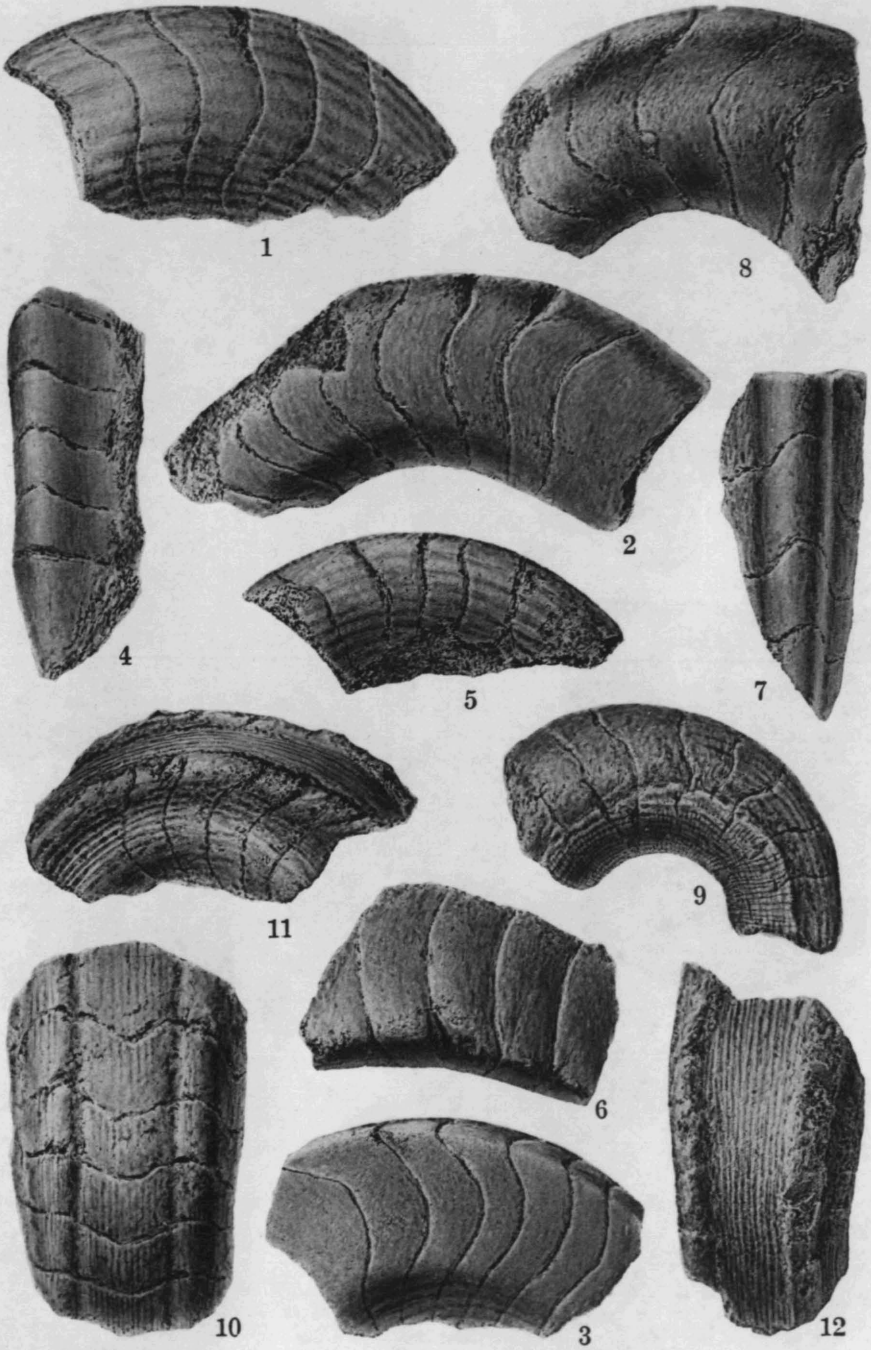
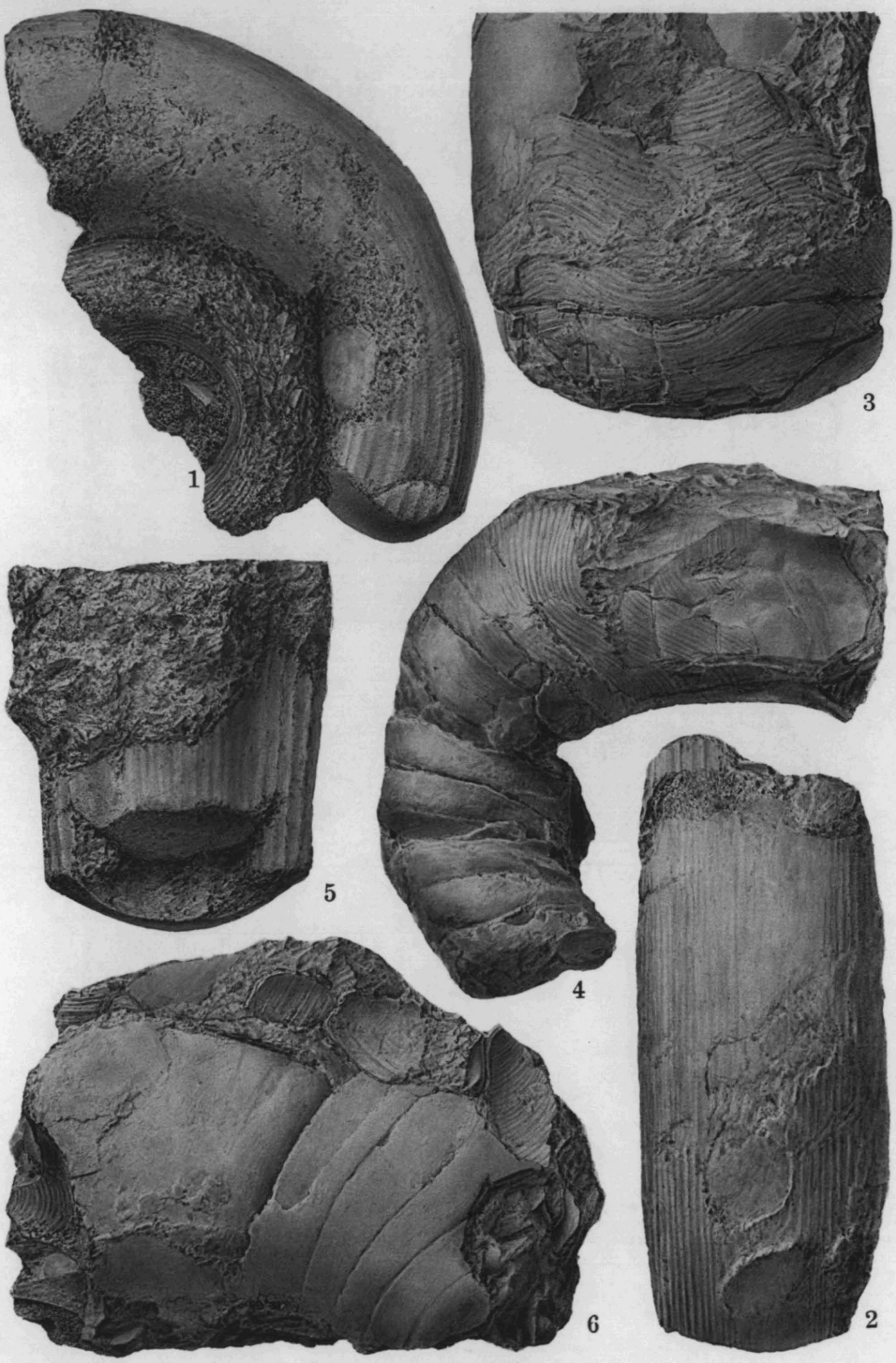


PLATE IV



EXPLANATION OF PLATE IV

PAGE

Maccoyoceras discoidale (Winchell) 143

FIGS. 1–2. Lateral and ventral views of hypotype, No. 23762. Marshall sandstone at Marshall, Michigan. × 2.

See also Plates II–III.

Vestinautilus altidorsalis (Winchell) 130

FIGS. 3–4. Ventral and lateral views of hypotype, No. 30431. Coldwater shale; abandoned shale quarry of Wolverine Portland Cement Co., NW. ¼ sec. 32, T. 6 S., R. 6 W., about 1¼ miles southwest of Coldwater, Michigan. × 1.

See also Plates I–III.

Stroboceras intermedium Miller and Garner, sp. nov. 138

FIG. 5. Ventral view of holotype, No. 30435. Marshall sandstone at Burnt Cabin Point, Michigan. × 2. Same specimen as Fig. 8, Plate I.

See also Plate II.

Chouteauoceras? ingenitor (Winchell) 120

FIG. 6. Lateral view of holotype, No. 23551. Marshall sandstone at Marshall, Michigan. × 1.

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