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NOTES ON THE FORAMINIFERA FROM BOWDEN, JAMAICA

By

Dorothy K. Palmer

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NOTES ON THE FORAMINIFERA FROM BOWDEN, JAMAICA

By

Dorothy K. Palmer

INTRODUCTION

The beautifully preserved molluscan fauna of the Bowden formation has been the subject of numerous reports during the past 80 years. In 1928 Dr. W. P. Woodring[1] published a notable monograph in which he described 610 forms from the type locality. So complete was this contribution that little of importance has been added since its publication.

According to a report quoted by Woodring (Publ. 366, p. 7) much of the material from which the Mollusca were described was collected by shovelling it into barrels from a 2- to 3-foot bed of loosely consolidated gravel in a marly matrix. This method of collecting furnished an unusually large number of small mollusks and also about a dozen species of the conspicuous larger Foraminifera.

Fifteen species of Foraminifera from Bowden were listed in the Geology of Jamaica by R. T. Hill[2]. This list and some notes on the fauna had been prepared by Dr. R. M. Bagg, Jr. In "Fossil Foraminifera from the West Indies" published in 1919, Dr. J. A. Cushman[3] gave another list of species from Bowden. These comprise the only known lists of Foraminifera definitely stated as coming from the type locality of the Bowden formation and the total is only 36 species.

The Foraminifera listed by these authors are chiefly the larger, conspicuous species and were doubtless separated incidentally to the study of the small mollusks. Since the average fossiliferous horizon in the Caribbean Tertiary usually yields about 100 spec-

[1] Woodring, Wendell P.: *Miocene Mollusks from Bowden, Jamaica*, Carnegie Inst. Washington, *Pt. I. Pelecypods and Scaphopods*, Publ. 336, 1925; *Pt. II. Gastropods and Discussion of Results*, Publ. 385, 1928.

[2] Hill, R. T.: *The Geology and Physical Geography of Jamaica*, Bull. Mus. Comp. Zool., vol. 34, 1899, pp. 146-152.

[3] Cushman, J. A.: *Fossil Foraminifera from the West Indies*, Carnegie Inst. Washington, Publ. 291, 1919, pp. 27-29.

ies of Foraminifera it was suspected that there were more than 36 species in the Bowden deposits and that a search of the finer material of the marly matrix would yield a census comparable to other Caribbean horizons. With this in view the present paper has been prepared.

MATERIAL EXAMINED

In 1934 Dr. Katherine Van Winkle Palmer made collections at Bowden for Mollusca and she has generously sent me for examination two large samples of the marly matrix. In addition, the Paleontological Research Institution of Ithaca, New York, has sent two small samples of matrix from other collections of mollusks from Bowden, one by Dr. A. A. Olsson in 1923 (P. R. I. Sta. No. 574) and the other by Dr. C. Rappenecker in 1933 (P. R. I. Sta. No. 1126). In 1940 Dr. H. D. Hedberg made a collection at Bowden and also generously shared the sample.

Careful examination of these four samples has yielded 171 species and varieties.

The samples collected by Olsson and Rappenecker were described simply as coming from Bowden. Dr. Hedberg's sample is labelled "type locality of the Bowden formation." The two large samples from the Bowden formation collected by Dr. Palmer were described as follows:

1. Port Morant, Jamaica, at foot of hill where road to old Capt. Baker house turns off the main road to Bowden P. O. and the United Fruit Co. wharf.

2. About halfway up the hill, in the side of the road leading to the old Capt. Baker house. This locality is stratigraphically higher than locality 1.

The material from Palmer Sta. 1 comprises a rather loosely consolidated, moderately coarse sandstone in a marly matrix with very occasional, small, well-rounded pebbles of altered igneous rock and abundant coral, bryozoan and mollusk fragments. The washed residue of the marly matrix is a fine sand composed largely of altered igneous rock grains and a small percentage of subangular quartz grains and a little gray and pinkish chert.

The sample from Palmer Sta. 2 is similar to that from Sta. 1 though somewhat more firmly consolidated and containing much less shell debris. Hedberg's sample is almost identical to that of Palmer Sta. 1 but lacks the abundant shell fragments. The other samples were small in quantity and composed largely of coarse sandstone of fine gravel. All the samples are grayish tan in color.

All of the samples yielded abundant Foraminifera. The very coarse siftings contain numerous *Cuneolina, Frondicularia, Liebusella, Sphærogypsina* and *Amphistegina angulata.* The moderately coarse fraction is dominated by abundant smaller specimens of *Amphistegina* associated with numerous *Robulus calcar, Lenticulina bowdenensis, Planularia woodringi, Eponides coryelli, E. parantillarum, Dentalina vertebralis, Elphidium advena, Cibicides lobatus, C. pseudoungerianus* and pelagic species. The finest fraction is characterized by abundant pelagic specimens and the numerous smaller forms listed as common to occasional in the discussion of the ecology which follows.

The composition, ecology, and age of the Bowden invertebrate fauna has been very completely treated by Dr. Woodring. Only a few comments, particularly applicable to the Foraminifera, can be added.

Composition.—The Foraminifera from the material examined from the type locality of the Bowden formation comprises 171 species and varieties of 88 genera. It is fitting to repeat here, in order to emphasize the richness of the Bowden fauna, that in addition to this foraminiferal fauna it contains 610 species of Mollusca of which 406 are gastropods (including 3 pulmonates and 4 pteropods), 20 scaphopods and 184 pelecypods together with 17 corals and 33 bryozoans. The material examined also yielded about a dozen species of ostracodes. Occasional fragments of echinoid spines occur in the washings and it is surprising to note that no echinoids have been reported in this large invertebrate fauna.

Origin.—The majority of the Bowden Foraminifera are descendants of Caribbean upper Oligocene and lower Miocene species. There appear to be few newcomers. Relationships to the Caribbean lower Oligocene are not conspicuous except in the case of a few lagenids and rotalids.

Age and correlations.—The Bowden foraminiferal fauna has a very modern aspect. The majority of the species, approximately 67%, are either still living or are close relatives of species living in the West Indies. In this connection it is worthy of note that the Bowden foraminiferal fauna contains a few species, about 3%, that do not appear in the late Tertiary or Recent Caribbean fauna but do occur in the late Tertiary or living fauna of the Pacific. That is, they became extinct in the Caribbean region after Bowden time but their descendants survived in the Pacific. Woodring made a similar observation with reference to the Mollusca and listed five species which have analogues living in the Pacific but are not represented in the Recent Caribbean fauna. He observed:[4]

"The most dramatic event in the history of the West Indian fauna is the wholesale disappearance of genera at and soon after the close of the Miocene time. Genus after genus, many of which are now living on the other side of Central America, then became extinct there and relatively few genera have taken their places."

The Choctawhatchee Miocene fauna of Florida[5] is very closely related to that of the Bowden.

Two small assemblages correlated with the Bowden fauna were described by Cushman and Jarvis[6] from Buff Bay and Port Antonio, Jamaica. In a recent paper discussing the late Tertiary geology of Jamaica, Dr. Trechmann[7] described sections in the vicinity of Buff Bay and Port Antonio, including the localities

[4] Woodring, Wendell P.: *Miocene Mollusks from Bowden, Jamaica*, Carnegie Inst. Washington, Publ. 385, 1928, p. 28.

[5] Cushman, J. A.: *The Foraminifera of the Choctawhatchee Formation of Florida*, Florida State Geol. Survey, Bull. 4, 1930.

[6] Cushman, J. A., and Jarvis, P. W.: *Miocene Foraminifera from Buff Bay, Jamaica*, Jour. Paleont., vol. 4, No. 4, 1930, pp. 353-68, pls. 32-34; *Three new Foraminifera from the Miocene, Bowden marl of Jamaica*, Contr. Cushman Lab. Foram. Res., vol. 12, pt. 1, 1936, pp. 305, pl. 1, figs. 11-14.

[7] Trechmann, C. T.: *The Manchioneal beds of Jamaica*, Geol. Mag., vol. LXVII, 1930, pp. 204-5.

above mentioned, and stated that they are the Manchioneal beds and thus stratigraphically above the Bowden formation.

A large fauna from the vicinity of Port-au-Prince, Haiti, described by Coryell and Rivero,[8] was assigned to the middle Miocene and considered closely related to the Bowden fauna. This assemblage, as a result of the present study of the fauna of the type locality of the Bowden, is now believed to be slightly older Miocene.

The resemblance of the Bowden assemblage to that of the Cuban upper Oligocene Cojimar formation suggests ecological similarity because of the presence of conspicuous large specimens of *Frondicularia, Cuneolina, Liebusella, Nodosaria, Cristellaria* and *Amphistegina.* These genera, though usually represented by distinct species, are conspicuous in the Bowden fauna. Lithologically, however, there is scarcely any resemblance between the two formations.

In identity of species, the only described closely related Cuban fauna is that from the late Tertiary of the Canímar River region, Matanzas Province[10]. This fauna carries a number of species in common with the Bowden fauna but it came from beds stratigraphically above those which have been correlated with the Bowden.

Summarizing the age of the Bowden molluscan fauna, Dr. Woodring made the following statements:[11]

"On the basis of percentage of living species and in terms of the standard European section the Bowden fauna is Miocene, and the evidence seems to warrant considering it middle Miocene (Vindobonian). In terms of the American section it falls at the top of the middle Miocene or at the base of the upper Miocene.

[8] Coryell, H. N., and Rivero, F. C.: *A Miocene microfauna from Haiti,* Jour. Paleont., vol. 14, No. 4, 1940, pp. 324-44, pls. 41-44.

[9] Palmer, Dorothy K.: *Foraminifera of the upper Oligocene Cojimar formation of Cuba,* Mem. Soc. Cubana Hist. Nat., vol. 14, No. 1, 1940.

[10] Palmer, Dorothy K., and Bermudez, Pedro J.: *Late Tertiary Foraminifera from the Matanzas Bay region, Cuba,* Mem. Soc. Cubana Hist. Nat., vol. 9, No. 4, 1936.

[11] Woodring, Wendell P.: *Miocene mollusks from Bowden, Jamaica,* Carnegie Inst. Washington, Publ. 385, 1928, pp. 108, 56, 57.

"The Bowden fossils are more similar to those of the Cercado and Gurabo formations (of the Dominican Republic) than to those of any other Miocene deposits.

"It is concluded that the Bowden fossils are more like those of the Gurabo formation than like any other Dominican fossils. In view of the closer similarity of the Gurabo and Gatun faunas, . . . and in view of the presence in the Bowden formation of some Recent species not found in either the Gurabo or Gatun formations, the Bowden fossils are regarded as representing a younger horizon."

Additional evidence of the close relationship of the Bowden and Gurabo faunas is found in the fact that Dr. K. V. W. Palmer collected *Spondylus bostrichites* (Guppy)[12] at Sta. 2 of the type Bowden (see locality description above), the type of which species came from the Gurabo formation of the Dominican Republic.

Deposits subsequent to the White limestone of Jamaica, which probably comprises beds of upper Eocene to lower Miocene inclusively, are mainly marginal. These are limestones, marls, and conglomerates. The gravelly shell marl at Bowden on the southeast coast, is by far the best known of these marginal deposits and its age, by its exceptionally large and well-preserved molluscan fauna, has been well established as Vindobonian, late Miocene. Other marginal deposits, some of them younger than the Bowden, as, for example, the Manchioneal beds of Hill and the Pteropod marl of Barrett, have been referred to in the literature as Bowden in age. This fact is of interest because in 1876 Jones and Parker[13] described 13 species of Foraminifera from a sample of Pteropod marl sent them by Lucas Barrett, the director of the Geological Survey of Jamaica. The sample was without locality and following the trend of correlation it has been regarded as Bowden in age. Trechmann, however, believes that the Ptero-

[12] Palmer, Katherine VanWinkle: *Neocene Spondyli from the southern United States and tropical America,* Palæontographica Americana, vol. II, No. 8, 1938, p. 8.

[13] Jones, T. Rupert, and Parker, W. K.: *Notice sur les Foraminifères vivants et fossiles de la Jamaique,* Ann. Soc. Malac. Belg. vol. 11, 1876, pp. 96-98.

pod marl of Barrett is, at least, in part equivalent to the Manchioneal beds. He has presented the correlation of the Manchioneal beds concisely in the following paragraph[14]:

"The Mollusca and also the Corals of the Manchioneal beds show a decidedly closer affinity with those of the Bowden beds than with the living fauna, a feature I hardly expected to find in view of the position of the beds immediately under the Coral rock or Coast limestone. The number of species in the Bowden fauna closely allied to, if not actually identical with, the living forms is remarkable. Furthermore, the Bowden and Manchioneal formations both enter equally slightly into the tectonics of Jamaica. They never occur so far as I know in any of the inland or upland valleys, but are purely marginal in distribution. Hitherto the Manchioneal beds have been referred by most writers to the Pliocene, presumably on account of their position rather than their fauna, which has been practically uninvestigated. Possibly if they were in Europe the Manchioneal and perhaps also the Bowden beds might be placed in the Pliocene rather than the Miocene."

Possibly this slight difference in age of some of the collections from the late Tertiary may explain the fact noted by Dr. Cushman[15] that he failed to find in his sample from Bowden a number of the species listed by Jones and Parker from the Pteropod marl.

In the same volume in which Jones and Parker discussed the sample from the Pteropod marl, H. B. Brady described *Sphærogypsina* (*Tinoporus*) *pilaris* from a sample sent him by C. P. Gloyne, from the Miocene limestone of Jamaica in the gorge of Hope River, back of Long Mountain, a few miles east of Kingston. This species has also been referred to as coming from the Bowden beds. It is conspicuous at Bowden but the locality from which it was described may or may not be the Bowden formation.

Ecology.—The temperature, salinity, character of bottom and

[14] Trechmann, C. T.: *The Manchioneal beds of Jamaica*, Geol. Mag., vol. LXVII, 1930, p. 216.

[15] Cushman, J. A.: *Fossil Foraminifera from the West Indies*, Carnegie Inst. Washington, Publ. 291, 1919, p. 28.

depth of water during deposition as indicated by the molluscan fauna have been discussed by Woodring. His conclusions are briefly summarized as follows[16]:

" . . . if number of genera and species is a measure of temperature, the Caribbean Sea during the time when the Bowden formation was deposited was at least as warm as it now is.

"Aside from a few species the Bowden mollusks are such as live in the open sea in water having only a slight range of salinity. (P. 29).

"It is apparent from a glance at the faunal list that most of the Bowden mollusks represent the neritic zone, or the zone from low-water mark to a depth of 200 meters, or about 100 fathoms. A few genera, however, were suspected of representing deeper water." (P. 32).

The study of the Foraminifera provides some detailed evidence supporting those conclusions.

The Bowden foraminiferal fauna is obviously tropical in type and would be recognized as such if its geographical origin were not known. The absence of well-preserved specimens of strictly shore or estuarine species and the abundance of pelagic species is evidence of open ocean environment.

As in the case of the molluscan fauna, the foraminiferal fauna appears to have accumulated in moderately deep water. Analysis of the faunal list shows that approximately 70% of the species are still living. Of these living species 37½% are now found characteristically in water deeper than 60 fathoms, some being reported only in depths exceeding 150 fathoms and 13% range from shallow to very deep water. This figure includes 12 pelagic species, which are of course frequently carried inshore but are more normal to deep water assemblages. A considerable number of species of the remaining 50% of the fauna which points to shallow water accumulation, such as most of the Miliolidæ and Peneroplidæ, are represented in the collection by a few, frequently poorly preserved, specimens.

[16] Woodring, Wendell P.: *Miocene mollusks from Bowden, Jamaica*, Carnegie Inst. Washington, Publ. 385, 1928.

Comparison of fossil and Recent faunas, in order to determine the depth of water in which the former accumulated, is hampered by the fact that very little information is available concerning the species living between 60 and 150 fathoms. Norton[17] studied samples from the West Indian and Floridian region which ranged in depth from the beach to 2849 fathoms. He divided his material into zones on the basis of depth and temperature and prepared graphs to show the relationships of the families to the fauna as a whole at different depths. These data are very useful but unfortunately he did not have samples from depths between 60 and 500 fathoms.

The following table was prepared for comparison with the zones established by Norton. It presents the percentages of the species in each family to the fauna as a whole. It does not agree with any of the zonal graphs given by Norton. For example, from the trend of percentages of species in Norton's zones, the abundance in the Bowden fauna suggests that the Miliolidæ accumulated in depths greater than 2000 fathoms (Zone D), the Lagenidæ between 500 and 2000 fathoms (zones C and D) and the Rotaliidæ between the beach and 5 fathoms (Zone A).

Percentage of Species in each family compared to the Fauna as a whole expressed graphically

	%
Textulariidæ	2.9
Verneuilinidæ	2.3
Valvulinidæ	3.5
Miliolidæ	11.0
Ophthalmidiidæ	.6
Placopsilinidæ	.6
Lagenidæ	14.0
Polymorphinidæ	1.7
Nonionidæ	4.6
Peneroplidæ	1.2
Heterohelicidæ	1.2
Buliminidæ	15.8
Ellipsoidinidæ	.6

[17] Norton, Richard D.: *Ecologic relations of some Foraminifera,* Bull. Scripps Instit. Oceanography, Tech. ser., vol. 2, No. 9, 1930, pp. 331-388.

Rotaliidæ	14.6
Amphisteginidæ	2.3
Cymbaloporidæ	.6
Cassidulinidæ	2.9
Chilostomellidæ	1.7
Globigerinidæ	5.2
Globorotaliidæ	2.3
Anomalinidæ	7.0
Planorbulinidæ	2.3
Homotremidæ	.6

The Bowden list comprises 171 species and varieties of Foraminifera. Some of these are very rare, a number having been identified from single specimens. The following species are common to occasional in the assemblage:

Textulariella barrettii (Jones and Parker)
Cuneolina? angusta Cushman
Liebusella soldanii (Jones and Parker)
Quinqueloculina lamarckiana d'Orbigny
Robulus calcar (Linnæus)
Robulus rotulatus (Lamarck)
Lenticulina bowdenensis (Cushman)
(Closely related to the living Cristellaria antillea Cushman)
Planularia woodringi, n. sp.
(Closely related to the living Cristellaria gemmata Brady)
Dentalina vertebralis (Batsch)
Saracenaria cushmani, n. sp.
Frondicularia sagittula Vanden Broeck
Raphanulina gibba (d'Orbigny)
Nonion grateloupii (d'Orbigny)
Nonion pompilioides (Fichtel and Moll)
Elphidium advena (Cushman)
Elphidium fimbriatulum (Cushman)
Virgulina punctata d'Orbigny
Bolivina alata (Seguenza)
Bolivina marginata Cushman var. multicostata Cushman
Reussella spinulosa (Reuss) var. Cushman and Ponton
Uvigerina proboscidea Schwager var. vadescens Cushman
Discorbis orbicularis (Terquem)
Eponides coryelli, n. sp.
(Rare in the deep water off Cuba)
Eponides parantillarum Galloway and Heminway
Rotalia rosea (d'Orbigny)
Siphonina pulchra Cushman
Baggina cojimarensis Palmer
Asterigerina carinata d'Orbigny
Amphistegina angulata (Cushman)

Amphistegina lessonii (d'Orbigny) var. bowdenensis, n. var.
Globigerina bulloides d'Orbigny
Globigerina subcretacea Chapman
Globigerina triloba Reuss
Globigerinoides rubra (d'Orbigny)
Globigerinoides sacculifera (Brady)
Orbulina universa d'Orbigny
Sphæroidinella dehiscens (Parker and Jones)
Sphæroidinella dehiscens (Parker and Jones) var. immatura Cushman
Globorotalia menardii (d'Orbigny)
Globorotalia menardii (d'Orbigny) var. miocenica, n. var.
Cibicides lobatus (d'Orbigny)
Cibicides pseudoungerianus (Cushman)
Cibicides spirolimbatus Galloway and Heminway
Sphærogypsina pilaris (Brady)
(Closely related to the living Gypsina globulus (Reuss))

All but five of the species or varieties in the above list are still living or are very closely related to living species. Analysis of the distribution of the living and closely related living forms shows that 50% (including the pelagic species) are now found chiefly at depths of 60 fathoms or more; approximately 39% are found characteristically in shallow water and 11% are found in both shallow and deep water. These percentages again point toward a probable depth habitat of the Bowden fauna of 60 fathoms or slightly more, a conclusion indicated also by the analysis of the living species in the fauna as a whole. The abundance of individuals of the species of *Amphistegina*—by far the most numerous forms in the assemblage—appears to contradict this conclusion. However, the living *Amphistegina lessonii* d'Orbigny, though most common to about 30 fathoms, ranges into deep water and according to Brady[18] "is found with some frequency down to depths of 300 and 400 fathoms."

This conclusion is not what was expected from the inspection of the lithology of the Bowden deposit. Woodring likewise noted a mixture of shallow-water mollusks with others indicating a depth of 100 fathoms or more. This association of species of diverse depth habitats has no ready explanation.

[18] Brady, H. B.: Rep. Voy. *Challenger*, Zool., vol. 9, 1884, p. 741.

Species previously identified from the typical Bowden.—

Only three of the species listed by Bagg and Cushman from the type locality of the Bowden formation have not been found or provisionally identified with species found in the present collections.

The species listed by Bagg (pp. 147-148) have been identified as follows:

Haplostiche soldanii (Jones and Parker)	Liebusella soldanii (Jones and Parker)
Textularia barrettii (Jones and Parker)	Textulariella barrettii (Jones and Parker)
Textularia trochus d'Orbigny	D'Orbigny's type of this species was from the Cretaceous; no specimens of this general type could be identified unless they be immature T. barrettii as suggested by Cushman.
Orbiculina adunca (Fichtel and Moll)	Archaias aduncus (Fichtel and Moll)
Orbiculina compressa d'Orbigny	Not definitely identified; specimens of Archaias are very poorly preserved and fragmentary.
Cristellaria cultrata (Montfort)	Robulus cultratus Montfort
Cristellaria cassis (Fichtel and Moll)	Possibly Planularia woodringi, n. sp.
Gypsina globulus (Reuss)	Sphærogypsina pilaris (Brady)
Gypsina vesicularis (Parker and Jones)	Gypsina vesicularis (Parker and Jones)
Cuneolina pavonia d'Orbigny	Cuneolina? angusta Cushman
Cuneolina, sp. perhaps new	Possibly the microspheric form of C.? angusta Cushman
Vaginulina legumen (Linnæus)	Possibly herein referred to as Vaginula clavata Costa
Nummulites ramondi d'Archiac	This species was not figured by D'Archiac and cannot be identified in the collections
Amphistegina lessonii d'Orbigny	Amphistegina lessonii d'Orbigny var. bowdenensis, n. var.

The species listed by Cushman (p. 29) have been identified as follows:

Psammosphæra fusca Schultze	Not identified
Haplostiche dubia var. dubia v. Brk.	Liebusella soldanii (Jones and Parker)
Haddonia minor Chapman	Possibly the very rare Haddonia, sp.
Textularia barrettii Jones and Parker	Textulariella barrettii (Jones and Parker)
Cuneolina pavonia d'Orbigny	Cuneolina? angusta Cushman (microspheric form)
Cuneolina pavonia var. angusta, n. var.	Cuneolina? angusta Cushman (megalospheric form)
Bulimina ovata d'Orbigny	Bulimina ovata d'Orbigny
Nodosaria vertebralis Batsch	Dentalina vertebralis (Batsch)
Frondicularia alata d'Orbigny	Frondicularia sagittula Vanden Broeck
Cristellaria calcar Linnæus	Robulus calcar (Linnæus)

Cristellaria calcar var. aspinosa, n. var.	Robulus calcar (L.) var. aspinosa (Cushman)
Cristellaria bowdenensis, n. sp.	Lenticulina bowdenensis (Cushman)
Cristellaria italica (Defrance)	Saracenaria italica Defrance
Cristellaria gemmata Brady	Planularia woodringi, n. sp.
Globigerina bulloides d'Orbigny	Globigerina bulloides d'Orbigny
Globigerina rubra d'Orbigny	Globigerinoides rubra (d'Orbigny)
Globigerina sacculifera Brady	Globigerinoides sacculifera (Brady)
Globigerina subcretacea Chapman	Globigerina subcretacea Chapman
Sphæroidina dehiscens var. immatura, n. var.	Sphæroidinella dehiscens var. immatura (Cushman)
Discorbis allomorphinoides (Reuss)	The type is from the Cretaceous of Westphalia; probably the form here identified as Baggina cojimarensis Palmer
Truncatulina præcincta Karrer	Eponides coryelli, n. sp.
Gypsina vesicularis (Parker and Jones)	Gypsina vesicularis (Parker and Jones)
Gypsina globulus var. pilaris (Brady)	Spræogypsina pilaris (Brady)
Pulvinulina sagra d'Orbigny	Cancris sagra (d'Orbigny)
Amphistegina lessonii d'Orbigny	Amphistegina lessonii d'Orbigny var. bowdenensis, n. var.
Quinqueloculina auberiana d'Orbigny	Quinqueloculina lamarckiana d'Orbigny
Quinqueloculina parkeri var. bowdenensis, n. var.	Quinqueloculina parkeri (Brady) var. bowdenensis Cushman
Triloculina brongniartiana d'Orbigny	Triloculina brongniartiana d'Orbigny
Triloculina tricarinata d'Orbigny	Triloculina tricarinata d'Orbigny
Vertebralina striata d'Orbigny	Possibly the poorly preserved Vertebralina, sp. listed here.
Orbiculina compressa d'Orbigny	Not definitely identified.

The following forms have been described as new:

Barbourinella bermudezi, n. sp.
Planularia woodringi, n. sp.
Saracenaria cushmani, n. sp.
Uvigerina charltonæ, n. sp.
Ellipsonodosaria caribæa, n. sp.
Eponides coryelli, n. sp.
Globorotalia menardii d'Orbigny var. *miocenica,* n. var.
Amphistegina lessonii d'Orbigny var. *bowdenensis,* n. var.

LIST OF SPECIES

Textulariidæ
1. Spiroplectammina gramen (d'Orbigny)
2. Textularia agglutinans d'Orbigny
3. Textularia candeana d'Orbigny
4. Textularia sica Lalicker and Bermudez
5. Bigenerina nodosaria d'Orbigny var. textularioidea (Goës)

Verneuilinidæ
6. Verneuilina mexicana Nuttall
7. Bermudezina cf. B. pariana (Guppy)
8. Pseudoclavulina mexicana Cushman
9. Barbourinella bermudezi, n. sp.

Valvulinidæ
10. Clavulina tricarinata d'Orbigny

11. Dorothia caribæa Cushman
12. Listerella nodulosa (Cushman)
13. Textulariella barrettii (Jones and Parker)
14. Cuneolina? angusta Cushman
15. Liebusella soldanii (Jones and Parker)

Miliolidæ

16. Quinqueloculina collumnosa Cushman
17. Quinqueloculina lamarckiana d'Orbigny
18. Quinqueloculina cf. Q. panamensis Cushman
19. Quinqueloculina parkeri (Brady) var. bowdenensis Cushman
20. Quinqueloculina cf. Q. philippi Reuss
21. Quinqueloculina cf. Q. polygona d'Orbigny
22. Massilina crenata (Karrer)
23. Spiroloculina depressa d'Orbigny
24. Spiroloculina poeyiana d'Orbigny
25. Sigmoilina cf. S. schlumbergeri A. Silvestri
26. Sigmoilina tenuis (Czjzek)
27. Triloculina brongniartiana d'Orbigny
28. Triloculina carinata d'Orbigny
29. Triloculina linneiana d'Orbigny
30. Triloculina quadrilateralis d'Orbigny
31. Triloculina transversistriata Brady
32. Triloculina tricarinata d'Orbigny
33. Pyrgo denticulata (Brady) var. striolata (Brady)
34. Pyrgo subsphærica (d'Orbigny)

Ophthalmidiidæ

35. Vertebralina, sp.

Placopsilinidæ

36. Haddonia, sp.

Lagenidæ

37. Robulus calcar (Linnæus)
38. Robulus calcar (Linnæus) var. aspinosa (Cushman)
39. Robulus clericii (Fornasini)
40. Robulus cultratus Montfort
41. Robulus falcifer (Stache)
42. Robulus cf. R. foliatus (Stache)
43. Robulus iota (Cushman)
44. Robulus occidentalis (Cushman) var. torrida (Cushman)
45. Robulus rotulatus (Lamarck)
46. Robulus submamilligerus (Cushman)
47. Lenticulina bowdenensis (Cushman)
48. Planularia woodringi, n. sp.
49. Astacolus crepidula (Fichtel and Moll)
50. Dentalina cf. D. baggi Gallowey and Wissler
51. Dentalina vertebralis (Batsch)
52. Lagenonodosaria, sp.
53. Saracenaria cushmani, n. sp.
54. Saracenaria italica Defrance
55. Vaginulina clavata Costa
56. Vaginulina? cf. V. peregrina Cushman
57. Frondicularia sagittula Vanden Broeck
58. Lagena hexagona (Williamson) var. scalariformis (Williamson)
59. Lagena cf. L. marginata (Walker and Boys)
60. Lagena marginato-perforata Seguenza

Polymorphinidæ
61. Guttulina lactea (Montagu) var. earlandi Cushman and Ozawa
62. Raphanulina gibba (d'Orbigny)
63. Ramulina globulifera Brady
Nonionidæ
64. Nonion grateloupii (d'Orbigny)
65. Nonion nicobarense Cushman
66. Nonion pompilioides (Fichtel and Moll)
67. Astrononion cf. A. stelligerum (d'Orbigny)
68. Eliphidium advena (Cushman)
69. Elphidium fimbriatulum (Cushman)
70. Elphidium lanieri (d'Orbigny)
71. Elphidium poeyanum (d'Orbigny)
Peneroplidæ
72. Archaias aduncus (Fichtel and Moll)
73. Sorites, sp.
Heterohelicidæ
74. Bolivinella folium (Parker and Jones)
75. Plectofrondicularia floridana Cushman
Buliminidæ
76. Buliminella pulchra Tolmachoff
77. Bulimina marginata d'Orbigny
78. Bulimina cf. ovata d'Orbigny
79. Virgulina mexicana Cushman
80. Virgulina punctata d'Orbigny
81. Bolivina alata (Seguenza)
82. Bolivina arta Macfadyen
83. Bolivina bierigi Palmer and Bermudez
84. Bolivina marginata Cushman var. multicostata Cushman
85. Bolivina pulchella (d'Orbigny)
86. Bolivina rhomboidalis (Millett)
87. Bolivina scalprata Schwager var. miocenica Macfadyen
88. Bolivina subænariensis Cushman var. mexicana Cushman
89. Bolivina tortuosa Brady
90. Loxostomum limbatum (Brady) var. costulatum (Cushman)
91. Reussella spinulosa (Reuss)
92. Reussella spinulosa (Reuss) var. Cushman and Ponton
93. Pavonina miocenica Cushman and Ponton
94. Uvigerina charltonæ, n. sp.
95. Uvigerina coartata Palmer
96. Uvigerina pigmea d'Orbigny
97. Uvigerina cf. U. selseyensis Heron-Allen and Earland
98. Uvigerina proboscidea Schwager var. vadescens Cushman
99. Siphogenerina advena Cushman
100. Siphogenerina cf. S. raphanus (Parker and Jones)
101. Angulogerina carinata Cushman
102. Angulogerina cf. A. eximia Cushman and Jarvis
Ellipsoidinidæ
103. Ellipsonodosaria caribæa, n. sp.
Rotaliidæ
104. Spirillina aff. S. vivipara Ehrenberg
105. Discorbis bertheloti (d'Orbigny) var. floridensis Cushman
106. Discorbis cf. D. corrugatus (Millett)
107. Discorbis cushmani Palmer and Bermudez
108. Discorbis floridanus Cushman
109. Discorbis mirus Cushman

110. Discorbis cf. D. obtusus (d'Orbigny)
111. Discorbis orbicularis (Terquem)
112. Discorbis pileolus (d'Orbigny)
113. Lamarckina atlantica Cushman
114. Valvulineria araucana (d'Orbigny)
115. Cibicorbis herricki Hadley
116. Gyroidina cf. G. soldanii d'Orbigny
117. Eponides coryelli, n. sp.
118. Eponides lateralis (Terquem)
119. Eponides parantillarum Galloway and Heminway
120. Eponides pulvinus Galloway and Heminway
121. Rotalia beccarii (Linnæus) var. tepida Cushman
122. Rotalia rosea (d'Orbigny)
123. Rotalia cf. R. tholus Galloway and Heminway
124. Epistomina elegans (d'Orbigny)
125. Siphonina pulchra Cushman
126. Siphoninella soluta (Brady)
127. Cancris sagra (d'Orbigny)
128. Baggina cojimarensis Palmer

Amphisteginidæ
129. Asterigerina carinata d'Orbigny
130. Amphistegina angulata (Cushman)
131. Amphistegina chipolensis Cushman and Ponton
132. Amphistegina lessonii d'Orbigny var. bowdenensis, n. var.

Cymbaloporidæ
133. Tretomphalus atlanticus Cushman

Cassidulinidæ
134. Cassidulina crassa d'Orbigny
135. Cassidulina lævigata d'Orbigny var. carinata Cushman
136. Cassidulina subglobosa Brady
137. Cassidulinoides bradyi (Norman)
138. Cassidulinoides cf. C. parkerianus (Brady)

Chilostomellidæ
139. Chilostomella czizeki Reuss
140. Pullenia sphæroides (d'Orbigny)
141. Sphæroidina bulloides d'Orbigny

Globigerinidæ
142. Globigerina bulloides d'Orbigny
143. Globigerina subcretacea Chapman
144. Globigerina triloba Reuss
145. Globigerinoides rubra (d'Orbigny)
146. Globigerinoides sacculifera (Brady)
147. Globigerinella æquilateralis (Brady)
148. Orbulina universa d'Orbigny
149. Sphæroidinella dehiscens (Parker and Jones)
150. Sphæroidinella dehiscens (Parker and Jones) var. immatura (Cushman)

Globorotaliidæ
151. Globotruncana, sp. (probably derived from the Upper Cretaceous)
152. Globorotalia menardii (d'Orbigny)
153. Globorotalia menardii (d'Orbigny) var. miocenica, n. var.
154. Globorotalia truncatulinoides (d'Orbigny)

Anomalinidæ
155. Planulina edwardsiana (d'Orbigny) var. canimarensis Palmer and Bermudez

156. Planulina foveolata (Brady)
157. Cibicides candei (d'Orbigny)
158. Cibicides concentricus (Cushman)
159. Cibicides lobatus (d'Orbigny)
160. Cibicides nucleatus (Seguenza)
161. Cibicides perforatus Coryell and Rivero
162. Cibicides pseudoungerianus (Cushman)
163. Cibicides robertsonianus (Brady) var. haitiensis Coryell and Rivero
164. Cibicides spirolimbatus Galloway and Heminway
165. Dyocibicides cf. D. biserialis Cushman and Valentine
166. Cibicidella variabilis (d'Orbigny)

Planorbulinidæ

167. Planorbulina acervalis Brady
168. Planorbulina mediterranensis d'Orbigny
169. Gypsina vesicularis (Parker and Jones)
170. Sphærogypsina pilaris (Brady)

Homotremidæ

171. Homotrema cf. H. rubrum (Lamarck)

DESCRIPTION OF SPECIES

Family TEXTULARIIDÆ

Genus SPIROPLECTAMMINA Cushman, 1927

Spiroplectammina gramen (d'Orbigny)

Vulvulina gramen d'Orbigny, 1840, in De la Sagra, Hist. Fis., Pol., Nat. Cuba, Foraminiferas, (Spanish ed.), p. 139, pl. 1, figs. 30, 31.
Textularia transversaria Flint, 1897 (1899), Rep. U. S. Nat. Mus., p. 283, pl. 28, fig. 4. Not Brady.
Textularia floridana Cushman, 1922, Carnegie Inst. Washington, Publ. 311, p. 24, pl. 1, fig. 7; Cushman, 1922, U. S. Nat. Mus., Bull. 104, pt. 3, p. 18, pl. 2, figs. 11, 12; Bermudez, 1935, Mem. Soc. Cubana Hist. Nat., vol. 9, No. 3, p. 152.
Spiroplectammina gramen (d'Orbigny), Lalicker and Bermudez, 1941, Torreia (Habana), No. 8, p. 3, pl. 1, figs. 5, 6.

Specimens are rare at Sta. 1. They attain greater size than has been indicated in the descriptions (maximum length, .83 mm.) and more closely resemble the original figure of *T. floridana* Cushman (which has been placed in synonomy with D'Orbigny's species) than either the original figure of *Vulvulina gramen* or the latest figures by Lalicker and Bermudez. The species has been reported by Lalicker and Bermudez from shallow water to 225 fms. (*Atlantis* stations) off the coast of Cuba.

Genus TEXTULARIA Defrance, 1824

Textularia agglutinans d'Orbigny

Textularia agglutinans d'Orbigny, 1839, in De la Sagra, Hist. Phys., Pol., Nat. Cuba, ''Foraminifères'', p. 136, pl. 1, figs. 17, 18, 32, 34; Lalicker and Bermudez, 1941, Torreia (Habana), No. 8, p. 6, pl. 1, fig. 7 (references).

Rare in the Bowden deposit; specimens agree well with the description and figures by Lalicker and Bermudez (1941).

Textularia candeana d'Orbigny[19]

Textularia candeana d'Orbigny, 1839, in De la Sagra, Hist. Fis., Pol., Nat. Cuba, "Foraminifères," p. 143, pl. 1, figs. 25-27; Cushman, 1919, Carnegie Inst. Washington, Publ. 291, p. 32; Lalicker and Bermudez, 1941, Torreia (Habana), No. 8, p. 8, pl. 2, fig. 4 (references).

Textularia candeana d'Orbigny, Galloway and Heminway, 1941, Sci. Surv. Porto Rico, New York Acad. Sci., vol. 3, p. 328, pl. 8, fig. 5.

Specimens are rare; they agree well with the figures by Lalicker and Bermudez (1941).

Textularia sica Lalicker and Bermudez

Textularia sica Lalicker and Bermudez, 1941, Torreia (Habana), No. 8, p. 16, pl. 4, figs. 5, 6.

The species was described from the north coast of Cuba, *"Atlantis"* Station 2999, 230 fathoms. It is rare at Bowden. The specimens agree closely with the original figures.

Genus BIGENERINA d'Orbigny, 1826

Bigenerina nodosaria d'Orbigny var. textularioidea (Goës)

Textularia sagittula Defrance, *forma Bigenerina* Goës, 1882, Köngl, Svensk. Vet. Akad. Handl., vol. 19, pt. 4, p. 78, pl. 5, figs. 159, 160.

Clavulina textularioidea Goës, 1894, Köngl. Svensk. Vet. Akad. vol. 25, p. 42, pl. 8, figs. 387-389; 1896, Bull. Mus. Comp. Zoöl., p. 37, pl. 4, figs. 26-38.

Bigenerina nodosaria d'Orbigny var. *textularioidea* Goës, Cushman, 1922, U. S. Nat. Mus., Bull. 104, pt. 3, p. 25, pl. 5, figs. 8, 9; Cushman and Cahill, 1933, U. S. Geol. Survey, Prof. Paper 175, p. 8, pl. 1, fig. 14 (references); Lalicker and Bermudez, 1941, Torreia (Habana), No. 8, p. 4, pl. 1, fig. 2.

Very rare. The specimens are of the type figured by Cushman and Cahill (1933) but have fewer uniserial chambers.

Family VERNEUILINIDÆ

Genus VERNEUILINA d'Orbigny, 1840

Verneuilina mexicana Nuttall

Verneuilina mexicana Nuttall, 1932, Jour. Paleont., vol. 6, No. 1, p. 6, pl. 2, figs. 1, 2; Palmer and Bermudez, 1936, Mem. Soc. Cubana Hist. Nat., vol. 10, No. 4, p. 242; Palmer, 1940, Mem. Soc. Cubana Hist. Nat., vol. 14, No. 2, p. 117, pl. 17, fig. 9; Galloway and Heminway, 1941, New York Acad. Sci., Sci. Survey Porto Rico and Virgin Islands, vol. III, pt. 4, p. 321, pl. 6, fig. 5.

Karreriella mexicana (Nuttall), Cushman, 1937, Cushman Lab. Foram. Res. Special Publ., No. 8, p. 130, pl. 15, figs. 13, 14.

Very rare. The specimens are large and quite typical except that the aperture is indistinct.

[19] Galloway and Heminway call attention to the fact that D'Orbigny corrected the spelling of this species to "*candeana*" in the Spanish edition (1840) of the Cuba monograph.

Genus BERMUDEZINA Cushman, 1937

Bermudezina cf. B. pariana (Guppy)

Gaudryina pariana Guppy, 1894, Proc. Zoöl. Soc. London, p. 651, pl. 41, figs. 21, 22.

Bermudezina pariana (Guppy), Cushman, 1937, Cushman Lab. Foram. Res., Special Publ., No. 7, p. 103, pl. 13, figs. 13, 14, 17, 18; Palmer, 1940, Mem. Soc. Cubana Hist. Nat., vol. 14, No. 2, p. 140, pl. 17, fig. 10.

Rare. The biserial portion is more distinctly triangular in section than is indicated by the figures given by Cushman (1937) and the triserial portion is longer than that indicated by the figure of the upper Oligocene Cojimar specimen from Cuba (Palmer, 1940).

Genus **PSEUDOCLAVULINA** Cushman, 1936

Pseudoclavulina mexicana (Cushman)

Clavulina humilis Brady, var. *mexicana* Cushman, 1922, U. S. Nat. Mus., Bull. 104, pt. 3, p. 83, pl. 16, figs. 1-3; Cushman and Jarvis, 1930, Jour. Paleont., vol. 4, No. 4, p. 355, pl. 32, fig. 3.

Pseudoclavulina mexicana (Cushman), Cushman, 1937, Cushman Lab. Foram Res., Special Publ., No. 7, p. 117, pl. 16, figs, 5-11; Coryell and Rivero, 1940, Jour. Paleont., vol. 14, No. 4, p. 325, pl. 43, fig. 4; Palmer, 1940, Mem. Soc. Cubana Hist. Nat., vol. 14, No. 2, p. 120, pl. 18, fig. 11.

Rare specimens with a very short triserial portion are quite similar to the form figured by Cushman and Jarvis from Buff Bay.

Genus **BARBOURINELLA** Bermudez, 1939

Barbourinella bermudezi, n. sp. Plate 1, figs. 1a-b

Test of medium size for the genus, elongated, triserial and triangular in cross section throughout; broadest in the middle, narrowing to the bluntly pointed apex and truncated apertural extremities; angles acute; sutures very slightly depressed and inconspicuous; aperture a short tube in the face of the final chamber, removed from the margin; surface finely arenaceous with much cement. Rather rare at Bowden.

Length of holotype, 0.7 mm.; maximum diameter, 0.38 mm.

The new species differs from *B. atlantica* Bermudez[20] in having only slightly depressed sutures and smoothly finished surface with much cement.

Holotype.—No. 20040, Paleontological Research Institution.

20 Bermudez, Pedro J.: *Nuevo genero y especies nuevas de foraminiferos,* Mem. Soc. Cubana Hist. Nat., vol. 13, No. 1, 1939, p. 10, pl. 1, figs. 1-4.

Family **VALVULINIDÆ**

Genus **CLAVULINA** d'Orbigny, 1826

Clavulina tricarinata d'Orbigny

Clavulina tricarinata d'Orbigny, 1839, in De la Sagra, Hist. Phys., Pol., Nat. Cuba, ''Foraminifères'', p. 111, pl. 2, figs. 16-18; Galloway and Heminway, 1941, Sci. Surv. Porto Rico, vol. 3, New York Acad. Sci., p. 326, pl. 7, fig. 8.

Very rare.

Genus **DOROTHIA** Plummer, 1931

Dorothia caribæa Cushman

Dorothia caribaea Cushman, 1936, Special Publ., No. 6, Cushman Lab. Foram. Res., p. 31, pl. 5, fig. 3; 1937, Special Publ., No. 8, p. 99, pl. 11, fig. 5.

Very rare. A single specimen from Palmer Sta. 1 agrees well with the figure of the type which came from an *Atlantis* station in 305 fathoms off Cabo Cruz, Cuba.

Genus **LISTERELLA** Cushman, 1933

Listerella nodulosa (Cushman)

Clavulina communis Brady, 1884, (in part), Rept. Voy. *Challenger*, Zoöl. vol. 9, p. 394, pl. 48, figs. 9-13; Cushman and Jarvis, 1940, Jour. Paleont., vol. 4, No. 4, p. 356, pl. 32, fig. 4.

Clavulina communis d'Orbigny var. *nodulosa* Cushman, 1922, U. S. Nat. Mus., Bull. 104, pt. 3, p. 85, pl. 18, figs. 1-3.

Listerella nodulosa (Cushman), Cushman, 1937, Cushman Lab. Foram. Res., Spec. Publ., No. 8, p. 150, pl. 17, figs. 13-19.

Very rare; immature specimens are tentatively assigned to this species. They comprise an expanded fusiform apex with 3 or 4 rectilinear chambers separated by distinct, moderately depressed sutures. Determination of species is unsatisfactory from immature specimens; they most closely resemble the apical extremity of Atlantic specimens figured by Cushman (1937, figs. 16 and 19) and are quite close to the specimens from Buff Bay, Jamaica (Cushman and Jarvis, 1940, listed as *C. communis*) except that the apex is regularly fusiform.

Genus **TEXTULARIELLA** Cushman, 1927

Textulariella barrettii (Jones and Parker)

Textularia barrettii Jones and Parker, 1863, Rep. Brit. Assoc. Newcastle Meeting, pp. 80, 105; 1876, Ann. Soc. Mal. Belg. vol. 11, p. 99, text fig.; Cushman, 1919, Carnegie Inst. Washington, Publ. 291, p. 31, pl. 6, figs. 5-7; 1922, U. S. Nat. Mus., Bull. 104, pt. 3, p. 20, pl. 3, figs. 3-6.

Textulariella barrettii (Jones and Parker), Palmer, 1936, Mem. Soc. Cubana Hist. Nat., vol. 9, No. 4, p. 239; Cushman, 1937, Cushman Lab. Foram. Res., Special Publ., No. 8, p. 66, pl. 7, figs. 5-8; Palmer, 1938, Mem. Soc. Cubana Hist. Nat., vol. 12, No. 4, p. 299, pl. 23, fig. 14; Coryell and Rivero, 1940, Jour. Paleont., vol. 14, No. 4, p. 325; Galloway and Heminway, 1941, New York Acad. Sci., Sci. Survey Porto Rico and Virgin Islands, vol. 3, pt. 4, p. 332, pl. 7, fig. 9.

This species was common in the material examined by Cushman. It is occasional in the Bowden samples at hand. Specimens resemble those figured by Cushman (1919). They are with difficulty distinguished from those believed to be immature *Cuneolina? angusta* Cushman. Several characters have been used in separating the two forms: specimens referred to *Textulariella* are usually slightly less compressed than those referred to *Cuneolina?*; the sutures are very slightly elevated and the margin of the final chamber is angled in the former while in the latter the sutures are gently depressed and the margin of the final chamber is well rounded.

The constant association of *Textulariella barrettii* with *Cuneolina?* in the Tertiary and Recent of the Caribbean area, as well as their morphological relationship, has been repeatedly noted and it is believed that some specimens figured as *Textulariella barrettii* are actually *Cuneolina? angusta* C. (Palmer, 1938). Therefore not only the specific but also the generic determination should be reëxamined. Since the genotype came from the Caribbean Sea it is hoped that the study of the *"Atlantis"* material from this area will clarify its relationship to the living forms referred to *Cuneolina*.

This species is widely distributed in the Caribbean area. Cushman (1922) recorded it from 37 to 338 fathoms. Norton[21] found it at 60 fathoms and made the following comment: "Like the *Textularia,* this genus usually appears at shallow depths, although Flint records it off the Bahamas in 338 fathoms."

Genus **CUNEOLINA** d'Orbigny, 1839

Cuneolina? angusta Cushman

Textularia trochus Goës, 1882, Kongl. Svensk. Vet. Akad. Handl., vol. 19, No. 4, p. 80, pl. 5, figs. 167-70; pl. 6, figs. 171, 172. Not D'Orbigny.

Cuneolina pavonia Jones and Parker, 1876, Ann. Soc. Mal. Belg., vol. 11, p. 98; Hill, 1899, Bull. Mus. Comp. Zoöl., vol. 34, p. 147; Cushman, 1919, Carnegie Inst. Washington, Publ. 291, p. 34, pl. 7, fig. 1. Not

21 Norton, Richard D.: *Ecologic relations of some Foraminifera,* Bull. Scripps Inst. Oceanography, La Jolla, California, Tech. Ser., vol. 2, No. 9, 1930, p. 337.

D'Orbigny.
Textularia barrettii Flint, 1897 (1899) Ann. Rept. U. S. Nat. Mus., p. 285, pl. 30, fig. 2. Not Jones and Parker.
Cuneolina pavonia d'Orbigny var. *angusta* Cushman, 1919, Carnegie Inst. Washington, Publ. 291, p. 34, pl. 7, fig. 2.
Cuneolina angusta Cushman, 1922, U. S. Nat. Mus., Bull. 104, pt. 3, p. 53, pl. 10, figs. 1-3; 1937, Cushman Lab. Foram. Res., Special Publ., No. 8, p. 69, pl. 7, figs. 19-22; Palmer, 1938, Mem. Soc. Cubana Hist. Nat., vol. 12, No. 4, p. 296, pl. 19, fig. 5, pl. 20, figs. 15-17, 20; pl. 21, figs. 3-5; pl. 23, figs. 1-3.
Cuneolina angusta Cushman var. *lata* Cushman, 1922, U. S. Nat. Mus., Bull. 104, pt. 3, p. 54; Palmer, 1938, Mem. Soc. Cubana Hist. Nat., vol. 12, No. 4, p. 297, pl. 19, fig. 2, pl. 23, figs. 5-7.

This is one of the most conspicuous species in the Bowden samples. Most of the specimens are of average size for the Tertiary and Recent forms referred to this genus and are narrow in side view; occasional specimens are very large and flabelliform, attaining 6 mm. in maximum diameter. Both of these forms were reported by Dr. Cushman (1919), the broad form being referred to *C. pavonia* d'Orbigny and the narrow one to a new variety *angusta*.

In the monograph of the Textulariidæ of the Atlantic Ocean, Dr. Cushman (1922, p. 53) indicated his conclusion that the specimens in the Bowden marl were undoubtedly distinct from the Cretaceous *C. pavonia* d'Orbigny. The narrow form occurring at Bowden was considered the same as the living Caribbean species and consequently the name, *C. angusta,* was applied to both. At the same time the broad form occurring at Bowden was given a new varietal name, *lata,* with the note that it had not been found in the Recent material.

In the revision of the Valvulinidæ (1937, p. 69) Dr. Cushman concluded that the flabelliform specimens from Bowden, *C. angusta* var. *lata,* were probably the megalospheric representative of the species and it was therefore placed in synonymy with *C. angusta.*

The genus has been living in the Caribbean area from late Oligocene time. *C. cojimarensis* Palmer, described from the upper Oligocene of Cuba (1938, p. 298; 1940, p. 122), is distinct from the species living in Cuban waters, of which abundant specimens are available for comparison, and also from the Cuban

Miocene species. Unfortunately, at the time this species was described the specimens from Bowden were not available for comparison but the original description and figures indicated specific distinction which has been corroborated by examination of actual specimens.

The specimens from Bowden have been examined with care. In spite of the fact that they are not uncommon in the collection, scarcely any can be found in which the apex is not eroded. From the partial sections prepared it has been concluded that the broad form is probably microspheric (not megalospheric as suspected by Dr. Cushman) and the narrow form is megalospheric. Both forms are therefore referred to the species *C. angusta*. As stated above, the species is distinct from the upper Oligocene *C. cojimarensis* Palmer. It also appears to be distinct from the living Caribbean form as reference to the figures and discussion of the genus indicates (Palmer, 1938). This specific distinction is emphasized by the absence of the broad member of the pair from the Recent fauna. The living specimens are being carefully studied and sectioned and the results will soon be available. Since the type of *C. angusta* came from Bowden the specific reference of the living form is not involved in this re-study of Bowden specimens.

The generic reference of these specimens is not satisfactory. *Cuneolina pavonia* d'Orbigny, the genotype, came from the Senonian of France. Comparative Cretaceous material is not available. However, specimens closely resembling *C. conica* d'Orbigny, as figured by Schlumberger, have been found in upper Cretaceous deposits in the Caribbean area (Palmer, *op. cit.* 1938, p. 295). These are with little doubt generically distinct from the Tertiary and Recent species which have been referred to *Cuneolina*. Also, these Tertiary and Recent species of *Cuneolina?* are closely related to *Textulariella barrettii* (Jones and Parker), the type of that genus. In fact, immature specimens believed to be *C. angusta* are with difficulty distinguished from *T. barrettii*. The revision of the generic nomenclature therefore involves not only the careful study of the Cretaceous genotype of *Cuneolina* but also the study of the relationship of the living species referred to *Cuneolina* with *Textulariella barrettii*.

This species is occasional at Bowden but conspicuous because of its size. The living species of *Cuneolina* has been reported by Cushman as common at 100 fathoms.

Genus **LIEBUSELLA** Cushman, 1933

Liebusella soldanii (Jones and Parker)

Lituola soldanii Jones and Parker, 1860, Quart. Jour. Geol. Soc., vol. 16, p. 307, No. 184; Carpenter, Parker and Jones, 1862, Introd. Foram., pl. 6, figs. 42, 43; Jones and Parker, 1876, Ann. Soc. Malac. Belg. vol. 11, p. 98.

Liebusella soldanii (Jones and Parker), Cushman, 1937, Cushman Lab. Foram. Res., Special Publ., No. 8, p. 166, pl. 20, figs. 1-11; Palmer, 1938, Mem. Soc. Cubana Hist. Nat., vol. 12, No. 4, p. 282, pl. 19, figs. 1, 3, 6, 9, 10; pl. 20, figs. 6, 7; pl. 22, figs. 21, 22 (see synonymy).

Lituola soldanii Jones and Parker var. *intermedia* Van den Broeck, 1876, Ann. Soc. Belge Micr., vol. 2, p. 74, pl. 2, figs. 1, 3, 4, 6.

Haplostiche dubia (d'Orbigny) var. *intermedia* (Van den Broeck), Cushman, 1919, Carnegie Inst. Washington, Publ. 291, p. 30, pl. 6, figs. 1-4; Cushman and Jarvis, 1930, Jour. Paleont., vol. 4, No. 4, p. 354, pl. 32, fig. 1.

Liebusella soldanii (Jones and Parker) var. *intermedia* (Van den Broeck) Cushman, 1937, Cushman Lab. Foram. Res., Special Publ., No. 8, p. 167, pl. 20, figs. 12-14; Palmer, 1938, Mem. Soc. Cubana Hist. Nat. vol. 12, No. 4, p. 285, pl. 19, figs. 4, 7, 8; pl. 20, fig. 1; pl. 21, figs. 1, 2; pl. 22, figs. 17-20 (see synonymy).

Two forms are conspicuous and abundant in the Bowden samples. The elongate form with well-depressed sutures (var. *intermedia*) is more abundant than the short, stout, smaller form with less conspicuous sutural depressions. Partial sections indicate that the var. *intermedia* is microspheric and the typical species is megalospheric. For this reason the variety has been placed in the synonymy.

The occurrence of this species in the Caribbean area has been discussed in detail (Palmer, D. K., 1938). Specimens from the upper Oligocene of Cuba are much smaller than those from the Miocene and Recent but are otherwise typical. The specimen figured as var. *intermedia* by Cushman and Jarvis from Buff Bay, Jamaica, is smaller than the average microspheric specimen from Bowden and lacks the pronounced sutural depressions and is considered more probably a megalospheric specimen (Palmer, 1938, p. 287). The typical species are not listed from Bowden by Cushman in 1919 but later (1937, p. 167) he noted that it does occur there occasionally.

The abundance of this species in the Bowden samples gives it importance as an index to the conditions under which the sediments accumulated. The following are records of its occurrence in the Caribbean:

Brady, H. B., (1884), 40-435 fms.[22]

Flint, J. M., (1897), 196-210 fms.[23]

Cushman, J. A., (1920), 60-210 fms.[24]

Family MILIOLIDÆ

Genus QUINQUELOCULINA d'Orbigny, 1826

Quinqueloculina collumnosa Cushman

Quinqueloculina collumnosa Cushman, 1922, Carnegie Inst. Washington, Publ. 311, p. 65, pl. 10, fig. 10; 1929, U. S. Nat. Mus., Bull. 104, pt. 6, p. 27, pl. 3, fig. 2.

A single specimen found in Hedberg's sample resembles the type except that the aperture is not so elongate and may have been broken.

Quinqueloculina lamarckiana d'Orbigny

Quinqueloculina lamarckiana d'Orbigny, 1839, in De la Sagra, Hist. Phys., Pol., Nat. Cuba, "Foraminifères", p. 189, pl. 11, figs. 14, 15; Cushman, 1922, Carnegie Inst. Washington, Publ. 311, p. 64; 1929, U. S. Nat. Mus., Bull. 104, pt. 6, p. 26, pl. 2, fig. 6; 1930, Florida State Geol. Survey, Bull. 4, p. 20, figs. 3-5.

Only occasional but the most common of the Miliolidæ. The specimens may be compared with the figure of a specimen from Tortugas, Florida, given by Cushman (1929).

Quinqueloculina cf. Q. panamensis Cushman

Quinqueloculina panamensis Cushman, 1918, U. S. Nat. Mus., Bull. 103, p. 80, pl. 31, fig. 1.

Several specimens rather closely resemble the original figures of this species from the Gatun formation except that they do not become so loosely coiled and the final chamber is not separated from the others.

Quinqueloculina parkeri (Brady) var. bowdenensis Cushman

Quinqueloculina parkeri (Brady) var. *bowdenensis* Cushman, 1919, Carnegie Inst. Washington, Publ. 291, p. 68, pl. 14, fig. 6.

Occasional.

Quinqueloculina cf. Q. philippi Reuss

Quinqueloculina philippi Reuss, 1856, Sitz. k. Akad. Wiss., Wien, vol.

22 Brady, H. B.: Rep. Voy. *Challenger*, Zoöl., vol. 9, 1884, p. 319.

23 Flint, James M.: *Recent Foraminifera. A descriptive catalogue of specimens dredged by the U. S. Fish Commission Steamer Albatross.* Rept. U. S. Nat. Mus., 1897, (1899), p. 277.

24 Cushman, J. A.: *The Foraminifera of the Atlantic Ocean,* U. S. Nat. Mus., Bull. 104, pt. 2, 1920, p. 34.

18, p. 252, pl. 9, fig. 87; Galloway and Heminway, 1941, Sci. Survey Porto Rico and the Virgin Islands, New York Acad. Sci., vol. III, pt. 4, p. 303, pl. 2, fig. 4.

A single specimen closely resembles the specimen figured by Galloway and Heminway and differs from the type figure in having more nearly parallel margins in side view and in having more compressed chambers.

Quinqueloculina cf. Q. polygona d'Orbigny

Quinqueloculina polygona d'Orbigny, 1839, in De la Sagra, Hist. Phys., Pol., Nat. Cuba, "Foraminifères", p. 198, pl. 12, figs. 21-23; Cushman, 1929, U. S. Nat. Mus., Bull. 104, pt. 6, p. 28, pl. 3, fig. 5; Bermudez, 1935, Mem. Soc. Cubana Hist. Nat., vol. 9, No. 3, p. 159.

Very rare. The specimens have less distinctly separated chambers than the type and in this more closely resemble the specimen from Tortugas figured by Cushman (1929).

Genus MASSILINA Schlumberger, 1893

Massilina crenata (Karrer)

Spiroloculina crenata Karrer, 1868, Sitz. Akad. Wiss., Wien, vol. 57, p. 135, pl. 1, fig. 9.

Massilina crenata (Karrer), Cushman, 1929, U. S. Nat. Mus., Bull. 104, pt. 6, p. 38, pl. 7, fig. 5; Bermudez, 1935, Mem. Soc. Cubana Hist. Nat., vol. 9, No. 3, p. 162.

A single poorly preserved specimen from Sta. 1 has indistinct crenulations, resembling in this character the Recent specimens from the coast of Cuba.

Genus SPIROLOCULINA d'Orbigny, 1826

Spiroloculina depressa d'Orbigny

Spiroloculina depressa d'Orbigny, 1826, Ann. Sci. Nat., vol. 7, p. 298; Cushman, 1917, U. S. Nat. Mus., Bull. 71, pt. 6, p. 29, pl. 3, figs. 6, 10; Cushman, 1930, Florida Geol. Survey, Bull. 4, p. 21, pl. 3, fig. 2.

Spiroloculina limbata Brady, 1884, Rep. Voy. *Challenger* Zoöl., vol, 9, p. 150, pl. 9, fig. 15. Not D'Orbigny.

A single specimen from Sta. 1 resembles Brady's species cited above.

Spiroloculina poeyiana d'Orbigny

Spiroloculina poeyiana d'Orbigny, 1840, in De la Sagra, Hist. Fis., Pol., Nat. Cuba, Foraminiferas, (Spanish ed.,) p. 150, pl. 10, figs. 1, 2; Bermudez, 1935, Mem. Soc. Cubana Hist. Nat. vol. 9, No. 3, p. 164.

A single well-preserved specimen from Sta. 574 has strongly inflated, finely costate chambers and closely approaches D'Orbigny's species.

Genus SIGMOILINA Schlumberger, 1887

Sigmoilina cf. S. schlumbergeri A. Silvestri

Sigmoilina schlumbergeri Silvestri, 1904, Mem. Pont. Accad. Nuovi Lincei, vol. 22, p. 267; Cushman, 1929, U. S. Nat. Mus., Bull. 104, pt. 6, p. 49, pl. 11, figs. 1-3; Bermudez, 1935, Mem. Soc. Cubana Hist. Nat., vol. 9, No. 3, p. 164; Palmer, 1940, Mem. Soc. Cubana Hist. Nat., vol. 14, No. 2, p. 125.

Sigmoilina celata schlumbergeri (Silvestri), Coryell and Rivero, 1940, Jour. Paleont., vol. 14, No. 4, p. 324.

Several specimens are doubtfully referred to this species; they are broader in side view and a little more coarsely arenaceous than the Tertiary specimens from the Caribbean region which have been listed as this species.

Sigmoilina tenuis (Czjzek)

Quinqueloculina tenuis Czjzek, 1847, Haidinger's Nat. Abhandl, vol. 2, p. 149, pl. 13, figs. 31-34.

Spiroloculina tenuis (Czjzek), Brady, 1884, Rep. Voy. *Challenger*, Zoöl., vol. 9, p. 152, pl. 10, figs. 7-11.

Sigmoilina tenuis (Czjzek), Cushman, 1918, U. S. Nat. Mus., Bull 103, p. 81, pl. 31, fig. 4; 1930, Florida Geol. Survey, Bull. 4, p. 22, pl. 2, fig. 8; Palmer, 1940, Mem. Soc. Cubana Hist. Nat., vol. 14, No. 2, p. 125.

Very rare.

Genus TRILOCULINA d'Orbigny, 1826

Triloculina brongniartiana d'Orbigny

Triloculina brongniartiana d'Orbigny, 1839, in De la Sagra, Hist. Phys., Pol., Nat. Cuba "Foraminifères" p. 176, pl. 10, figs. 6-8; Cushman, 1919, Carnegie Inst. Washington, Publ. 291, p. 68; Bermudez, 1935, Mem. Soc. Cubana Hist. Nat., vol. 9, No. 3, p. 170; Galloway and Heminway, 1941, New York Acad. Sci., Sci. Survey Porto Rico and the Virgin Islands, vol. 3, pt. 4, p. 306, pl. 3, fig. 2.

A few delicately striate specimens with well-rounded chambers and slightly constricted aperture agree closely with D'Orbigny's description and figures.

Triloculina carinata d'Orbigny

Triloculina carinata d'Orbigny, 1839, in De la Sagra, Hist. Phys., Pol., Nat. Cuba, "Foraminifères", p. 179, pl. 10, figs. 15-17; Cushman, 1922, Carnegie Inst. Washington, Publ. 311, p. 75, pl. 12, fig. 6; 1929, U. S. Nat. Mus., Bull. 104, pt. 6, p. 65, pl. 17, fig. 4; Bermudez, 1935, Mem. Soc. Cubana Hist. Nat., vol. 9, No. 3, p. 169, pl. 12, figs. 1-3.

Very rare. The specimens are similar to the type from the shore sands of Cuba.

Triloculina cf. T. linneiana d'Orbigny

Triloculina linneiana d'Orbigny, 1839, in De la Sagra, Hist. Phys., Pol., Nat. Cuba, "Foraminifères" p. 172, pl. 9, figs. 11-13; Cushman, 1922, Carnegie Inst. Washington, Publ. 311, p. 75; 1929, U. S. Nat. Mus., Bull. 104, pt. 6, p. 61, pl. 16, figs. 1, 2; Bermudez, 1935, Mem. Soc. Cubana Hist. Nat., vol. 9, No. 3, p. 170.

Several poorly preserved specimens appear to belong to this species, though they may be the var. *caloosahatcheënsis* Cole[25]. Sta. 1.

Triloculina quadrilateralis d'Orbigny

Triloculina quadrilateralis d'Orbigny, 1839, in De la Sagra, Hist. Phys., Pol. Nat., Cuba, "Foraminifères", p. 173, pl. 9, figs. 14-16; Cushman, 1921, U. S. Nat. Mus., Proc., vol. 59, p. 71, text fig. 11; Cushman, 1922, Carnegie Inst. Washington, Publ. 311, p. 76; Bermudez, 1935, Mem, Soc. Cubana Hist. Nat., vol. 9, No. 3, p. 171.

A single typical specimen was found at Sta. 1.

Triloculina cf. T. transversestriata (Brady)

Miliolina transversestriata Brady, 1881, Jour. Micr. Sci., vol. 21, p. 45; 1884, Rept. Voy. *Challenger*, Zoöl. vol. 9, p. 177, pl. 4, fig. 6; Heron-Allen and Earland, 1915, Trans. Zool. Soc. London, vol. 20, pt. 17, p. 566, pl. 42, figs. 17-20.

Triloculina transversestriata (Brady), Cushman, 1929, U. S. Nat. Mus., Bull. 104, pt. 6, p. 62, pl. 16, fig. 3; Bermudez, 1935, Mem. Soc. Cubana Hist. Nat., vol. 9, No. 3, p. 171.

Very rare and the specimens are not well preserved. They are similar to the specimen from Tortugas figured by Cushman (1929).

Triloculina tricarinata d'Orbigny

Triloculina tricarinata d'Orbigny, 1826, Ann. Sci. Nat., vol. 7, p. 299, No. 7; 1826, Modeles, No. 94; Brady, 1864, Trans. Linn. Soc. London, vol. 24, p. 446, pl. 48, fig. 3; Cushman, 1919, Carnegie Inst. Washington, Publ. 291, p. 68, pl. 14, fig. 4; Galloway and Heminway, 1941, New York Acad. Sci., Sci. Survey Porto Rico and the Virgin Islands, vol. 3, pt. 4, p. 309, pl. 3, fig. 10.

Rare. The specimens are sharply angled, resembling that figured by Galloway and Heminway (1941).

Genus PYRGO Defrance, 1824

Pyrgo denticulata (Brady) var. striolata (Brady)

Biloculina ringens (Lamarck) var. *striolata* Brady, 1884, Rep. Voy. *Challenger*, Zoöl., vol. 9, p. 143, pl. 3, figs. 7, 8.

Biloculina denticulata (Brady) var. *striolata* (Brady), Cushman, 1922, Carnegie Inst., Washington, Publ. 311, p. 78; 1929, U. S. Nat. Mus., Bull. 104, pt. 6, p. 69, pl. 18, fig. 5.

Very rare specimens are similar to those living in the shallow water of the West Indian area (Cushman, 1929, pl. 18, fig. 5).

25 Cole, W. S.: *The Pliocene and Pleistocene Foraminifera of Florida,* Florida Geol. Survey, Bull. 6, 1931, p. 25, pl. 1, figs. 4-6.

Pyrgo subsphærica (d'Orbigny)

Biloculina subsphaerica d'Orbigny, 1839, in De la Sagra, Hist. Phys., Pol., Nat. Cuba, "Foraminifères", p. 162, pl. 8, figs. 25-27; Cushman, 1922, Carnegie Inst. Washington, Publ. 311, p. 77.

Pyrgo subsphaerica (d'Orbigny), Cushman, 1929, U. S. Nat. Mus., Bull. 104, pt. 6, p. 68, pl. 18, figs. 1, 2; 1930, Florida State Geol. Survey, Bull. 4, p. 23, pl. 3, fig. 5.

Very rare. The specimens resemble that from the Choctawhatchee Miocene figured by Cushman (1930).

Family OPHTHALMIDIIDÆ

Genus VERTEBRALINA d'Orbigny, 1826

Vertebralina, sp.

A single worn specimen from locality 574 has the size and form of *V. insignis* Brady[26] but is worn and shows no ornamentation.

Family PLACOPSILINIDÆ

Genus HADDONIA Chapman, 1898

Haddonia, sp.

A single specimen comprising about six loosely coiled chambers was found at Sta. 1. The test is finely arenaceous, well cemented and one chamber shows the characteristic crescent-shaped aperture. The maximum diameter of the fragmentary specimen is 4.5 mm.

This incomplete specimen cannot be referred to *H. minor* Chapman, a species listed from Bowden by Cushman[27] since it is more closely coiled than that species appears to be in the original figure and the aperture is a narrower longer crescent.

Family LAGENIDÆ

Genus ROBULUS Montfort, 1808

Robulus calcar (Linnæus)

Nautilus calcar Linnæus, 1758, Systema Naturæ, ed. 10, p. 709.

Cristellaria calcar (Linnæus), Jones and Parker, 1876, Ann. Soc. Malac. Belg., vol. 11, p. 98; Cushman, 1923, U. S. Nat. Mus., Bull. 104, pt. 4, p. 115, pl. 31, figs. 4, 5; pl. 30, fig. 7.

Robulus calcar (Linnæus), Galloway and Morrey, 1929, Bull. Amer. Paleont., vol. 15, No. 55, p. 20, pl. 2, fig. 10; Cushman, 1929, Contr. Cushman Lab. Foram. Res., vol. 5, pt. 4, p. 84, pl. 12, fig. 18; Cushman and Jarvis, 1930, Jour. Paleont., vol. 4, No. 4, p. 358, pl. 32, fig. 9; Coryell and Rivero, 1940, Jour. Paleont., vol. 14, No. 4, p. 332, pl. 41, fig. 9.

26 Brady, H. B.: Rept. Voy. *Challenger*, Zool., vol. 9, 1884, p. 187, pl. 12, figs. 9-11.

27 Cushman, Joseph A.: *Fossil Foraminifera from the West Indies*, Carnegie Inst. Washington, Publ. 291, 1919, p. 31.

Lenticulina calcar (Linnæus), Palmer, 1940, Mem. Soc. Cubana Hist. Nat., vol. 14, No. 2, p. 127.

Occasional. The specimens are strongly biconvex with few chambers and sutures flush with the surface. A few specimens resemble the specimen from the Atlantic figured by Cushman (1923) in having a few, long, slender spines. The majority of the specimens, however, have short, poorly developed spines as illustrated by Cushman (1929).

Robulus calcar (Linnæus) var. aspinosa (Cushman)

Cristellaria calcar (Linnæus) var. *aspinosa* Cushman, 1919 Carnegie Inst. Washington, Publ. 291, p. 37, pl. 6, fig. 8.

Only a few specimens of this variety, described from the type locality of the Bowden, have been found in the material examined. They differ from the typical species in having more chambers and the spines so reduced that they may be merely short, angular projections on the peripheral margin.

Robulus clericii (Fornasini)

Cristellaria clericii Fornasini, 1895, "*Cristellaria clericii* n. sp." Bologna, text fig.; 1901, Acad. Sci. Ist. Bologna, Mem., ser. 5, vol. 9, p. 65, fig. 17 (in text).

Robulus clericii (Fornasini), Cushman, 1929, Contr. Cushman Lab. Foram. Res., vol. 5, pt. 4, p. 84, pl. 12, figs. 16, 17; Coryell and Rivero, 1940, Jour. Paleont., vol. 14, No. 4, p. 332, pl. 43, fig. 7.

A single specimen from Sta. 1 agrees well with the figures given by Cushman (1929).

Robulus cf. R. cultratus Montfort

Robulus cultratus Montfort (?), 1808, Conch. Syst., vol. 1, p. 214, 54e genre.

Cristellaria cultrata (Montfort), Jones and Parker, 1876, Ann. Soc. Malac. Belg., vol. 11, p. 98; Cushman, 1913, U. S. Nat. Mus., Bull. 71, pt. 3, p. 64, pl. 29, fig. 4.

Rare specimens resemble that figured by Cushman (1913) from the Pacific. They differ from *R.* cf. *R. rotulatus* by the possession of a well-developed keel.

Robulus falcifer (Stache)

Cristellaria falcifer Stache, 1864, *Novara*-Exped., Geol. Theil, vol. 1, p. 240, pl. 23, fig. 19.

Robulus falcifer (Stache), Galloway and Heminway, 1941, New York Acad. Sci., Sci. Survey Porto Rico and Virgin Islands, vol. 3, pt. 4, p. 349, pl. 12, figs. 5, 6.

Very rare. The specimens resemble that figured by Galloway and Heminway (1941) from the Quebradilla formation, lower Miocene, of Puerto Rico.

Robulus cf. R. foliatus (Stache)

Robulus foliata Stache, 1864, *Novara*-Exped., Geol. Theil, vol. 1, pt. 2, p. 245, pl. 23, fig. 24.

Very rare. Specimens referred to this species differ from *R. chambersi* Garrett[28] in that the sutures are very narrow and not elevated.

Robulus cf. R. iota (Cushman)

Cristellaria iota Cushman, 1923, U. S. Nat. Mus., Bull. 104, pt. 4, p. 111, pl. 29, fig. 2; pl. 30, fig. 1.

Robulus iotus (Cushman), Cushman and Cahill, 1933, U. S. Geol. Survey, Prof. Paper 175, p. 12, pl. 4, fig. 1.

Rare. The specimens are close coiled with numerous chambers and a broad peripheral keel, resembling the type which came from 196 fathoms in the northern part of the Gulf of Mexico.

Robulus occidentalis (Cushman) var. torrida (Cushman)

Cristellaria occidentalis Cushman var. *torrida* Cushman, 1923, U. S. Nat. Mus., Bull. 104, pt. 4, p. 105, pl. 25. fig. 1.

Robulus occidentalis (Cushman) var. *torridus* (Cushman), Cushman and Jarvis, 1930, Jour. Paleont., vol. 4, No. 4, p. 357, pl. 32, fig. 8; Galloway and Heminway, 1941, New York Acad. Sci., Sci. Survey Porto Rico and the Virgin Islands, vol. 3, pt. 4, p. 349, pl. 12, fig. 4.

Very occasional specimens closely resemble the specimen figured from Buff Bay (Cushman and Jarvis, 1930).

Robulus rotulatus (Lamarck)

Lenticulites rotulata Lamarck, 1806, Ann. Mus. Hist. Nat., vol. VIII p. 188, pl. 62, fig. 11.

Cristellaria rotulata (Lamarck), Jones and Parker, 1876, Ann. Soc. Belgique, vol. 11, p. 98; Cushman, 1918, U. S. Nat. Mus., Bull. 103, p. 60, pl. 22, fig. 1.

Lenticulina rotulata (Lamarck), Tolmachoff, 1934, Ann. Carnegie Mus., vol. 23, p. 207, pl. 40, figs. 11-12.

This species has been frequently listed from many horizons in many parts of the world. Dr. Cushman[29] concluded that the type is from the Upper Cretaceous and the long list of references undoubtedly involves a number of closely related species. In listing this species from the Bowden formation we are following Tolmachoff (1934) in using the name for the form with a small, biconvex test, periphery sharp but not keeled, chambers not more

[28] Garrett, J. B.: *Some middle Tertiary smaller Foraminifera from subsurface beds of Jefferson County, Texas,* Jour. Paleont., vol. 13, No. 6, 1939, p. 576, pl. 65, figs. 8, 9.

[29] Cushman, J. A.: *Notes on the collection of Defrance,* Contr. Cushman Lab. Foram, Res., vol. 3, pt. 3, 1927, p. 142, pl. 28, fig. 7.

than nine in the final whorl, sutures almost radial, flushed with the surface and ending in the umbonal deposit which is also flush with the general contour of the test. Specimens are occasional in the Bowden material and are of the type assigned to this species from the middle Tertiary of the Canal Zone (Cushman, 1918).

Robulus cf. R. submamilligerus (Cushman)

Cristellaria mamilligera Brady 1884, Rept. Voy. *Challenger*, Zoöl., vol. 9, p. 553, pl. 70, figs. 17, 18; Cushman, 1913, U. S. Nat. Mus., Bull. 71, pt. 3, p. 74, pl. 34, fig. 6a (not 6b which should read 5b)). Not Karrer.

Cristellaria submamilligera Cushman, 1921, Proc. U. S. Nat. Mus., vol. 51, p. 657; 1921, U. S. Nat. Mus., Bull. 100, vol. 4, p. 235; 1923, U. S. Nat. Mus., Bull. 104, pt. 4, p. 109, pl. 28, fig. 3.

Very rare specimens agree quite closely with Brady's figures (1884).

Genus **LENTICULINA** Lamarck, 1804

Lenticulina bowdenensis (Cushman)

Cristellaria bowdenensis Cushman, 1919, Carnegie Inst. Washington, Publ. 291, p. 37, pl. 8, fig. 2.

? *Cristellaria antillea* Cushman, 1923, Bull. U S. Nat. Mus., vol., 104, pt. 4, p. 116, pl. 31, fig. 1; pl. 32, fig. 1; pl. 33, fig. 1; pl. 34, fig. 1.

This handsome species is moderately common in the Bowden samples. Specimens attain a maximum diameter of 4 mm. The early chambers are planispirally arranged and the entire test is strongly compressed. The aperture is peripheral but seldom well preserved. One perfect specimen, with a maximum diameter of 3.8 mm., has a slightly smaller planispiral portion than the majority of the specimens and the last two chambers show a definite tendency toward rectilinear development. The aperture of this perfect specimen is radiate without a robuline slit.

Specimens of the living *Cristellaria antillea* Cushman have not been available for comparison but examination of the description and figures fails to show any constant characters which may be used to distinguish it from the Bowden species. The specimen of *C. antillea* figured on plate 31, figure 1 (Bull. 104, pt. 4) has more inflated chambers and less beading on the sutures; the other specimens figured are very similar to Bowden specimens of *L. bowdenensis.*

Genus PLANULINA d'Orbigny, 1826

Planularia woodringi, n. sp. Plate 1, figs. 7a-b

Cristellaria gemmata Cushman, 1919, Carnegie Inst. Washington, Publ. 291, p. 38. Not Brady.

Test large for the genus; compressed, lateral faces almost parallel; early chambers closely coiled; later uncoiled and about 11 visible in the adult specimen; sutures extending obliquely from the coiled portion and gradually separating from it. Sutures marked by rows of beads which become elongated at right angles to the suture in mature specimens. Periphery truncated and bearing a thin, sharp, narrow median keel and lateral keels. The latter are formed by the coalescence of elongated sutural beads and are consequently not uniformly developed on the entire margin. The keels are frequently weak between the sutures and seldom present on the earliest chambers. Apertural face flat to slightly concave; aperture radiate and protruding at the outer peripheral margin. Surface smooth between the sutures.

Length of holotype, 2.06 mm.; breadth, 1.27 mm.; maximum thickness of apertural face, 0.24 mm.

The new species is distinguished from *Cristellaria gemmata* Brady[30] by the well-developed median keel and the tendency for the development of lateral keels in mature specimens. Also the later chambers of the new species recede regularly from the coiled portion of the test and the test between the beaded sutures is smooth.

The living *C. gemmata* Brady was recorded from 95 to 210 fathoms in the Indo-Pacific.

Holotype.—No. 20041, Paleontological Research Institution. Palmer Sta. I.

Genus ASTACOLUS Montfort, 1808

Astacolus crepidula (Fitchel and Moll)

Nautilus crepidula Fitchel and Moll, 1803, Text. Micr., p. 107, pl. 19, figs. g-i.

Cristellaria crepidula (Fitchel and Moll), Brady, 1884, Voy. *Challenger*, Zoöl., vol. 9, p. 542, pl. 67, figs. 17, 19, 20; pl. 68, figs. 1, 2; Cushman, 1923, U. S. Nat. Mus., Bull. 104, pt. 4, p. 117, pl. 35, figs. 3, 4; Nuttall, 1928, Quart. Jour. Geol. Soc. London, vol. 84, pt. 1, p. 89.

Rare. Specimens resemble Cushman's figure 3, 1923, cited

30 Brady, H. B.: Rept. Voy. *Challenger*, Zoöl., vol. 9, 1884, p. 554, pl. 71, figs. 6, 7.

above. In the *Albatross* collections this species was recorded from 56 to 417 fathoms, rare except at 60 fathoms.

Genus **DENTALINA** d'Orbigny, 1826

Dentalina cf. D. baggi Galloway and Wissler

Dentalina baggi Galloway and Wissler, 1927, Jour. Paleont., vol. 1, No. 1, p. 49, pl. 8, figs. 14, 15.

Very rare; incomplete specimens are with some doubt referred to this species described and figured from the Pleistocene of California.

Dentalina vertebralis (Batsch)

Nautilus (Orthoceras) vertebralis Batsch, 1791, Conch., Seesandes, p. 3, No. 6, pl. 2, fig. 6.

Nodosaria vertebralis (Batsch), Cushman, 1919, Carnegie Inst. Washington, Publ. 291, p. 25, pl. 7, figs. 3-5; Cushman and Jarvis, 1930, Jour. Paleont., vol. 4, No. 4, p. 360.

Dentalina vertebralis (Batsch), Cushman, 1931, Contr. Cushman Lab. Foram. Res., vol. 7, pt. 3, p. 66, pl. 8, figs. 20, 21; Coryell and Rivero, 1940, Jour. Paleont., vol. 14, No. 4, p. 327, pl. 42, figs. 1, 3.

Occasional specimens like those figured by Cushman (1919) have been found. Specific identification of this species from fragmentary specimens would be difficult, as inspection of Cushman's figures shows. The specimens attain 7.5 mm. in length and the early chambers are not inflated though the later chambers are distinctly inflated and the sutures are depressed. Cushman carefully searched his material from Rimini for a complete specimen but failed to find one; the specimen he figured (1931) shows continuous costæ and noninflated chambers and approximates the early part of microspheric Bowden specimens.

This species was found in an *Albatross* collection from 169 fathoms in the north Atlantic.

Genus **LAGENONODOSARIA** Silvestri, 1900

Lagenonodosaria, sp.

Several fragmentary specimens comprising only two or three chambers have been found. One type of smooth, oval, well-separated chambers recalls *L. pyrula* (d'Orbigny); others have round only slightly separated and slightly hispid chambers.

Genus **SARACENARIA** Defrance, 1824

Saracenaria cushmani, n. sp. Plate 1, figs. 5 a-b.

Test small for the genus, triangular in cross section; early chambers closely coiled, final two or three tending to become rectilinear; margin sharp but not keeled; early sutures inconspicuously beaded; later sutures limbate and elevated, particularly near the ventral margin. Aperture radiate and protruding, situated on the apex of the final chamber. Apertural face of final chamber triangular; first rectilinear chamber slightly overhanging the preceding; later one receding. Occasional.

Maximum length of holotype, 0.76 mm.

In type of ornamentation this species recalls *Cristellaria subaculeata* Cushman var. *glabrata* Cushman[31], *Robulus senni* Cushman and Renz[32], and *Robulus vaughani* (Cushman)[33] but differs from all of them in that the mature test is definitely triangular in cross section.

Holotype.—No. 20042, Paleontological Research Institution. Palmer Sta. 1.

Saracenaria italica Defrance

Saracenaria italica Defrance, 1824, Dict. Sci. Nat., vol. 32, p. 177.
Cristellaria italica (Defrance), Jones and Parker, 1876, Ann. Soc. Mal. Belg. vol. 11, p. 98; Cushman, 1919, Carnegie Inst. Washington, Publ. 291, p. 38; 1923, U. S. Nat. Mus., Bull. 104, pt. 4, p. 125, pl. 35, figs. 2, 5-7.

A single broken specimen was found. Jones and Parker listed this species from the "Pteropod marl". Cushman did not find it in his material from Bowden.

Genus **VAGINULINA** d'Orbigny, 1826

Vaginulina clavata Costa

Vaginulina clavata Costa, 1855, (1857), Mem. Accad. Sci. Napoli, vol. 2, p. 145, pl. 2, fig. 18; Cushman and Jarvis, 1930, Jour. Paleont., vol. 4, No. 4, p. 359, pl. 32, fig. 12; Palmer and Bermudez, 1936, Mem. Soc. Cubana Hist. Nat., vol. 10, No. 5, p. 277, pl. 17, figs. 3, 4.

Rare specimens closely resemble the specimen from Buff Bay figured by Cushman and Jarvis.

Vaginulina? cf. V. peregrina Cushman

Vaginulina peregrina Cushman, 1923, U. S. Nat. Mus., Bull. 104, pt. 4, p. 134, pl. 39, fig. 5.
Nodosaria communis d'Orbigny, Cushman, 1923, U. S. Nat. Mus. Bull. 104, pt. 4, p. 75, pl. 12, fig. 4 "compressed or vaginuline form" after Heron-Allen and Earland.

Very rare. The specimen closely resembles the original figure

[31] Cushman, J. A.: *Foraminifera of the Atlantic Ocean*, U. S. Nat. Mus., Bull. 104, pt. 4, 1923, p. 124, pl. 32, fig. 4.

[32] Cushman, J. A., and Renz, H. H.: *New Oligocene-Miocene Foraminifera from Venezuela*, Contr. Cushman Lab. Foram. Res., vol. 17, pt. 1, 1941, p. 12, pl. 2, figs. 14, 15.

[33] Cushman, J. A., and Ponton, G. M.: *The Foraminifera of the upper, middle and part of the lower Miocene of Florida*, Florida State Geol. Survey, Bull. No. 9, 1932, p. 59, pl. 8, figs. 5-10.

but is a microspheric form with more chambers. The dorsal margin is slightly more lobate and curved than that of the compressed or vaginuline form of *Nodosaria communis* cited above.

Genus **FRONDICULARIA** Defrance, 1826

Frondicularia sagittula Van den Broeck

Frondicularia alata d'Orbigny var. *sagittula* Van den Broeck, 1876, Ann. Soc. Belg. Micr., vol. 2, p. 113, pl. 2, figs. 12, 14.

Frondicularia sagittula Van den Broeck, Cushman, 1923, U. S. Nat. Mus., Bull. 104, pt. 4, p. 143, pl. 21, fig. 2; Cushman, 1943, Contr. Cushman Lab. Foram. Res., vol. 19, pt. 2, p. 25, pl. 5, pl. 6, figs. 1-3.

Frondicularia alata d'Orbigny, Cushman, 1918, Carnegie Inst. Washington, Publ. 291, p. 36, pl. 8, fig. 1.

In spite of their fragile tests specimens are occasional in the material examined. The specimens vary greatly in outline. Both megalospheric and microspheric forms are present (the former being the more abundant), and they closely resemble the specimens from off Puerto Rico figured by Cushman (1943). A broken specimen closely resembling the Bowden specimen figured by Cushman (1918) has a maximum diameter of 4 mm.

The species and its variety are reported in the Caribbean area between 37 and 399 fathoms.

Genus **LAGENA** Walker and Jacob, 1789

Lagena hexagona (Williamson) var. **scalariformis** (Williamson)

Entosolenia squamosa (Montagu) var. *scalariformis* Williamson, 1858, Recent Foraminifera of Great Britain, p. 13, pl. 1, fig. 30.

Lagena hexagona (Williamson) var. *scalariformis* (Williamson), Cushman, 1913, U. S. Nat. Mus., Bull. 71, pt. 3, p. 17, pl. 6, fig. 4; Cushman and Cahill, 1933, U. S. Geol. Survey, Prof. Paper 175, p. 15, pl. 5, fig. 9 (references); Palmer and Bermudez, 1936, Mem. Soc. Cubana Hist. Nat., vol. 9, No. 4, p. 239.

Very rare.

Lagena cf. L. marginata (Walker and Boys)

Serpula (*Lagena*) *marginata* Walker and Boys, 1784, Test. Min., p. 2, pl. 1, fig. 7.

Lagena marginata (Walker and Boys), Brady, 1884, Rept. Voy. *Challenger*, Zoöl., vol. 9, p. 476, pl. 59, figs. 21-23.

Small, very rare specimens.

Lagena marginato-perforata Seguenza

Lagena marginato-perforata Seguenza, 1880, Atti. Accad. Lincei, ser. 3, vol. 6. p. 332, pl. 17, fig. 34; Heron-Allen and Earland, 1915, Trans. Zoöl. Soc. London, vol. 20, p. 663, pl. 50, figs. 24-30; Palmer and

Bermudez, 1936, Mem. Soc. Cubana Hist. Nat., vol. 9, No. 4, p. 239, pl. 20, fig. 14.

Rare. The specimens resemble those from the late Tertiary of the Canímar River region, Cuba (Palmer and Bermudez, 1936); they differ from the specimen figured as *L.* cf. *marginato-perforata* (Seguenza) from the Yorktown formation of Virginia[34] in having a well-developed keel.

Family POLYMORPHINIDÆ

Genus GUTTULINA d'Orbigny, 1839

Guttulina cf. lactea (Montagu) var. earlandi Cushman and Ozawa

Guttulina lactea (Montagu) var. *earlandi* Cushman and Ozawa, 1930, U. S. Nat. Mus., Proc., vol. 77, art. 6, p. 45, pl. 10, fig. 5; Cushman, 1930, Florida Geol. Survey, Bull. 4, p. 34, pl. 5, fig. 19.

A single specimen resembles the Florida Miocene specimen figured by Cushman (1930) in general form. It does not appear to have been attached as was the type.

Genus RAPHANULINA Zborzewski, 1834

Raphanulina gibba (d'Orbigny)[35]

Globulina gibba d'Orbigny, 1826, Ann. Sci. Nat., vol. 7, p. 266, No. 10, Modeles. No. 63; 1846, Foram. Foss. Bass. Tert. Vienne, p. 227, pl. 13, figs. 13, 14; Cushman and Ozawa, 1930, U. S. Nat. Mus., Proc., vol. 77, art. 6, p. 60, pl. 16, figs. 1-4; Cushman, 1930, Florida Geol. Survey, Bull. 4, p. 33, pl. 5, fig. 21.

Polymorphina gibba (d'Orbigny), Nuttall, 1928, Quart. Jour. Geol. Soc. London, vol. 84, pt. 1, p. 92.

Occasional specimens are similar to that figured by Cushman (1930) from the Choctawhatchee Miocene of Florida.

Genus RAMULINA Rupert Jones, 1875

Ramulina globulifera Brady

Ramulina globulifera Brady, 1879, Quart. Jour. Micr. Sci. vol. 19, p. 58, pl. 8, figs. 32, 33; 1884, Rept. Voy. *Challenger*, Zoöl., vol. 9, p. 587, pl. 76, figs. 22-28; Flint, 1897 (1899), Rept. U. S. Nat. Mus., p. 321, pl. 68, fig. 6.

Very rare; nearly globular chambers with as many as six tubular apertures resemble chambers of the form figured by Flint (1897).

[34] Cushman, J. A., and Cahill, E. D.: *Miocene Foraminifera of the Coastal plain of the eastern United States*, U. S. Geol. Survey, Prof. Paper 175, 1933, p. 17, pl. 5, fig. 15.

[35] For the use of *Raphanulina* in place of *Globulina*, see Galloway, J. J., and Heminway, Caroline E.: *The Tertiary Foraminifera of Porto Rico*, New York Acad. Sci., Sci. Survey Porto Rico and the Virgin Islands, vol. 3, pt. 4, 1941, p. 355, footnote.

Family NONIONIDÆ

Genus NONION Montfort, 1808

Nonion grateloupii (d'Orbigny)

Nonionina grateloupii d'Orbigny, 1826, Ann. Sci. Nat., vol. 7, p. 294, No. 19; 1839, in De la Sagra, Hist. Phys., Pol., Nat. Cuba, "Foraminiferes", p. 46, pl. 6, figs. 6, 7; Cushman, 1919, Carnegie Inst. Washington, Publ. 291, p. 48.

Nonion grateloupii (d'Orbigny), Cushman, 1930, Florida Geol. Survey, Bull. 4, p. 36, pl. 6, figs. 1-3; Cushman and Ponton, 1932, Florida Geol. Survey, Bull. 9, p. 68; Cushman and Cahill, 1933, U. S. Geol. Survey, Prof. Paper 175, p. 20, pl. 7, fig. 1; Palmer, 1940, Mem. Soc. Cubana Hist. Nat., vol. 14, No. 4, p. 289.

Occasional. The specimens agree well with the type figures of a specimen from the shore sands of Cuba.

Nonion nicobarense Cushman

Nonion nicobarensis Cushman, 1936, Contr. Cushman Lab. Foram. Res., vol. 12, pt. 3, p. 67, pl. 12, fig. 9.

Nonion nicobarense Cushman, 1939, U. S. Geol. Survey, Prof. Paper 191, p. 17, pl. 4, fig. 16.

A single specimen from Sta. 1.

Nonion pompilioides (Fichtel and Moll)

Nautilus pompilioides Fichtel and Moll, 1799, Test. Micro. p. 31, pl. 2, figs. a-c.

Nonion pompilioides (Fichtel and Moll). Cushman 1930, U. S. Nat. Mus., Bull. 104, pt. 7, p. 4, pl. 1, fig. 10; Coryell and Rivero, 1940, Jour. Paleont., vol. 14, No. 4, p. 333; Galloway and Heminway, 1941, New York Acad. Sci., Sci. Survey Porto Rico and Virgin Islands, vol. 3, pt, 4, p. 357, pl. 14, fig. 1.

Occasional specimens with about 10 chambers in the final whorls, are conspicuously umbilicate and are only moderately broad in proportion to the diameter. These specimens are of the type which have been referred to *N. umbilicatula* (Montagu)[36] but more recently referred to *N. pompilioides* (Fichtel and Moll) (see Cushman, 1930, fig. 10 cited above).

Genus ASTRONONION Cushman and Edwards, 1937

Astrononion cf. A. stelligerum (d'Orbigny) Plate 1, figs. 8 a-b.

Nonionina stelligera d'Orbigny, 1839, in Barker-Webb and Berthelot, Hist. Nat. Iles Canaries, vol. 2, pt. 2, Foraminifères, p. 128, pl. 3, figs. 1, 2.

Nonion cf. stelligerum (d'Orbigny), Palmer. and Bermudez, 1936, Mem. Soc. Cubana Hist. Nat., vol. 9, No. 4, p. 239.

[36] Cushman, J. A.: *Monograph of the Foraminifera of the north Pacific Ocean*, U. S. Nat. Mus., Bull. 71, pt. IV, 1914, p. 24, pl. 17, fig. 1.

Astrononion stelligerum (d'Orbigny), Cushman and Edwards, 1937, Contr. Cushman Lab. Foram. Res., vol. 13, pt. 1, p. 31, pl. 3, fig. 7; Cushman, 1939, U. S. Geol. Survey, Prof. Paper 191, p. 36, pl. 10, fig. 1.

A few specimens are very doubtfully referred to this species. They differ from the original figures in being slightly less compressed and in having very short, inconspicuous supplementary chambers. Maximum diameter of figured specimen, 0.6 mm. Similar specimens are abundant in the late Tertiary of the Canimar River region, Cuba, (Palmer and Bermudez, 1936) and are very rare in the shallow water along the coast of Cuba.

Figured specimen.—No. 20049, Paleontological Research Institution. Palmer Sta. 1.

Genus **ELPHIDIUM** Montfort, 1808

Elphidium advena (Cushman)

Polystomella subnodosa Brady, 1884. Rept. Voy. *Challenger*, Zoöl. vol. 9, p. 734, pl. 110, fig. 1. Not Von Münster.

Polystomella advena Cushman, 1922, Carnegie Inst. Washington, Publ. 311, p. 356, pl. 9, figs. 11, 12.

Elphidium advenum (Cushman), Cushman, 1930, U. S. Nat. Mus., Bull. 104, pt. 7, p. 25, pl. 10, figs. 1, 2; Palmer and Bermudez, 1936, Mem. Soc. Cubana Hist. Nat., vol. 9, pt. 4, p. 239; Cushman, 1939, U. S. Geol. Survey, Prof. Paper 191, p. 60, pl. 16, figs. 31-35.

Test medium sized, compressed, biconvex; periphery acute, slightly lobate; umbilical region with a small knob of clear shell material in which there are several puncta, not projecting above the general contour of the test; sutures gently depressed, almost radial; retral processes small and confined to the sutural depressions; 9-10 chambers in the final whorl; wall translucent, very finely perforate. Aperture seldom well preserved; apparently at the base of the final chamber. Average diameter, 0.58 mm.

This is the most common species of the genus in the Bowden samples. The specimens are very similar to the type of the species figured by Brady; they have a more conspicuous umbilical knob than Cushman's Tortugas specimen and fewer chambers and a less conspicuous keel than his Pacific specimens (1939, pl. 16).

Elphidium fimbriatulum (Cushman)

Polystomella fimbriatula Cushman, 1918, U. S. Geol. Survey, Bull. 876, p. 20, pl. 8, fig. 5.

Elphidium fimbriatulum (Cushman), Cole, 1931, Florida Geol. Survey, Bull. 6 p. 33, pl. 4, fig. 7; Cushman and Ponton, 1932, Florida Geol. Survey, Bull. 9, p. 79, pl. 11, fig. 2; Cushman, 1939, U. S. Geol. Survey, Prof. Paper 191, p. 17, pl. 12, fig. 13.

Specimens are moderately common and agree well with the figure given by Cushman (1939).

Elphidium lanieri (d'Orbigny)

Polystomella lanieri d'Orbigny, 1839, in De la Sagra, Hist. Phys., Pol., Nat. Cuba, "Foraminifères", p. 54, pl. 7, figs. 12, 13; Cushman, 1919, Carnegie Inst. Washington, Publ. 291, p. 49.

Elphidium lanieri (d'Orbigny), Cushman, 1939, U. S. Geol. Survey, Prof. Paper 191, p. 55, fig. 4; Galloway and Heminway, 1941, New York Acad. Sci., Sci. Survey Porto Rico and Virgin Islands, vol. 3, pt. 4, p. 360, pl. 14, fig. 7.

Rare specimens agree closely with the original figure. The species is distinguished from *E. sagra* (d'Orbigny) by its angular, not rounded, peripheral margin. It has been noted that in collections from the shore sands of Cuba, type area for both species, the two species appear to intergrade.

Elphidium poeyanum (d'Orbigny)

Polystomella poeyana d'Orbigny, 1839, in De la Sagra, Hist. Phys., Pol. Nat. Cuba, "Foraminifères", p. 55, pl. 6, figs. 25, 26.

Elphidium poeyanum (d'Orbigny), Cushman, 1939, U. S. Geol. Survey, Prof. Paper 191, p. 54, pl. 14, figs. 25, 26 (references).

Rare. The specimens are small but closely resemble the figures given by Cushman (1939) and immature specimens collected on the coast of Cuba.

Family PENEROPLIDÆ

Genus Archaias Montfort, 1808

Archaias aduncus (Fichtel and Moll)

Nautilus aduncus Fichtel and Moll, 1803, Test. Micr. p. 115, pl. 23, figs. a-e.

Orbiculina adunca (Fichtel and Moll), d'Orbigny, 1839, in De la Sagra, Hist. Phys., Pol., Nat. Cuba "Foraminifères", p. 64, pl. 8, figs. 10, 11, 14, 15, 16 (not 8, 9, 12).

Archaias angulatus (Fichtel and Moll), Cushman, 1930, U. S. Nat. Mus., Bull. 104, pt. 7, p. 46, pl. 16; pl. 17, figs. 3-5.

Archaias aduncus (Fichtel and Moll), Galloway and Heminway, 1941, New York Acad. Sci., Sci. Survey Porto Rico and Virgin Islands, vol. 3, pt. 4, p. 317, pl. 5, fig. 8.

Very rare and poorly preserved specimens have been referred to this species. *A. aduncus* is characterized by a large, flabelliform test. The specimens which are also flabelliform in outline when fully developed but are conspicuously inflated in the early portion have been referred to *A. angulatus* by some authors. These are believed to be the megalospheric form of this species. *A. aduncus* is common in the West Indies. Cushman (1930) considered it a synonym of *A. angulatus* (Fichtel and Moll) which he recorded down to 514 fathoms, abundant from 2 to 20 fathoms.

Genus **SORITES** Ehrenberg, 1840

Sorites, sp.

Several fragments of *Sorites*, sp. are of the type figured by Cushman and Ponton[37] from the Chipola marl of Florida.

Family **HETEROHELICIDÆ**

Genus **BOLIVINELLA** Cushman, 1927

Bolivinella folium (Parker and Jones)

Textularia agglutinans d'Orbigny var. *folium* Parker and Jones, 1865, Philos. Trans. Roy. Soc., vol. 155, pp. 370, 420, pl. 18, fig. 19.
Textularia folium Parker and Jones, Brady, 1884, Rept. Voy. *Challenger*, Zoöl., vol. 9, p. 357, pl. 42, figs. 1, 2 (not 3-5).
Bolivinella folia (Parker and Jones), Parr, 1932, Roy. Soc. Victoria, Proc., vol. 44, pt. 2, p. 223, pl. 21, fig. 23.
Bolivinella folia (Parker and Jones) var. *ornata* Cushman, 1929, Contr. Cushman Lab Foram. Res., vol. 5, pt. 2, p. 32, pl. 5, figs. 3, 4.

Two poorly preserved specimens closely resemble the original figures of the var. *ornata* Cushman which Parr (1932) found to be the typical form of the species. These specimens have raised sutures broken into beads which are sometimes elongated at right angles to the direction of the suture. The type of this species is from the shore sand of Hardwicke Bay, South Australia.

Genus **PLECTOFRONDICULARIA** Liebus, 1903

Plectofrondicularia floridana Cushman

Plectofrondicularia floridana Cushman, 1930, Florida Geol. Survey, Bull. 4, p. 41, pl. 8, fig. 1.

A single specimen agrees closely with the original figure of this species except that it possesses two basal costæ instead of one and these are somewhat longer than the typical. The test increases in breadth more rapidly than does that of *P. californica* Cushman and Stewart[38].

[37] Cushman, J. A., and Ponton, G. M.: *Foraminifera of the upper, middle and part of the lower Miocene of Florida*, Florida State Geol. Survey, Bull. 9, 1932, p. 72, pl. 17, figs. 1-8.

[38] Cushman, J. A., and Stewart, R. E.: Contr. Cushman Lab. Foram. Res., vol. 2, pt. 2, 1926, p. 39, pl. 6, figs. 9-11.

Family BULIMINIDÆ

Genus BULIMINELLA Cushman, 1911

Buliminella pulchra Tolmachoff

Buliminella pulchra Tolmachoff, 1934, Carnegie Museum Annals, vol. 23, p. 305, pl. XL, fig. 28.

A single specimen from Sta. 1.

Genus BULIMINA d'Orbigny, 1826

Bulimina marginata d'Orbigny

Bulimina marginata d'Orbigny, 1826, Ann. Sci. Nat. vol. 7, p. 269, pl. 12, figs. 10-12; Cushman, 1922, U. S. Nat. Mus., Bull. 104, pt. 3, p. 91, pl. 21, figs. 4, 5; Cole, 1931, Florida Geol. Survey. Bull. 6, p. 39; Cushman and Ponton, 1932, Florida Geol. Bull. 9, p. 77, pl. 11, fig. 12; Coryell and Rivero, 1940, Jour. Paleont., vol. 14, No. 4, p. 341.

Very rare and not well preserved. The specimens are similar to that figured by Cushman and Ponton (1932) from the Miocene of Florida.

Bulimina cf. B. ovata d'Orbigny

Bulimina ovata d'Orbigny, 1846, Foram. Foss. Bassin Tert. Vienne, p. 185, pl. 11, figs. 13, 14; Jones and Parker, 1876, Ann. Soc. Mal. Belg., vol. 11, p. 98; Brady 1884, Rep. Voy. *Challenger*, Zoöl., vol. 9, p. 400, pl. 50, fig. 13; Cushman, 1922, U. S. Nat. Mus., Bull. 104, pt. 3, p. 109, pl. 21, fig. 3.

Very rare specimens are similar to the one figured by Cushman (1922) from an *Albatross* station in the Atlantic.

Genus VIRGULINA d'Orbigny, 1826

Virgulina mexicana Cushman

Virgulina mexicana Cushman, 1922, U. S. Nat. Mus., Bull. 104, pt. 3, p. 120, pl. 23, fig. 8; 1932, Cont. Cushman Lab. Foram. Res., vol. 8, p. 15, pl. 2, fig. 13; 1937, Cushman Lab. Foram. Res., Special Publ. 9, p. 29, pl. 5, fig. 4.

Several specimens closely resemble the original figure of this species which came from the Gulf of Mexico in 347 fathoms.

Virgulina punctata d'Orbigny

Virgulina punctata d'Orbigny, 1839, in De la Sagra, Hist. Phys., Pol., Nat., Cuba, "Foraminifères", p. 139, pl. 1, figs. 35, 36; Cushman, 1919, Carnegie Inst. Washington, Publ. 291, p. 35; Cushman and Ponton, 1932, Florida Geol. Survey, Bull. 9, p. 79; Cushman and Cahill, 1933, U. S. Geol. Survey, Prof. Paper 175, p. 25, pl. 8, fig. 8; Cushman, 1937, Cushman Lab. Foram. Res., Spec. Publ. No. 9, p. 23, pl. 3, figs. 25-27.

Specimens are occasional and variable in respect to number of pairs of chambers and degree of inflation of the test. The specimens are of the type figured by Cushman and Cahill (1933) from the Choctawhatchee formation of Florida.

Genus **BOLIVINA** d'Orbigny, 1839

Bolivina alata (Seguenza)

Vulvulina alata Seguenza, 1862, Atti Accad. Gioenia Sci. Nat., ser. 2, vol. 18, p. 115, pl. 2, fig. 5.

Bolivina alata (Seguenza), Cushman, 1937, Cushman Lab. Foram. Res., Spec. Publ. No. 9, p. 106, pl. 13, figs. 3-11 (references).

Occasional. The specimens resemble Cushman's figure (1937, fig. 11) of a specimen from the western Atlantic. The species was found in the *Albatross* Atlantic samples from 58 to 818 fathoms.

Bolivina arta Macfadyen

Bolivina arta Macfadyen, 1930 (1931), Geol. Survey Egypt, p. 58, pl. 4, fig. 21; Cushman, 1937, Cushman Lab. Foram. Res., Spec. Publ. No. 9, p. 79, pl. 9, figs. 23-26; Coryell and Rivero, 1940, Jour. Paleont., vol. 14, No. 4, p. 341, pl. 44, fig. 18.

Occasional specimens agree closely with that figured by Coryell and Rivero (1940).

Bolivina bierigi Palmer and Bermudez

Bolivina bierigi Palmer and Bermudez, 1936, Mem. Soc. Cubana Hist. Nat., vol. 9, No. 4, p. 248, pl 20, figs. 5, 6.

Very rare. This small but distinctive species was described from the late Tertiary of the Matanzas Bay region, Cuba.

Bolivina marginata Cushman var. multicostata Cushman

Bolivina aenariensis (Costa) var. *multicostata* Cushman, 1918, U. S. Geol. Survey, Bull. 676, p. 48, pl. 10, fig. 2.

Bolivina marginata Cushman var. *multicostata* Cushman, 1930, Florida Geol. Survey, Bull. 4, p. 46, pl 8, figs. 13, 14.

Occasional. The specimens are smooth except at the apex, closely resembling the specimens figured by Cushman (pl. 18, fig. 13) from the Choctawatchee formation.

Bolivina pulchella (d'Orbigny)

Sagrina pulchella d'Orbigny, 1839, in De la Sagra, Hist. Phys., Pol., Nat. Cuba "Foraminifères" p. 150, pl. 1, figs. 23, 24.

Bolivina pulchella (d'Orbigny), Cushman, 1937, Cushman Lab. Foram. Res., Spec. Publ. No. 9, p. 151, pl. 15, figs. 9-11 (references).

Very rare. The species has been well illustrated by Cushman (1937).

Bolivina rhomboidalis (Millett)

Textularia rhomboidalis Millett, 1899, Jour. Roy. Micro. Soc., p. 559, pl. 7, fig. 4.

Bolivina rhomboidalis (Millett), Cushman, 1922, Carnegie Inst. Washington, Publ. 311, p. 28; Bermudez, 1935, Mem. Soc. Cubana Hist Nat., vol. 9, No. 3, p. 194; Palmer and Bermudez, 1936, Mem. Soc. Cubana Hist. Nat., vol. 9, No. 4, p. 240; Cushman, 1937, Cushman Lab. Foram. Res., Spec. Publ. 9, p. 138, pl. 18, fig. 7.

Specimens are rare. They are similar to those from the late Tertiary of the Canímar River region, Cuba.

Bolivina scalprata Schwager var. miocenica Macfadyen

Plate 1, figs. 2 a-b.

Bolivina scalprata Schwager var. *miocenica* Macfadyen, 1931, *Miocene Foraminifera from the Clysmic area of Egypt and Sinai,* Geol. Survey of Egypt.

Bolivina byramensis Coryell and Rivero, 1940, Jour. Paleont., vol. 14, No. 4, p. 341, pl. 44, fig. 17. Not Cushman.

Very rare. This species differs from *B. goësii* Cushman[39] living in the Caribbean in its larger size, limbate sutures and the slightly elevated median suture.

Figured specimen.—No. 20051, Paleontological Research Institution. Palmer Sta. 1.

Bolivina subaenariensis Cushman var. mexicana Cushman

Bolivina subaenariensis Cushman var. *mexicana* Cushman, 1922, U. S. Nat. Mus., Bull. 104, pt. 3, p. 47, pl. 8, fig. 1.

Rare. The specimens closely resemble the figure of the type which came from an *Albatross* station in 200 fathoms in the northern part of the Gulf of Mexico.

Bolivina tortuosa Brady

Bolivina tortuosa Brady, 1881, Quart. Jour. Micr. Soc., vol. 21, p. 57; 1884, Rept. Voy. *Challenger*, Zoöl., vol. 9, p. 420, pl. 52, figs. 31, 32; Bermudez, 1935, Mem. Soc. Cubana Hist. Nat., vol. 9, No. 3, p. 195; Cushman 1937, Cushman Lab. Foram. Res., Spec. Publ. No. 9, p. 135, pl. 17, figs. 11-19 (references).

Very occasional. The specimens are less compressed than the Pacific representatives of the species and approximate the specimen from the east coast of South America figured by Cushman (1937, pl. 17, fig. 18).

Genus LOXOSTOMUM Ehrenberg, 1854

Loxostomum limbatum (Brady) var. costulata (Cushman)[40]

[39] Cushman, J. A.: *The Foraminifera of the Atlantic Ocean*, U. S. Nat. Mus., Bull. 104, pt. 3, p. 34, pl. 6, fig. 5.

[40] The form first used for this genus is *Loxostomum*. See Macfadyen, W. A. and Kenny, E. J. André, *On the correct writing in form and gender of the names of the Foraminifera*, Jour. R. Micr. Soc., 1934, vol. LIV, p. 180.

Note: Varietal names are regarded by the author as feminine in accordance with Macfadyen and Kenny's opinions—*Eds.*

Bolivina limbata (Brady) var. *costulata* Cushman, 1922, Carnegie Inst. Washington, Publ. 311, p. 26, pl. 3, fig. 8.
Loxostoma limbata (Brady) var. *costulata* (Cushman), Palmer and Bermudez, 1935, Mem. Soc. Cubana Hist. Nat., vol. 9, No. 4, p. 248; Cushman, 1937, Cushman Lab. Foram. Res., Spec. Publ. 9, p. 187, pl. 21, figs. 30, 31.

Rare and not well developed. The specimens agree well with the type figure.

Genus **REUSSELLA** Galloway, 1933

Reussella spinulosa (Reuss)

Verneuilina spinulosa Reuss, 1850, Denkschr. Akad. Wiss. Wien, vol. 1, p. 374, pl. 47, fig. 12; Brady, 1884, Rept. Voy. *Challenger*, Zoöl., vol. 9, p. 384, pl. 47, figs. 1-3; Cushman, 1919, Carnegie Inst. Washington, Publ. 291, p. 34 (marl, Yumuri Gorge, Matanzas, Cuba).
Reussella spinulosa (Reuss), Bermudez, 1935, Mem. Soc. Cubana Hist. Nat., vol. 9, No. 3, p. 197; Palmer and Bermudez, 1936, Mem. Soc. Cubana Hist. Nat., vol. 9, No. 4, p. 240.

Specimens are rare and small. The spines on the peripheral angles are short as illustrated by Brady (1884, fig. 1).

Reussella spinulosa (Reuss) var.

Reussella spinulosa (Reuss) var. Cushman and Ponton, 1932, Florida Geol. Survey, Bull. 9, p. 84, pl. 12, fig. 15.

The Bowden specimens agree with the figure of the above cited variety from the Choctawhatchee Miocene of Florida which differs from the typical species in having more closely appressed chambers and only slightly developed peripheral spines. The variety is more common than the typical species at Bowden. It does not have as many chambers nor the complete absence of spines indicated by the specimen from Los Puertos formation, Puerto Rico, figured as *R. glabrata* (Cushman) by Galloway and Heminway.[41]

Genus **PAVONINA** d'Orbigny, 1826

Pavonina miocenica Cushman and Ponton

Pavonina miocenica Cushman and Ponton, 1932, Florida Geol. Survey, Bull. 9, p. 73, pl. 12, fig. 19.

A single specimen of this distinctive species was found at Palmer Sta. 1.

Genus **UVIGERINA** d'Orbigny, 1826

Uvigerina charltonæ, n. sp. Plate 1, figs. 3 a-b.

Test moderately large, stout, maximum diameter about mid-

[41] Galloway, J. J., and Heminway, C. E.: *The Tertiary Foraminifera of Porto Rico*, New York Acad. Sci., Sci. Survey Porto Rico and the Virgin Islands, vol. 3, pt. 4, 1941, p. 423, pl. 31, fig. 8.

dle; bluntly pointed in microspheric form, rounded in megalospheric form. The test has a tendency to be triangular in cross section, particularly in the early portion, and immature specimens look like stout *Angulogerina* with rounded angles. Sutures depressed, chambers slightly inflated; surface covered with numerous sharp, closely set costæ which may be continuous over more than one chamber. Aperture with a very short neck set in a depression in the final chamber. Very rare at Bowden.

Holotype, microspheric form, maximum length, 0.7 mm.; maximum breadth, 0.4 mm.

This species is close to *U. peregrina* Cushman[42] from which it differs in the marked tendency toward a triangular cross section, less sharply depressed sutures and consequently less inflated chamber, and more numerous costæ which may be continuous over more than one chamber. It appears from the figure that the form listed by Coryell and Rivero[43] as *U. peregrina* may be this species.

U. rutila Cushman and Todd[44] has a similar tendency toward a rounded, triangular cross section but the new species has coarser, more numerous costæ which may not be limited to a single chamber.

Holotype.—No. 20043, Paleontological Research Institution. Palmer Sta. 1.

Specimens figured as *U.* cf. *pigmea* d'Orbigny from the Florida Miocene show a closer relation to the new species than to *U. pigmea.* Concerning these specimens Cushman made the following statement, "The four specimens figured show somewhat of the range of variation in the species of the Choctawhatchee marl which may be referred tentatively to this species of d'Orbigny. It is unlike any of the recent material now living off the coast. The Uvigerinas are so variable and in such a state of chaos that reference to type material with large series must be made before

[42] Cushman, J. A.: *Foraminifera of the Atlantic Ocean,* U. S. Nat. Mus. Bull. 104, pt. 4, 1923, p. 166, pl. 42, figs. 7-10.

[43] Coryell, H. N., and Rivero, F. C.: *A Miocene microfauna of Haiti,* Jour. Paleont., vol. 14, No. 4, 1940, p. 343, pl. 44, fig. 19.

[44] Cushman, J. A., and Todd, Ruth: *Notes on the species of the Uvigerina and Angulogerina described from the Pliocene and Pleistocene,* Contr. Cushman Lab. Foram. Res., vol. 17, pt. 3, 1941, p. 78, pl. 20, figs. 16-22.

very intelligent work can be done in straightening out this group."[45]

Uvigerina coartata Palmer

Uvigerina compressa Palmer, 1941. Mem. Soc. Cubana Hist. Nat., vol. 15, No. 2, p. 182, pl. 15, fig. 10, 11. Not Cushman, 1925.
Uvigerina coartata Palmer (new name), 1941, Mem. Soc. Cubana Hist. Nat., vol. 15, No. 3, p. 304.

Very occasional. The Bowden specimens are generally a bit more inflated in the early portion than the type from the Cojimar formation, upper Oligocene of Cuba.

Uvigerina pigmea d'Orbigny

Uvigerina pigmea d'Orbigny, 1826, Ann. Sci. Nat., vol. 7, p. 269, pl. 12, figs. 8, 9; Galloway and Morrey, 1929, Bull. Amer. Paleont., vol. 15, No. 55, p. 39, pl. 6, fig. 5; Cushman, 1930, Contr. Cushman Lab. Foram. Res., vol. 6, pt. 3, p. 62, pl. 9, figs. 14-20; Hadley, 1934, Bull. Amer. Paleont., vol. 20, No. 70A, p. 19, pl. 2, fig. 16; Coryell and Rivero, 1940, Jour. Paleont., vol. 14, No. 4, p. 343, pl. 44, fig. 20; Palmer, 1941, Mem. Soc. Cubana Hist. Nat., vol. 15, No. 2, p. 183.

Very rare. Specimens agree closely with the figures by Cushman (1930).

Uvigerina cf. **U. selseyensis** Heron-Allen and Earland

Uvigerina selseyensis Heron-Allen and Earland, 1909, Jour. Roy. Micro. Soc., p. 437, pl. 18, figs. 1-3; Bermudez, 1935, Mem. Soc. Cubana Hist. Nat., vol. 9, No. 3, p. 198; Palmer, 1941, Mem. Soc. Cubana Hist. Nat., vol. 15, No. 2, p. 184.

Very rare, small specimens are provisionally referred to this species which Bermudez found living off the north coast of Cuba. The specimens differ from *U. occidentalis* Cushman[46] described from the Tortugas area, Florida, in lacking longitudinal costæ. They differ from the type in being shorter with fewer triangular chambers.

Uvigerina proboscidea Schwager var. **vadescens** Cushman

Uvigerina proboscidea Schwager var. *vadescens* Cushman, 1933, Contr. Cushman Lab. Foram. Res., vol. 9, p. 85, pl. 8, figs. 14, 15; Cushman, 1942, U. S. Nat. Mus., Bull. 161, pt. 3, p. 50, pl. 14, figs. 5-9.

Small specimens of *Uvigerina* closely resembling the type figures of Pacific specimens (especially fig. 14) are fairly common in the Bowden material. The small apical spine described as

[45] Cushman, J. A.: *The Foraminifera of the Choctawhatchee formation of Florida,* Florida State Geol. Survey, Bull. 4, 1930, p. 49, pl. 9, figs. 3-6.
[46] Cushman, J. A.: *Foraminifera of the Atlantic Ocean,* U. S. Nat. Mus., Bull. 104, pt. 4, Lagenidæ, 1923, p. 169.

characteristic of this variety is not well developed on Bowden specimens. The specimens identified as this variety differ from the forms figured as *U. ampullacea* by Brady[47] in having more nearly uniform diameters throughout. They differ from the specimens referred to *U. auberiana* d'Orbigny[48] in the Florida Miocene in being less conspicuously hispid and more uniform in diameter. Neither the Bowden nor the Florida Miocene specimens referred to can be called *U. auberiana* as described and figured by D'Orbigny from the shore sands of Cuba.[49] There is, however, doubt about the characters of *U. auberiana* for Bermudez failed to find it after careful examination of many shore and shallow-water samples.[50]

Genus **SIPHOGENERINA** Schlumberger, 1883

Siphogenerina advena Cushman

Siphogenerina advena Cushman, 1922, Carnegie Inst. Washington, Publ. 311, p. 35, pl. 5, fig. 2.

Specimens are very rare; they differ from living specimens from the coast of Cuba in being slightly more compressed with more strongly constricted sutures. In outline the Bowden specimens resemble *S. advena* var. *ornata* from the late Tertiary of the Matanzas Bay region, Cuba[51] but lack its characteristic ornamentation.

Siphogenerina cf. S. raphanus (Parker and Jones)

Uvigerina (*Sagrina*) *raphanus* Parker and Jones, 1865, Philos. Trans., vol. 155, p. 364, pl. 18, figs. 16, 17.

Siphogenerina raphanus (Parker and Jones), Cushman, 1926, U. S. Nat. Mus., Proc. vol. 67, art. 25, No. 2597, p. 4, pl. 1, figs. 1-4; pl. 2, figs. 1-3, 10; pl. 5, figs. 1-2 (see references); Cushman and Parker, 1931, Proc. U. S. Nat. Mus., vol. 80, art. 3, No. 2903, p. 17, pl. 3, figs. 25, 26.

A single specimen from Sta. I is doubtfully referred to this species. The Bowden specimen differs from typical living spec-

47 Brady, H. B.: Rept. Voy. *Challenger,* Zoöl., vol. 9, 1884, p. 579, pl. 75, figs. 10, 11.

48 Cushman, J. A.: *The Foraminifera of the Choctawhatchee formation of Florida,* Florida Geol. Survey, Bull. 4, 1930, p. 49, pl. 9, fig. 7.

49 d'Orbigny, A.: In De la Sagra Hist. Fis., Pol., Nat. Cuba, Foraminiferas, 1840 (Spanish ed.), p. 110, pl. 2, figs. 23, 24.

50 Bermudez, P. J.: *Foraminiferas de la costa norte de Cuba,* Mem. Soc. Cubana Hist. Nat., vol. 9, No. 3, 1935, p. 143.

51 Palmer, D. K., and Bermudez, P. J.: Mem. Soc. Cubana Hist. Nat., vol. 9, No. 4, 1936, p. 249, pl. 22, figs. 4, 7.

imens in having the poorly developed and somewhat irregular costæ as do the specimens figured by Cushman and Parker (1931) from Rio de Janeiro Harbor.

Genus **ANGULOGERINA** Cushman, 1927

Angulogerina carinata Cushman

Angulogerina carinata Cushman, 1927, Bull. Scripps Instit. Oceanography, Tech. Ser., vol. 1, No. 10, p. 159, pl. 4, fig. 3; 1932, Contr. Cushman Lab. Foram. Res., vol. 8, pt. 2, p. 44, pl. 6, figs. 7, 8.

Very rare specimens closely resemble the figures given by Cushman in 1932. A few specimens have very faint costæ recalling the variety *bradyana* Cushman.[52]

Angulogerina cf. A. eximia Cushman and Jarvis

Angulogerina eximia Cushman and Jarvis, 1936, Contr. Cushman Lab. Foram. Res., vol. 12, pt. 1, p. 3, pl. 1, fig. 11; Coryell and Rivero, 1940, Jour. Paleont., vol. 14, No. 4, p. 342, pl. 44, fig. 26; Palmer, 1941, Mem. Soc. Cubana Hist. Nat., vol. 15, No. 2, p. 186, pl. 15, fig. 18.

Very rare specimens of *Angulogerina* are large for the genus, stout, with sharp but not carinate angles. The sutures are slightly depressed and marked by clear shell substance. Surface marked by numerous low costæ; aperture a short neck with phialine lip.

These specimens are closely related to *A. eximia* Cushman and Jarvis which was described from beds referred to the Bowden formation, half a mile east of Buff Bay, Jamaica. The specimens from the typical Bowden are probably a variety but are too rare to warrant a distinct name at this time. They differ from *A. eximia* in having blunter peripheral angles, fewer, less prominent costæ and less inflated chambers.

The specimen figured by Coryell and Rivero (1940) appears to be typical of the species while the figured Cojimar specimen (Palmer, 1940) is close to that of the typical Bowden.

Family **ELLIPSOIDINIDÆ**

Genus **ELLIPSONODOSARIA** Silvestri, 1900

Ellipsonodosaria caribæa, n. sp. Plate 1, fig. 6

Ellipsonodosaria verneuili Cushman and Jarvis, 1930, Jour. Paleont., vol.

52 Cushman, J. A.: *Some Recent Angulogerinas from the eastern Pacific*, Contr. Cushman Lab. Foram. Res., vol. 8, pt. 2, 1932, p. 45, pl. 6, figs. 9, 10.

4, No. 4, p. 364, pl. 33, fig. 12. Not *Dentalina verneuili* d'Orbigny.

Test small, delicately constructed, rectilinear, seldom arcuate; comprising about nine subglobular chambers; early chambers closely set; later becoming well separated by a narrow sutural neck; surface smooth except for an inconspicuous collar on the basal portion of some of the later chambers, probably marking the phialine lip of a former aperture. Aperture an elongated neck with a conspicuous lip and tooth.

Length of holotype, 1.0 mm.

Specimens are very rare and seldom complete. They differ conspicuously from the original figure of *Dentalina verneuili* d'Orbigny[53] in having subglobular, well-separated chambers and a well-developed phialine lip and tooth. The Bowden specimens agree closely with the specimen from Buff Bay, Jamaica, figured by Cushman and Jarvis, though they are not so distinctly arcuate and lack the apical spine. The new species is very closely related to *E. nuttalli* Cushman and Jarvis var. *gracillima* Cushman and Jarvis[54] of which this may be the microspheric form. The variety *gracillima* has longer sutural stolons, an apical spine and a toothed frill below the aperture on the neck.

Holotype.—No. 20044, Paleontological Research Institution. Palmer Sta. 1.

Family ROTALIIDÆ

Genus SPIRILLINA Ehrenberg, 1843

Spirillina aff. S. vivipara Ehrenberg

Spirillina vivipara Ehrenberg, 1841, Abhandl. k. Akad. Wiss. Berlin, p. 422, pl. 3, sec. 7, fig. 41; Cushman, 1931, U. S. Nat. Mus., Bull. 104, pt. 8, p. 3, pl. 1, figs. 1-4 (references).

A single specimen was found at Palmer Sta. 1.

Genus DISCORBIS Lamarck, 1804

Discorbis bertheloti (d'Orbigny) var. floridensis Cushman

Discorbis bertheloti (d'Orbigny) var. *floridensis* Cushman, 1931, U. S.

53 d'Orbigny, A.: Foram. Foss. Bass. Tert. Vienne, 1846, p. 48, pl. 2, figs. 7, 8.

54 Cushman, J. A., and Jarvis, P. W.: Contri. Cushman Lab. Foram. Res., vol. 10, pt. 3, 1934, p. 72, pl. 10, fig. 7.

Nat. Mus., Bull. 104, pt. 8, p. 17, pl. 3, figs. 3-5; Cushman and Jarvis, 1930, Jour. Paleont., vol. 4, No. 4, p. 364, pl. 33, fig. 13.

Discorbis floridensis Cushman, Tolmachoff, 1934, Ann. Carnegie Mus., vol. 23, p. 310, pl. XL, fig. 33.

Specimens referred to this species are rare. A few are similar to that figured from Buff Bay, Jamaica, by Cushman and Jarvis (1930), being only gently elevated dorsally with narrow, limbate but not elevated sutures. Most of the specimens found are more convex dorsally and the sutures are broadly limbate and distinctly elevated particularly in the early chambers on the dorsal side, and are usually even more strongly elevated than is indicated by the original figure 5.

This species is widely distributed in depth. It has been reported by Cushman (1931) from shore sands to 222 fathoms, being common at 68 fathoms.

Discorbis cf. D. corrugatus (Millett)

Discorbina corrugata Millett, 1903, Jour. Ray. Micros. Soc., p. 700, pl. 7, fig. 5.

Discorbis cf. *D. corrugata* (Millett), Palmer, 1941, Mem. Soc. Cubana Hist. Nat., vol. 15, No. 2, p. 190, pl. 6, figs. 6, 9, 10.

A single specimen found at Sta. 1 resembles the specimen figured from the Cojimar formation of Cuba (Palmer, 1941).

Discorbis cushmani Palmer and Bermudez

Discorbis cushmani Palmer and Bermudez, 1936, Mem. Soc. Cubana Hist. Nat., vol. 9, No. 4, p. 250, pl. 21, figs. 7-9.

Pulvinulina, sp? Cushman, 1918, U. S. Nat. Mus., Bull. 103, pl. 25, fig. 4.

Rare. The species was described from the late Tertiary of Cuba. *Pulvinulina*, sp. was figured but not described in the Tertiary fauna of the Panama Canal Zone.

Discorbis floridanus Cushman

Discorbis floridana Cushman, 1922, Carnegie Inst. Washington, Publ. 311, p. 39, pl. 5, figs. 11, 12; Cushman, 1931, U. S. Nat. Mus., Bull. 104, pt. 8, p. 21, pl. 4, figs. 7, 8; Bermudez, 1935, Mem. Soc. Cubana Hist. Nat., vol. 9, No. 3, p. 201.

A few specimens are referred to this species. They are smaller than *D. bertheloti* var. *floridensis* with usually one more chamber in the last whorl, and they lack the peripheral thickening. The specimens from Bowden resemble that figured from Tortugas, Florida, by Cushman (1922) except that the final chamber is larger as illustrated by Galloway and Heminway[55]. The specimens also closely resemble *D. oligospiratus* Galloway and Heminway[56], from which it appears to be separated by its less convex dorsal surface and less concave ventral surface.

Discorbis mirus Cushman

Discorbis mira Cushman, 1931, U. S. Nat. Mus., Bull. 104, pt. 8, p. 25, pl. 5, figs. 5, 6; Bermudez, 1935, Mem. Soc. Cubana Hist. Nat., vol. 9, No. 3, p. 205, pl. 15, figs. 1-5.

Occasional. The specimens resemble the living example from the coast of Cuba illustrated by Bermudez (1935). This species also has a wide depth distribution, having been reported by Cushman (1931) to be chiefly found between 1-35 fathoms though present to 1169 fathoms.

Discorbis cf. D. obtusus (d'Orbigny)

Rosalina obtusa d'Orbigny, 1846, Foraminiferes Fossiles du Bassin Tert. Vienna, p. 179, pl. 11, figs. 4-6.

Discorbis obtusa (d'Orbigny), Heron-Allen and Earland, 1932, *Discovery* Repts., vol. IV, pt. 1, p. 415, pl. 14, figs. 19-21; Bermudez, 1935, Mem. Soc. Cubana Hist. Nat., vol. 9, pt. 3, p. 202, pl. 17, figs. 11-13.

Several specimens are provisionally referred to this small species. They resemble that figured by Bermudez from the north coast of Cuba (1935).

Discorbis orbicularis (Terquem)

Rosalina orbicularis Terquem, 1876, Anim. sur la Plage de Dunkerque, p. 75, pl. 1, fig. 4.

Discorbis orbicularis (Terquem), Cushman, 1919, Carnegie Inst. Washington, Publ. 291, p. 40; Bermudez, 1935, Mem. Soc. Cubana Hist. Nat., vol. 9, No. 3, p. 205; Palmer and Bermudez, 1936, Mem. Soc. Cubana Hist. Nat., vol. 9, No. 4, p. 240; Cushman and Cahill, 1933, U. S. Geol. Survey, Prof. Paper 175, p. 29, pl. 10, fig. 1.

Occasional. The specimens closely resemble that figured by Cushman and Cahill from the Choctawhatchee formation of Florida (1933).

Discorbis cf. D. pileolus (d'Orbigny)

Valvulina pileolus d'Orbigny, 1839, Voy. Amer. Mérid., "Foraminifères", vol. 5, pt. 5, p. 46, pl. 1, figs. 15-17.

Very occasional specimens are provisionally referred to this

[55] Galloway, J. J., and Heminway, C. E.: *Tertiary Foraminifera of Porto Rico*, New York Acad. Sci., Sci. Survey of Porto Rico and the Virgin Islands, vol. 3, pt. 4, p. 383, pl. 21, fig. 5.

[56] *Op. cit.*, p. 384, pl. 21, fig. 1.

species. They more closely resemble the type figures of D'Orbigny's species from off Peru than any other that has been found but they tend to be somewhat more elevated and the apex is more pointed. Several plastogamic pairs were found.

These specimens cannot be referred to *D. pileolus* Brady[57] the name of which was subsequently changed to *D. australensis* by Heron-Allen and Earland[58].

Genus **LAMARCKINA** Berthelin, 1881

Lamarckina atlantica Cushman

Lamarckina atlantica Cushman, 1931, U. S. Nat. Mus., Bull. 104, pt. 8, p. 35, pl. 7, fig. 7; Cushman and Ponton, 1932, Florida Geol. Survey, Bull. 9, p. 91, pl. 13, fig. 7; Bermudez, 1935, Mem. Soc. Cubana Hist. Nat., vol. 9, No. 3, p. 209.

A single specimen agrees well with the type figure.

Genus **VALVULINERIA** Cushman

Valvulineria araucana (d'Orbigny)

Rosalina araucana d'Orbigny, 1839, Voy. Amer. Mérid., ''Foraminifères'', vol. 5, pt. 5, pl. 6, figs. 16-18.

Valvulineria araucana (d'Orbigny), Cushman, 1927, Scripps Inst. Ocean., Tech. Ser., vol. 1, No. 10, p. 160, pl. 4, figs. 6, 7; Palmer and Bermudez, 1936. Mem. Soc. Cubana Hist. Nat., vol. 9, No. 4, p. 251; Palmer, 1941, Mem. Soc. Cubana Hist. Nat., vol. 15, No. 2, p. 191, pl. 15, figs. 15-17.

Rare. There is considerable doubt about the correctness of the reference of this species. The specimens from Bowden agree well with the type figures except in the peripheral view. The Bowden specimens have a rather broadly rounded periphery and the final chambers are inflated as is the Cojimar Oligocene figured specimen (Palmer, 1941). In peripheral view the type, however, is compressed and narrowly rounded, suggesting *Discorbis* rather than *Valvulineria.*

Genus **CIBICORBIS** Hadley, 1934

Cibicorbis herricki Hadley

Cibicorbis herricki Hadley, 1934, Bull. Amer. Paleont., vol. 20, No. 70 A, p. 26, pl. 5, figs. 1-3; Palmer, 1941, Mem. Soc. Cubana Hist. Nat., vol. 15, No. 3, p. 297, pl. 30, fig. 1.

Valvulineria collis Coryell and Rivero, 1940, Jour. Paleont., vol. 14, No. 4, p. 338, pl. 43, fig. 24.

57 Brady, H. B.: Rept. Voy. *Challenger*, Zoöl., vol. 9, 1884, Foraminifera, p. 649, pl. 89, figs. 2-4.

58 Heron-Allen, E. and Earland, A.: *Discovery Reports*, vol. lv. 1932, *Foraminifera. Part 1. The Ice-free area of the Falkland Islands and adjacent seas,* p. 416.

Cibicides kugleri Cushman and Renz, 1941, Contr. Cushman Lab. Foram. Res., vol. 17, pt. 1, p. 27, pl. 4, fig. 11.

A single specimen was found at Palmer Sta. 1. This species is abundant and widely distributed in the upper Oligocene and lower Miocene of the Caribbean region and occurs very rarely in later Miocene deposits.

Genus GYROIDINA d'Orbigny, 1826

Gyroidina cf. G. soldanii d'Orbigny

Gyroidina soldanii d'Orbigny, 1826, Ann. Sci. Nat., vol. 7, No. 5; Modeles, No. 36; Galloway and Morrey, 1929, Bull. Amer. Paleont., vol. 15, No. 55, p. 27, pl. 4, fig. 4; Cushman, 1931, U. S. Nat. Mus., Bull. 104, pt. 8, p. 38 pl. 8, figs. 1-3.

Several small specimens, doubtfully referred to this species, resemble the young specimen from the east coast of the United States figured by Cushman (1931).

Genus EPONIDES Montfort, 1808

Eponides coryelli, n. sp. Plate 2, figs. 3, 4

Eponides praecinctus Coryell and Rivero, 1940, Jour. Paleont., vol. 14, No. 4, p. 336, pl. 43, fig. 25. Not Karrer.

Truncatulina praecincta Cushman, 1919, Carnegie Inst. Washington, Publ. 291, p. 41. Not Karrer.

Test large, strongly convex to conical ventrally, gently convex dorsally; periphery sharp but not keeled; 3½ whorls visible dorsally; 7-8 chambers in final whorl; dorsal sutures straight and tangential, limbate and elevated; spiral suture limbate and elevated; ventral sutures almost radial, limbate, becoming elevated near the umbilicus and terminating in knobs of shell substance forming a ring around the slightly open umbilicus. Aperture a long, conspicuous slit on the ventral inner margin of the final chamber; surface smooth.

This new species is moderately common in the Bowden samples. The specimens vary in outline, some being strongly conical, others more broadly rounded ventrally. The species, represented by two forms, lives in deep water off the coast of Cuba (*Atlantis* Sta. 2963, 190 fms.). Sections of the living specimens indicate that the conical forms are microspheric and the more rounded, convex forms are megalospheric.

Syntype, fig. 3, microspheric?, maximum diameter, 0.7 mm.; height, 0.43 mm. Syntype, fig. 4, megalospheric? maximum diameter, 0.89 mm.; height, 0.6 mm.

E. coryelli differs from *Rotalia præcinta* Karrer[59] in having fewer chambers in the final whorl, oblique and more strongly elevated dorsal sutures and radial, not curved, ventral sutures which are more conspicuously limbate at the inner ends, terminating in a ring around the umbilicus.

The new species is well illustrated by Coryell and Rivero from the Miocene of Haiti. Specimens of *E. byramensis* (Cushman) var. *campester* (Palmer and Bermudez) from the upper Oligocene Cojimar formation of Cuba[60] are transitional between that variety and *E. coryelli*, n. sp.

This is another member of the *E. jacksonensis-E. antillarum* series which has been living in this area since the Eocene. It differs from *E. byramensis* var. *campester* of the Cuban lower Oligocene in being more distinctly conical ventrally, even in the megalospheric forms; somewhat more tightly coiled with fewer, narrower chambers and more conspicuously elevated sutures. Comparisons of the var. *campester* and closely related species accompany the original description[61].

Types.—Syntypes, Paleontological Research Institution, No. 20045, ?megalospheric; No. 20046 ? microspheric. Palmer Sta. 1.

Eponides lateralis (Terquem)

Rosalina lateralis Terquem, 1878, Mem. Soc. Geol. France, ser. 1, vol. 4, p. 25, pl. 2 (7), figs. 11a-c.

[59] Karrer, F.: *Die Miocene Foraminiferenfauna von Kostej im Banat*, Sitz. k. Akad. Wiss. Wien, vol. 58, No. 15, 1868, p. 189, pl. 5, fig. 7.

[60] Palmer, D. K.: *Foraminifera from the upper Oligocene Cojimar formation of Cuba*, Mem. Soc. Cubana Hist. Nat., vol. 15, No. 2, 1941, p. 192. Listed as *E. byramensis* (Cushman) var. *campester* Palmer and Bermudez, new name for *E. byramensis* (Cushman) var. *cubensis* Palmer and Bermudez (not *Eponides cubensis* Palmer and Bermudez).

[61] Palmer, D. K., and Bermudez, P. J.: *An Oligocene foraminiferal fauna from Cuba*, Mem. Soc. Cubana Hist. Nat., vol. 10, No. 5, 1936, p. 302, pl. 20, figs. 4-6.

Eponides lateralis (Terquem), Cushman, 1930, Florida Geol. Survey, Bull. 4, p. 55, pl. 10, fig. 7.

A single specimen from Sta. 1 is typical except that it lacks conspicuous perforations on the ventral side of the final chamber.

Eponides parantillarum Galloway and Heminway

Eponides parantillarum Galloway and Heminway, 1941, New York Acad. Sci., Sci. Survey Porto Rico and the Virgin Islands, vol. 3, pt. 4, p. 374, pl. 18, fig. 1.

Eponides antillarum Cushman and Jarvis, 1930, Jour. Paleont., vol. 4, No. 4, p. 364, pl. 33, fig. 14, pl. 34, fig. 2. Not *Rotalina antillarum* d'Orbigny.

Occasional and typical.

Eponides pulvinus Galloway and Heminway

Eponides pulvinus Galloway and Heminway, 1941, New York Acad. Sci., Sci. Survey Porto Rico and Virgin Islands, vol. 3, pt. 4, p. 375, pl. 18, fig. 2.

Very rare. The specimens appear to be identical with the types figured from the Quebradillas formation, lower Miocene, of Puerto Rico.

Genus **ROTALIA** Lamarck, 1804

Rotalia beccarii (Linnæus) var. **tepida** Cushman

Rotalia beccarii (Linnæus) var. *tepida* Cushman, 1926, Carnegie Inst. Washington, Publ. 344, p. 79, pl. 1; Cole, 1931, Florida Geol. Survey, Bull. 6, p. 50, pl. 3 figs. 3, 4; Palmer and Bermudez, 1936, Mem. Soc. Cubana Hist. Nat., vol. 9, No. 4, p. 240.

Very rare. Very close to the type figures; the peripheral margin is not lobulate as in the specimen figured from the Pleistocene of Florida (Cole, 1931).

Rotalia rosea d'Orbigny

Rotalia rosea d'Orbigny, 1826, Ann. Sci. Nat., vol. 7, p. 272, No. 7; Modeles No. 36; Cushman, 1931, U. S. Nat. Mus., Bull. 104, pt. 8, p. 62, pl. 13, fig. 5.

Rotalina rosea d'Orbigny 1839, in De la Sagra, Hist. Phys., Pol., Nat. Cuba., "Foraminifères", p. 72, pl. 2, figs. 9-11.

Truncatulina rosea (d'Orbigny), Brady, 1884, Rept. Voy. *Challenger*, Zoöl., vol. 9, p. 667, pl. 96, fig. 1.

Occasional specimens are of the smooth type figured by D'Orbigny (1839).

Rotalia cf. **R. tholus** Galloway and Heminway

Rotalia tholus Galloway and Heminway, 1941, New York Acad. Sci., Sci. Survey Porto Rico and Virgin Islands, vol. 3, pt. 4, p. 382, pl. 20, fig. 2.

Very rare. The specimens resemble the type from the Ponce formation of Puerto Rico.

Genus EPISTOMINA Terquem, 1883

Epistomina elegans (d'Orbigny)

Rotalia (Turbinulina) elegans d'Orbigny, 1826, Ann. Sci. Nat., vol. 7, p. 276, No. 54.
Pulvinulina elegans (d'Orbigny), Parker, Jones and Brady, 1871, Ann. Mag. Nat. Hist., ser. 4, vol. 8, p. 174, pl. 12, fig. 142.
Epistomina elegans (d'Orbigny), Cushman, 1931, U. S. Nat. Mus., Bull. 104, pt. 8, p. 65, pl. 13, fig. 6 (reference); Cushman and Jarvis, 1930, Jour. Paleont., vol. 4, No. 4, p. 365, pl. 34, fig. 1.

Very rare and small. The specimens are probably megalospheric forms, having 6-7 chambers in the final whorl. They resemble living forms from the Caribbean area as figured by Cushman (1931). The specimen from Buff Bay (Cushman and Jarvis) is probably a microspheric form since it has about 11 chambers in the final whorl.

This is a very widely distributed species in the present seas, having been reported in the Atlantic from 23 to 2369 fathoms.

Genus SIPHONINA Reuss, 1850

Siphonina pulchra Cushman

Siphonina pulchra Cushman, 1919, Carnegie Inst. Washington, Publ. 291, p. 42, pl. 14, fig. 7; 1922, Carnegie Inst. Washington, Publ. 311, p. 49, pl. 7, figs. 11, 12; 1927, Proc. U. S. Nat. Mus., vol. 72, No. 2716, p. 8, pl. 2, fig. 5; Bermudez, 1935, Mem. Soc. Cubana Hist. Nat., vol. 9, No. 3, p. 211; Coryell and Rivero, 1940, Jour. Paleont., vol. 14, No. 4, p. 337, pl. 43, fig. 23; Palmer, 1941, Mem. Soc. Cubana Hist. Nat., vol. 15, No. 2, p. 196.
Siphonina reticulata Cushman, 1919, Carnegie Inst. Washington, Publ. 291, p. 42. Not Czjzek.

Common. The types came from the Yumurí River gorge, Matanzas, Cuba. In 1931 Cushman pointed out that the young, carinate stage had been identified as *S. reticulata*. The species is widely distributed in the West Indian region, chiefly in fairly shallow water but it was found in *Albatross* collections from 60 and 1169 fathoms.

Genus SIPHONINELLA Cushman, 1927

Siphoninella soluta (Brady)

Truncatulina soluta Brady, 1884, Rept. Voy. *Challenger*, Zoöl., vol. 9, p. 670, pl. 96, fig. 4.
Siphoninella soluta (Brady), Cushman, 1927, Contr. Cushman Lab. Foram. Res., vol. 3, pt. 1, p. 77, pl. 16, fig. 13; Bermudez, 1935, Mem.

Soc. Cubana Hist. Nat., vol. 9, No. 3, p. 212; Palmer and Bermudez, 1936, Mem. Soc. Cubana Hist. Nat., vol. 9, No. 4, p. 240; Palmer, 1941, Mem. Soc. Cubana Hist. Nat., vol. 15, No. 2, p. 197.

Very rare.

Genus CANCRIS Montfort, 1808

Cancris sagra (d'Orbigny)

Rotalina sagra d'Orbigny, 1839, in De la Sagra, Hist. Phys. Pol. Nat., Cuba, "Foraminifères", p. 77, pl. 5, figs. 13-15.

Pulvinulina sagra (d'Orbigny), Cushman, 1918, U. S. Geol. Survey, Bull. 676, p. 65, pl. 22, fig. 3; pl. 23, fig. 1; 1919, Carnegie Inst. Washington, Publ. 291, p. 44.

Cancris sagra (d'Orbigny). Cushman, 1931, U. S. Nat. Mus., Bull. 104, pt. 8, p. 74, pl. 15, fig. 2; 1933, U. S. Geol. Survey, Prof. Paper 175, p. 32, pl. 11, figs. 4, 5 (references); Palmer and Bermudez, 1935, Mem. Soc. Cubana Hist. Nat. vol. 9, No. 4, p. 240; Palmer, 1941, Mem. Soc. Cubana Hist., Nat. vol. 15, No. 2, p. 198.

Very rare. The specimens are small but closely resemble D'Orbigny's type.

Genus BAGGINA Cushman, 1926

Baggina cojimarensis Palmer

Baggina cojimarensis Palmer, 1941, Mem. Soc. Cubana Hist. Nat., vol. 15, No. 2, p. 198, pl. 16, figs. 13, 14.

?*Discorbis allomorphinoides* (Reuss), Cushman, 1919, Carnegie Inst. Washington, Publ. 291. p. 41; Cole, 1931, Florida Geol. Survey, Bull. 6, p. 45, pl. 6, figs. 8, 9.

Specimens resembling the type figures of this species are moderately common in the Bowden deposit. Cushman (1919) called attention to the similarity of this species to *Valvulineria allomorphinoides* (Reuss) living in the Pacific and expressed his doubt concerning the specific identity of that species with the Cretaceous form described by Reuss.

Family AMPHISTEGINIDÆ

Genus ASTERIGERINA d'Orbigny, 1839

Asterigerina carinata d'Orbigny

Asterigerina carinata d'Orbigny, 1839, in De la Sagra, Hist. Phys., Pol. Nat. Cuba, "Foraminifères", p. 118, pl. 5, fig. 25; pl. 6, figs. 1, 2; Cushman, 1919, Carnegie Inst. Washington, Publ. 291. p. 45; Cushman, 1931, U. S. Nat. Mus., Bull. 104, pt. 8, p. 77, pl. 15, figs. 4, 5; Palmer and Bermudez, 1936, Mem. Soc. Cubana Hist. Nat., vol. 9, No. 4, p. 240.

Occasional at Bowden and closely resembling the living Caribbean specimens illustrated by Cushman (1931). The species is common in 2 to 10 fathoms but also common in an *Albatross* collection at 1169 fathoms.

Genus AMPHISTEGINA d'Orbigny, 1826

Amphistegina angulata (Cushman) Plate 2, figs. 2 a-c.

Asterigerina angulata Cushman, 1919, Carnegie Inst. Washington, Publ. 291, p. 45, pl. 13, fig. 1.

Amphistegina angulata (Cushman), Coryell and Rivero, 1940, Jour. Paleont., vol. 14, No. 4, p. 339; Galloway and Heminway, 1941, New York Acad. Sci., Sci. Survey Porto Rico and Virgin Islands, vol. 3, pt. 4, p. 407, pl. 28, fig. 6; Palmer, 1941, Mem. Soc. Cubana Hist. Nat. vol. 15, No. 2, p. 199, pl. 15, figs. 14, 20, 21.

Specimens of *Amphistegina* are abundant in the Bowden samples. Conical specimens referred to this species are common and conspicuous because they attain a maximum diameter of 4 mm. The average diameter is about 2 mm. Diameter of figured specimen, 0.6 mm.; height, 0.46 mm.

The very large specimens seldom show the sutures distinctly. Small specimens show approximately 15 broadly curved dorsal sutures. Ventral supplementary chambers are obscure except in very small specimens in which they extend one-half to one-third the distance from the margin of the large umbilical deposit to the periphery. Partial sections show that both megalospheric and microspheric specimens are present; in general, the very large specimens are microspheric.

This species is characteristic of Oligo-Miocene moderately shallow water deposits in many localities in the Caribbean area. It is difficult to figure this species adequately, since the large and characteristic specimens show few details, even the sutures are indistinct. The convexity of the ventral side and its large boss, the apertural granules and sharp periphery are shown in figure 2, an immature specimen from Palmer Sta. 1. Galloway and Heminway gave a good figure of an immature specimen.

Figured specimen.—No. 20050, immature specimen, Paleontological Research Institution. Palmer Sta. 1.

Amphistegina chipolensis Cushman and Ponton

Amphistegina chipolensis Cushman and Ponton, 1932, Florida State Geological Survey, Bull. 9, p. 96, pl. 15, fig. 1.

Only a few specimens of this distinctive species were found. They differ from *A. lessonii* var. *bowdenensis,* n. var. in having a carinate periphery, a slight tendency to uncoil and a prominent ventral umbo.

Amphistegina lessonii d'Orbigny var. bowdenensis, n. var.

Plate 2, figs. 1 a-c.

Amphistegina lessonii d'Orbigny, Cushman (in part) 1919, Carnegie Inst. Washington, Publ. 291, p. 50.

?*Amphistegina gibbosa* d'Orbigny, Cole, 1931, Florida State Geol. Survey, Bull. 6, p. 52, pl. 5, fig. 14.

Test moderately large, biconvex to ventrally flattened, periphery sharp, not keeled. Final whorl with 18 to 23 chambers; dorsal sutures limbate, usually not elevated, sharply angled about midway between the periphery and the umbonal deposit; ventral secondary chambers conspicuous and extending about half the distance from the umbo to the periphery and frequently the final ones project in a narrow point between the lobes of the primary chambers. A small umbonal deposit is present both dorsally and ventrally but does not project beyond the general contour of the test. Partial sections indicate that in general the biconvex specimens are microspheric and the ventrally flat forms are usually megalospheric. Surface smooth except for apertural granules.

Holotype, maximum diameter, 1. 13 mm.; thickness, 0.57 mm.

There is a great deal of confusion in the nomenclature of the species of *Amphistegina*. Brady treated most of the early named forms as synonyms of *A. lessonii* d'Orbigny and most authors have followed him. *A. lessonii* was named in the Tableau Methodique in 1826 as coming from the Recent of l'Isle de France (Mauritius); it was neither described nor figured. The figure reference given for *A. lessonii* is identified as *A. quoii* in the explanation of the plate. This latter species was also listed in the Tableau Methodique, but not described, from the Recent of Rawak, New Holland. The Bowden specimens differ from the figure referred to, whether it be *A. lessonii* or *A. quoii*, in that they have fewer chambers with the dorsal sutures angled less sharply, the sutures being angled almost precisely halfway betwen the periphery and the umbo rather than close to the periphery, and in the lack of limbate lines between the sutures.

Amphistegina gibbosa d'Orbigny[62] was well described and figured in the Cuban monograph and differentiated from *A. quoii* by

[62] d'Orbigny, Alcides: in De la Sagra, Hist. Fis., Pol., Nat. Cuba, Foraminiferas, (Spanish ed.), 1840, p. 120, pl. 8, figs. 1-3.

the author. In as much as *A. gibbosa* was described as being flat ventrally it was suspected the Bowden form might be identical with it. However, comparisan with specimens from the Cuban coast reveals almost the same differences noted with reference to *A. lessonii*, with the exception that living West Indian forms have fewer chambers and in this respect resemble the Bowden form. Also, Cushman stated in 1931[63] that after examining a rather large suite of specimens he could not separate the West Indian from the Pacific form.

This variety is one of the most abundant species in the samples from Bowden.

Holotype.—No. 20048, Paleontological Research Institution. Palmer Sta. 1.

Family CYMBALOPORIDÆ

Genus TRETOMPHALUS Moebius, 1880

Tretomphalus atlanticus Cushman

Tretomphalus atlanticus Cushman, 1934, Contr. Cushman Lab. Foram. Res., vol. 10, pt. 4, p. 86, pl. 11, fig. 3; pl. 12, fig. 7; Palmer, 1941, Mem. Soc. Cubana Hist. Nat., vol. 15, No. 3, p. 281.

Cymbalopora (*Tretomphalus*) *bulloides* Brady, 1884, (in part), Rept. Voy. *Challenger*, Zoöl., vol. 9, p. 638, pl. 102, figs. 10, 11 (not 7-9, 12); Cushman, 1931, U. S. Nat. Mus., Bull. 104, pt. 8, p. 86, pl. 16, fig. 5. Not D'Orbigny.

Rare. The specimens are without float chambers and resemble those occurring in the shallow water of the Caribbean area, as illustrated by Cushman (1931).

Family CASSIDULINIDÆ

Genus CASSIDULINA d'Orbigny, 1826

Cassidulina crassa d'Orbigny

Cassidulina crassa d'Orbigny, 1839, Voy. Amer. Mérid., "Foraminifères", p. 56, pl. 7, figs. 18-20; Cushman, 1922, U. S. Mus., Bull. 104, pt. 3, p. 124, pl. 26, fig. 7; Cushman and Ponton, 1932, Florida Geol. Survey, Bull. 9, p. 97, Heron-Allen and Earland, 1932, *Discovery* Reports, vol. 4, Foraminifera, Pt. 1, p. 357, pl. 9, figs. 26-29.

Very rare. Less compressed laterally than is indicated by most figures and very similar to the typical specimens from the Falk-

63 Cushman, J. A.: *The Foraminifera of the Atlantic Ocean,* U. S. Nat. Nat. Mus., Bull. 104, pt. 8, 1931, p. 79.

land Islands area figured by Heron-Allen and Earland (1932).

Cassidulina lævigata d'Orbigny var. carinata Cushman

Cassidulina lævigata d'Orbigny var. *carinata* Cushman, 1922, U. S. Nat. Bull. 104, pt. 3, p. 124, pl. 25, figs. 6, 7; Cushman, 1930, Florida Geol. Survey, Bull. 4, p. 58, pl. 11, fig. 7; Cushman and Cahill, 1933, U. S. Geol. Survey, Prof. Paper 175, p. 33, pl. 12, fig. 3.

Specimens are small and rare and it is difficult to be certain that the narrow keel is sufficiently well developed to warrant reference to the var. *carinata*. They resemble the Choctawhatchee Miocene specimen figured by Cushman (1930).

Cassidulina subglobosa Brady

Cassidulina subglobosa Brady, 1881, Quart. Jour. Micro. Soc., vol. 21, p. 60; 1884, Rept. Voy. *Challenger*, Zoöl., vol. 9, p. 430, pl. 54, fig. 17; Cushman, 1922, U. S. Nat. Mus., Bull. 104, pt. 3, p. 127, pl. 24, fig. 6; Galloway and Morrey, 1929, Bull. Amer. Paleont., vol. 15, No. 55, p. 40, pl. 6, fig. 6; Palmer and Bermudez, 1936, Mem. Soc. Cubana Hist. Nat., vol. 9, No. 4, p. 240; Galloway and Heminway, 1941, New York Acad. Sci., Sci. Survey Porto Rico and the Virgin Islands, vol. 3. pt. 4, p. 425, pl. 32, fig. 2.

Rare. The specimens are similar to that illustrated by Galloway and Heminway (1941).

Genus **CASSIDULINOIDES** Cushman, 1927

Cassidulinoides bradyi (Norman)

Cassidulina bradyi (Norman ms.), Wright, 1880, Proc. Belfast Nat. Field Club, App., p. 152; Cushman, 1922, U. S. Nat. Mus., Bull. 104, pt. 3, p. 128, pl. 23, figs. 6, 7.

Cassidulinoides bradyi (Norman), Cushman, 1930, Florida Geol. Survey, Bull. 4, p. 58, pl. 11, fig. 8.

Very rare at Sta. 1 and resembling the Florida Miocene specimen figured by Cushman (1930).

Cassidulinoides cf. C. parkerianus (Brady) Plate 1, figs. 4 a-b.

Cassidulina parkeriana Brady, 1881, Quart. Jour. Micro. Soc., vol. 21, p. 59; 1884, Rept. Voy. *Challenger*, Zoöl., vol. 9, p. 432, pl. 54, figs. 11-16; Heron-Allen and Earland, 1932, *Discovery* Repts., vol. 4, Foraminifera, pt. 1, p. 359, pl. 9, fig. 22.

Three small specimens from Sta. 1 are with considerable doubt referred to this species. They differ from the type figures in that the sutures are scarcely depressed and the coiling of the early chambers is very inconspicuous. They are most similar to the microspheric specimen figured by Heron-Allen and Earland (1932) from the Falkland Islands area.

Length of figured specimen, 0.4 mm.

Figured specimen.—No. 20053, Paleontological Research Institution. Palmer Sta. 1.

Family CHILOSTOMELLIDÆ

Genus CHILOSTOMELLA Reuss, 1850

Chilostomella czizeki Reuss

Chilostomella czizeki Reuss, 1850, Denkschr. Akad. Wiss. Wien, vol. 1, p. 380, pl. 48, figs. 13a-d; Schwager, 1877, Boll. R. Com. Geol. Ital., vol. 8, p. 26, pl., fig. 70; Cushman, 1926, Contri. Cushman Lab. Foram. Res., vol. 1, pt. 4, p. 74, pl. 11, fig. 2; Galloway and Heminway, 1941, New York Acad. Sci., Sci Survey Porto Rico and Virgin Islands, vol. 3, pt. 4, p. 409, pl. 28, fig. 3.

Very rare specimens resemble the specimen figured by Galloway and Heminway.

Genus PULLENIA Parker and Jones, 1862

Pullenia sphæroides (d'Orbigny)

Nonionina sphaeroides d'Orbigny, 1826, Ann. Sci. Nat., vol. 7, p. 293, No. 1, Modeles, No. 43.

Pullenia sphaeroides (d'Orbigny), Cushman, 1924, U. S. Nat. Mus., Bull. 104, pt. 5, p. 40, pl. 8, figs. 3, 4 (references); Palmer and Bermudez, 1936, Mem. Soc. Cubana Hist. Nat., vol. 10, p. 309.

Nonionina bulloides d'Orbigny, 1826, Ann. Sci. Nat. vol. 7, p. 293, No. 2, 1846, Foram. Foss. Bass. Tert. Vienne, p. 107, pl. 5, figs. 9-10.

Pullenia bulloides (d'Orbigny), Galloway and Heminway, 1940, New York Acad. Sci., Sci. Survey Porto Rico and Virgin Islands, vol. 3, pt. 4, p. 360, pl. 15, fig. 4 (references).

A single specimen agrees well with the figures of living specimens given by Cushman (1924).

Genus SPHÆROIDINA d'Orbigny, 1826

Sphæroidina bulloides d'Orbigny

Sphaeroidina bulloides d'Orbigny, 1826, Ann. Sci. Nat., vol. 7, p. 267, Modeles, No. 16; Galloway and Heminway, 1941, New York Acad. Sci. Sci. Survey Porto Rico and Virgin Islands, vol. 3, pt. 4, p. 410, pl. 30, fig. 1.

Very rare.

Family GLOBIGERINIDÆ

Genus GLOBIGERINA d'Orbigny, 1826

Globigerina bulloides d'Orbigny

Globigerina bulloides d'Orbigny, 1826, Ann. Sci. Nat., vol. 7, p. 277, No. 1; Modeles, No. 17 and No. 76; Cushman, 1914, U. S. Nat. Mus., Bull. 71, pt. 4, p. 5, pl. 2, figs. 7-9; pl. 9 (references); Cushman, 1919, Carnegie Inst. Washington, Publ. 291, p. 38; Galloway and Heminway, 1941, New York Acad. Sci., Sci. Survey Porto Rico and Virgin Islands, vol. 3, pt. 4, p. 411, pl. 29, fig. 1; Cushman, 1941, Amer. Jour. Sci., vol. 239, p. 134.

The difficulty in identifying described species of this genus is great. The specimens assigned to this species in the Bowden material are usually small for the genus, compactly coiled with

3 to 4 chambers in the final whorl; sutures deep; aperture conspicuous and subcircular; surface finely reticulated. Occasional.

Dr. Cushman (1941) has called attention to the fact that in the cores from the Bartlett Deep it has not been possible to separate the young of other species from specimens usually assigned to *G. bulloides* and he therefore omitted this species from his list. The species is, however, retained on the Bowden list because the specimens approximate those usually assigned to it and though they may be the young of *G. rubra* d'Orbigny no trace of multiple apertures has been noted.

Globigerina subcretacea Chapman

Globigerina subcretacea Chapman, 1902, Jour. Linn. Soc., Zoöl., vol. 28, p. 410, pl. 36, fig. 16; Cushman, 1919, Carnegie Inst. Washington, Publ. 291, p. 39.

Common. The specimens agree well with the original description and figures.

Globigerina triloba Reuss

Globigerina tribloba Reuss, 1849-1850, Denkschr. Math. Kl. K. Akad. Wiss., Wien, vol. 1, p. 374, pt. ii (xlvii) fig. 11; Heron-Allen and Earland, 1924, Jour. R. Micros., Soc., pt. 2, p. 165.

Common. The specimens assigned to this species are very close to those referred to *G. bulloides* but have an almost slitlike usually very inconspicuous aperture.

Genus **GLOBIGERINOIDES** Cushman, 1927

Globigerinoides rubra (d'Orbigny)

Globigerina rubra d'Orbigny, 1839, in De la Sagra, Hist. Phys., Pol., Nat., Cuba, ''Foraminifères'', p. 89, pl. 4, figs. 12-14; Cushman, 1919, Carnegie Inst. Washington, Publ. 291, p. 39; 1922, Carnegie Inst. Washington, Publ. 311, p. 36, pl. 14, figs. 1, 2.

Globigerinoides rubra (d'Orbigny), Coryell and Rivero, 1940, Jour. Paleont., vol. 14, No. 4, p. 340.

Occasional specimens resemble the one figured by Cushman (1922).

Globigerinoides sacculifera (Brady)

Globigerina sacculifera Brady, 1884, Rept. Voy. *Challenger*, Zoöl., vol. 9, p. 604, pl. 80, figs. 11-17; pl. 82, fig. 4; Cushman, 1919, Carnegie Inst. Washington, Publ. 291, p. 39.

Globigerinoides sacculifera (Brady), Cushman and Jarvis, 1930, Jour. Paleont., vol. 4, No. 4, p. 366, pl. 34, fig. 4; Coryell and Rivero, 1940, Jour. Paleont., vol. 14, No. 4, p. 340, pl. 42, figs. 24, 25, 32.

Occasional. The specimens resemble those figured by Coryell and Rivero.

Genus GLOBIGERINELLA Cushman, 1927

Globigerinella æquilateralis (Brady)

Globigerina aequilateralis Brady, 1884, Rept. Voy. *Challenger*, Zoöl., vol. 9, p. 605, pl. 80, figs. 18-21; Cushman, 1918, U. S. Nat. Mus., Bull. 103, p. 67.

Globigerinella aequilateralis (Brady), Cushman, 1927, Contr. Cushman Lab., Foram. Res., vol. 3, p. 87; Bermudez, 1935, Mem. Soc. Cubana Hist. Nat., vol. 9, No. 3, p. 217; Palmer, 1941, Mem. Soc. Cubana Hist. Nat., vol. 15, No. 3, p. 286.

Rare. The specimens are similar to those from the coastal waters of Cuba.

Genus ORBULINA d'Orbigny, 1839

Orbulina universa d'Orbigny

Orbulina universa d'Orbigny, 1839, in De la Sagra, Hist. Phys., Pol., Nat. Cuba ''Foraminifères'', p. 108, pl. 2, figs. 27, 28; Cushman, 1919, Carnegie Inst. Washington, Publ. 291, p. 40; Cushman, 1924, U. S. Nat. Mus., Bull. 104, pt. 5, p. 35, pl. 5, fig. 1 (references); Cushman and Jarvis, 1930, Jour. Paleont., vol. 4, No. 4, p. 367; Coryell and Rivero, 1940, Jour. Paleont., vol. 14, No. 4, p. 340; Galloway and Heminway, 1941, New York Acad. Sci., Sci. Survey Porto Rico and Virgin Islands, vol. 3, pt. 4, p. 414, pl. 3, fig. 3; Palmer, 1941, Mem. Soc. Cubana Hist. Nat., vol. 15, No. 3, p. 287.

Occasional.

Genus Sphæroidinella Cushman, 1927

Sphæroidinella dehiscens (Parker and Jones)

Sphæroidina bulloides d'Orbigny var. *dehiscens* Parker and Jones, 1865, Philos. Trans., vol. 155, p. 369, pl. 19, fig. 5; Brady, 1884, Rep. Voy. *Challenger*, Zoöl., vol 9, p. 621, pl. 84, figs. 8-11; Cushman, 1924, U. S. Nat., Mus., Bull. 104, pt. 5, p. 38, pl. 7, figs. 7, 8; pl. 8, figs. 1, 2.

Sphæroidinella dehiscens (Parker and Jones), Cushman and Jarvis, 1930, Jour. Paleont., vol. 4, No. 4, p. 367, pl. 34, figs. 6, 7; Coryell and Rivero, 1940, Jour. Paleont., vol. 14, No. 4, p. 340, Cushman, 1941, Amer. Jour. Sci., vol. 239, pl. 5 fig. 1.

Very occasional specimens with three chambers in the final whorl, sutures jagged and separated in at least two, usually three, places resemble those figured by Cushman and Jarvis from Buff Bay, Jamaica (1930) and specimens from the Bartlett Deep figured by Cushman (1941). No specimens with the very deep reëntrants, such as figured by Brady (1884), were observed.

The closely related *S. seminulina* (Schwager)[64] from the late Tertiary of Kar Nikobar is distinguished by its regular sutures which are separated in only one place.

64 Schwager, Conrad: *Fossile Foraminifera von Kar-Nikobar, Novara-Expedition*, Geol. Theil, vol. 2, 1866, p. 256, pl. 7, fig. 112.

Sphæroidinella dehiscens (Parker and Jones) var. **immatura** Cushman

Sphaeroidina dehiscens Parker and Jones var. *immatura* Cushman, 1919, Carnegie Inst. Washington, Publ. 291, p. 40, pl. 14, fig. 2.

Occasional. The specimens are bilocular and the median suture, though jagged, is not open except in one or two places. The type of the variety is from Bowden.

Family **GLOBOROTALIIDÆ**

Genus **GLOBOTRUNCANA** Cushman, 1927

Globotruncana, sp.

A single poorly preserved specimen was found at Sta. 1. Specimens of this genus are occasionally found in Tertiary deposits in the West Indian area. They are usually found in gravelly beds such as this one at Bowden and believed to have been derived from the Upper Cretaceous.

Genus **GLOBOROTALIA** Cushman, 1927

Globorotalia menardii (d'Orbigny)

Rotalia menardii d'Orbigny, 1826, Ann. Sci. Nat., vol. 7, No. 26; Modèle, No. 10.

Pulvinulina menardii (d'Orbigny), Brady, 1884, Rep. Voy. *Challenger*, Zoöl., vol. 9, p. 690, pl. 103, figs. 1, 2; Nuttall, 1928, Quart. Jour. Geol. Soc. London, vol. 84, p. 101, pl. 7, fig. 20.

Globorotalia menardii (d'Orbigny), Cushman, 1930, Florida Geol. Survey, Bull. 4, p. 60, pl. 12, fig. 1; Coryell and Rivero, 1940 Jour. Paleont., vol. 14, No. 4, p. 336, pl. 42, figs. 34, 35; Palmer, 1941, Mem. Soc. Cubana Hist. Nat., vol. 15, No. 3, p. 291; Galloway and Heminway, 1941, New York Acad. Sci., Sci. Survey Porto Rico and the Virgin Islands, vol. 3, pt. 4, p. 368, pl. 16, fig. 5.

Common. The Bowden specimens resemble the one from the Miocene of Haiti figured by Coryell and Rivero (1940).

Globorotalia menardii (d'Orbigny) var. **miocenica, n. var.**

Plate 1, figs. 10 a-c

Test of average size; dorsally flat; ventrally strongly convex; composed of 2½ whorls with about six chambers in the final whorl; dorsal sutures broadly curved, clear, limbate but not generally elevated; spiral suture and periphery with limbate, elevated border; ventral sutures radial, depressed; ventrally the chambers terminate in a small, open umbilical depression. Aperture extending from the umbilical depression to the periphery on the inner base of the final chamber. Surface very finely but distinctly perforate. Moderately common.

Maximum diameter of holotype, 0.6 mm.; height, 0.02 mm.

The variety differs from the typical species in being strongly convex ventrally. Very probably the new variety is present in the Florida Miocene for Dr. Cushman made the following observation in his discussion of *G. menardii* (d'Orbigny)[65]: "A few specimens show much more variation in convexity of the ventral side than do most recent specimens."

The new variety also recalls *G. truncatulinoides* (d'Orbigny) but has more chambers in the final whorl with curved, not radial, dorsal sutures and the outline of the ventral chambers in side view is more oblique from the periphery toward the umbilicus.

Holotype.—No. 20047, Paleontological Research Institution. Palmer Sta. 1.

Globorotalia truncatulinoides (d'Orbigny)

Rotalina truncatulinoides d'Orbigny, 1839,in Barker-Webb and Berthelot, Hist. Nat. Iles Canaries, vol. 2, pt. 2, "Foraminifères", p. 132, pl. 2, figs, 25-27.

Globorotalia truncatulinoides (d'Orbigny), Cushman, 1931, U. S. Nat. Mus., Bull. 104, pt. 8, p. 97, pl. 17, fig. 4 (references).

Rare. This species is widely distributed in the present oceans. In the *Albatross* collections it was found chiefly in the *Globigerina* ooze but was also common at one station in 23 fathoms.

The Bowden specimens resemble the type in having five narrow chambers in the final whorl which are elongated parallel to the spiral suture.

Family **ANOMALINIDÆ**

Genus **PLANULINA** d'Orbigny, 1826

Planulina edwardsiana (d'Orbigny) var. canimarensis Palmer and Bermudez — Plate 1, figs. 9 a-c

Planulina edwardsiana (d'Orbigny) var. *canimarensis* Palmer and Bermudez, 1936, Mem. Soc. Cubana Hist. Nat., vol. 9, No. 4, p. 256, pl. 21, figs. 4-6.

Occasional. The specimens closely resemble the type from the late Tertiary on Canímar River, Cuba. The figured specimen has a maximum diameter of 0.6 mm.

[65] Cushman, J. A.: *The Foraminifera of the Choctawhatchee formation of Florida,* Florida State Geol. Survey, Bull. 4, 1930, p. 60.

Figured specimen.—No. 20052, Paleontological Research Institution. Palmer Sta. 1.

Planulina foveolata (Brady)

Anomalina foveolata Brady, 1884, Rept. Voy. *Challenger*, Zoöl., vol. 9, p. 674, pl. 94, fig. 1.

Anomalina ariminensis Brady, Parker and Jones (part), 1888, Trans. Zoöl. Soc. London, vol. 12, p. 228, pl. 45, fig. 21. Not d'Orbigny.

Planulina foveolata (Brady), Cushman, 1931, U. S. Nat. Mus., Bull. 104, pt. 8, p. 111, pl. 20, figs. 2 3; Coryell and Rivero, 1940, Jour. Paleont., vol. 14, No. 4, p. 337, pl. 44, fig. 1.

This is one of the distinctive species of the Bowden fauna and has been well figured by Coryell and Rivero. The specimens from the Miocene differ from those living in the Caribbean as figured by Cushman (1931, pl. 20, fig. 3) in that the periphery of the final chambers is not so conspicuously rounded. Occasional.

Genus **CIBICIDES** Montfort, 1808

Cibicides candei (d'Orbigny)

Truncatulina candei d'Orbigny, 1840, in De la Sagra, Hist. Fis., Pol., Nat. Cuba, ''Foraminiferas'' (Spanish ed.), p. 98, pl. 3, figs. 6-8.

Cibicides candei (d'Orbigny), Bermudez, 1935, Mem. Soc. Cubana Hist. Nat., vol. 9, No. 3, pp. 142 and 220; Palmer and Bermudez, 1936, Mem. Soc. Cubana Hist. Nat., vol. 9, No. 4, p. 241.

A very few specimens agree closely with specimens from the coast of Cuba and the late Tertiary of the Matanzas Bay region, Cuba (Palmer and Bermudez). They differ from the Bowden specimens referred to *Cibicides lobatus* (d'Orbigny) in being very much more compressed and in having a very narrow peripheral flange. In view of the variation indicated by figures of specimens referred to *C. lobatus* (d'Orbigny) it seems probable that this is merely another variant.

Cibicides concentricus (Cushman)

Truncatulina concentrica Cushman, 1918, U. S. Geol. Survey, Bull. 676, p. 64, pl. 21, fig. 3.

Cibicides concentricus (Cushman), Cushman, 1930, Florida Geol. Survey, Bull. 4, p. 61, pl. 12, fig. 4; Cushman and Ponton, 1932, Florida Geol. Survey, Bull. 9, p. 101; Cushman, 1931 (as *C. concentrica*), U.

S. Nat. Mus., Bull. 104, pt. 8, p. 120, pl. 21, figs. 4, 5; pl. 22, figs. 1, 2; Cushman and Cahill, 1933, U. S. Geol. Survey Prof. Paper 175A, p. 35, pl. 13, fig. 3; Coryell and Rivero, 1940, Jour. Paleont., vol. 14, No. 4, p. 334, pl. 44, fig. 9; Palmer, 1941, Mem. Soc. Cubana Hist. Nat., vol. 15, No. 3, p. 294, pl. 30, fig. 2.

Very rare at Sta. 1. The Bowden form more closely resembles the specimen figured by Cushman (1930) from the Choctawhatchee formation of Florida than any of the other figures cited.

Cibicides lobatus (d'Orbigny)

Truncatulina lobata d'Orbigny, 1839, in Barker-Webb and Berthelot, Hist. Nat. Iles Canaries, vol. 2, pt. 2, Foraminifères, p. 134, pl. 2, figs. 22-24.

Truncatulina lobatula d'Orbigny, Cushman, 1918, U. S. Geol. Survey, Bull. 676, pp. 16 and 60, pl. 1, fig. 10; Nuttall, 1928, Quart. Jour. Geol. Soc. London, vol. 84, pt. 1, p. 98 (as *T. lobatula* Walker and Jacob); Cushman. 1919, Carnegie Inst. Washington, Publ. 291, p. 41.

Cibicides lobatulus (Walker and Jacob), Cole, 1931, Florida Geol. Survey, Bull. 6, pl. 56; Cushman, 1931, U. S. Nat. Mus., Bull. 104, pt. 8, p. 118, pl. 21, fig. 3 (consult for references; listed as *C. lobatula*).

Cibicides lobatus (d'Orbigny), Galloway and Heminway, 1941, New York Acad. Sci., Sci. Survey Porto Rico and Virgin Islands, vol. 3, pt. 4, p. 393, pl. 24, fig. 4.

Moderately abundant specimens in the Bowden material appear to be within the limits of variation indicated by descriptions and figures of this species. The species is recorded from the Eocene to the Recent in the western Atlantic region. It is probably frequently adherent in habit and is consequently difficult to characterize precisely. Some of the variations probably include *C. depressus* and *C. concavus* Tolmachoff from the Miocene of Colombia[66]. The Bowden specimens agree well with the figures given by Galloway and Heminway (1941).

Cibicides nucleatus (Seguenza)

Truncatulina nucleata Seguenza, 1880, Accad. Lincei Atti, ser. 3, vol. 6, p. 64, pl. 7, fig. 8.

Cibicides nucleata (Seguenza), Galloway and Morey, 1929, Bull. Amer. Paleont., vol. 15, No. 55, p. 31, pl. 4, fig. 9; Palmer, 1941, Mem. Soc. Cubana Hist. Nat., vol. 15, No. 3, p. 296 (as *C. nucleatus*).

Anomalina nucleata (Seguenza), Coryell and Rivero, 1940, Jour. Paleont., vol. 14, No. 4, p. 334, pl. 44, fig. 2; Galloway and Heminway, 1941, New York Acad. Sci., Sci. Survey Porto Rico and Virgin Islands, vol. 3, pt. 4, p. 388, pl. 22, fig. 2.

Very occasional specimens agree closely with the original fig-

66 Tolmachoff, I. P.: *A Miocene microfauna and flora from the Atrato River, Colombia, South America,* Ann. Carnegie Mus., vol. 23, 1934, pp. 338-9, pl. XLII, figs. 19-24.

ures. They differ from the figures of a specimen from Ecuador given by Galloway and Morrey (1929) in having fewer chambers in the final whorl and very inconspicuous ventral umbo.

As Galloway and Heminway pointed out, this species is one of a group of closely related forms characterizing deposits of this general region from *Anomalina umbonata* Cushman of the middle Eocene of Louisiana to the living *Cibicides io* (Cushman). The members of the group differ in the amount of angulation of the periphery, number of chambers, sutural limbation and thickness of umbos. They evidently also differ in the position of the aperture, as indicated by the lack of agreement in generic reference. The Bowden specimens have been referred to *Cibicides* because the aperture is on the periphery and extends back along the dorsal spiral suture as indicated in the original figure of the species.

Cibicides perforatus Coryell and Rivero

Cibicides perforatus Coryell and Rivero, 1940, Jour. Paleont., vol. 14, No. 4, p. 335, pl. 44, fig. 13.

Rare. The specimens assigned to this species differ from *Cibicides pseudoungerianus* and *C. floridanus* in having fewer whorls which increase more rapidly in width and fewer chambers per whorl. The central dorsal spiral is obscured by the sutural deposit of clear shell substance.

Cibicides pseudoungerianus (Cushman)

Truncatulina ungeriana Brady, 1884, Rept. Voy. *Challenger*, Zoöl., vol. 9, p. 664, pl. 94, fig. 9. Not D'Orbigny.

Truncatulina pseudoungeriana Cushman, 1922, U. S. Geol. Survey, Prof. Paper, 129-E, p. 97, pl. 20, fig. 9.

Cibicides pseudoungeriana (Cushman), Cushman, 1931, U. S. Nat. Mus., Bull. 104, pt. 8, p. 123, pl. 22, figs. 3-7; Galloway and Heminway, 1941, New York Acad. Sci., Sci. Survey Porto Rico and the Virgin Islands, vol. 3, pt. 4, p. 395, pl. 23, fig. 5 (as *C. pseudoungerianus*).

Common at Bowden. The specimens closely resemble the figures by Cushman (1931), and Galloway and Heminway (1941). This species may be distinguished from the closely related *C.*

floridanus (Cushman)[67] by its more convex dorsal surface, more bluntly angled peripheral margin, gently depressed, not limbate sutures and the tendency to more complanate manner of growth with fewer whorls visible dorsally.

Cibicides robertsonianus (Brady) var. haitiensis Coryell and Rivero

Cibicides robertsonianus (Brady) var. *haitiensis* Coryell and Rivero, 1940, Jour. Paleont., vol. 14, No. 4, p. 335, pl. 44, figs. 4, 5, 6.

Very rare at Sta. 1.

Cibicides spirolimbatus Galloway and Heminway

Cibicides spirolimbatus Galloway and Heminway, 1941, New York Acad. Sci., Sci. Survey Porto Rico and Virgin Islands, vol. 3, pt. 4, p. 397, pl. 25, fig. 1.

The test is of average size for the genus, biconvex; periphery not keeled, not lobate except on the last chambers. Four whorls are visible dorsally, increasing very gradually in width; chambers numerous, averaging 12 in the final whorl; sutures slightly curved limbate and elevated on early whorls, less so on the final whorl; spiral suture broad, limbate and well elevated, constituting a distinguishing character of the species; ventral sutures gently curved, limbate but only slightly if at all elevated and uniting in a well-developed umbilical deposit of shell substance. Surface coarsely perforated.

This is one of the common and characteristic species of the Bowden fauna. It may be distinguished from *C. alleni* (Plummer) of Galloway and Morey[68], which is also characterized by a strongly limbate spiral suture, by its more elevated dorsal side with more whorls which are narrower. It also closely resembles the type of figure of *Truncatulina præcincta* (Karrer) var. *ornata* Silvestri[69] from the Pliocene of Italy, but has more chambers.

67 Cushman, J. A.: *Some Pliocene and Miocene Foraminifera of the Coastal Plain of the United States*, U. S. Geol. Survey, Bull. 676, 1918, p. 62, pl. 19, fig. 2.

68 Galloway, J. J., and Morrey, Margaret: *A lower Tertiary foraminiferal fauna from Manta, Ecuador*, Bull. Amer. Paleont., vol. 15, No. 55, 1929, p. 29, pl. 4, fig. 6.

69 Silvestri, A.: *Foraminiferi pliocenici della Provincia di Siena, Pt. II*, Accad. Pont. Nuovi Lincei Mem., Roma, 1898, vol. 15, p. 299, pl. 6, fig. 10.

Genus **DYOCIBICIDES** Cushman and Valentine, 1930

Dyocibicides cf. D. biserialis Cushman and Valentine

Dyocibicides biserialis Cushman and Valentine, 1930, Contr. Dept. Geol. Stanford University, vol. 1, p. 31, pl. 10, figs. 1, 2; Cushman and Cahill, 1933, U. S. Geol. Survey, Prof. Paper, 175, p. 35, pl. 13, fig. 5 (references).

A few specimens show incipient uncoiling with biserial arrangement of the final chambers. Positive specific identification is not warranted from these immature specimens. They are quite close to the original figure of a young specimen.

Genus **CIBICIDELLA** Cushman, 1927

Cibicidella variabilis (d'Orbigny)

Truncatulina variabilis d'Orbigny, 1839, in Barker-Webb and Berthelot, Hist. Nat. Iles Canaries, vol. 2, pt. 2, p. 135, pl. 2, fig. 29.
Cibicidella variabilis (d'Orbigny), Cushman and Ponton, 1932, Florida Geol. Survey, Bull. 9, p. 102, pl. 15, figs. 5-7.

Occasional small specimens from Bowden resemble the Florida Miocene specimens referred to this species.

Family **PLANORBULINIDÆ**

Specific determinations of representatives of this family and also of the irregularly spreading Cibicidinæ of the family Anomalinidæ from only a few or fragmentary specimens is very unsatisfactory. The habitat, whether free or attached, will largely control the shape of the test. The taxonomic difficulties involved have been well stated by Heron-Allen and Earland in their report on the Foraminifera of the Kerimba Archipelago[70]. The species identified in the Bowden samples have been referred to the figured specimens they most closely resemble.

Planorbulina acervalis Brady

Planorbulina acervalis Brady, 1884, Rep. Voy. *Challenger*, Zoöl., vol. 9, p. 657, pl. 92, fig. 4; Cushman, 1922, Carnegie Inst. Washington, Publ. 311, p. 45, pl. 6, fig. 3; 1931, U. S. Nat. Mus., Bull. 104, pt. 8, p. 130, pl. 25, fig. 1.

Very rare specimens resemble Brady's original figure.

Planorbulina mediterranensis d'Orbigny

Planorbulina mediterranensis d'Orbigny, 1826, Ann. Sci. Nat., vol. 7, p. 280, No. 2, pl. 14, figs. 4-6; Modeles, No. 79; Cushman, 1931, U. S. Nat. Mus., Bull. 104, pt. 8, p. 129, pl. 24, figs. 5-8.

[70] Heron-Allen, E., and Earland, A.: Trans. Zoöl. Soc. London, 1914, vol. 20, pp. 705 and 724-726.

Occasional immature specimens resemble those figured by Cushman (1931).

Genus **GYPSINA** Carter, 1877

Gypsina cf. G. vesicularis (Parker and Jones)

Orbitolina vesicularis Parker and Jones, 1860, Ann. Mag. Nat. Hist., ser. 3, vol. 6, p. 31, No. 5.

Gypsina vesicularis (Parker and Jones), Brady, 1884, Rept. Voy. *Challenger,* Zoöl., vol. 9, p. 718, pl. 101, figs. 9-12; Cushman, 1931, U. S. Nat. Mus., Bull. 104, pt. 8, p. 135.

Several specimens have been provisionally referred to this species as figured by Brady. They are distinguished from *Sphærogypsina pilaris* (Brady) by their subspherical or hemispherical shape and smaller size.

Genus **SPHÆROGYPSINA** Galloway, 1933

Sphærogypsina pilaris (Brady)

Tinoporus pilaris Brady, 1876, Ann. Soc. Mal. Belg., vol. 11, p. 103.

Gypsina globulus (Brady), Hill, 1899, Bull. Mus. Comp. Zool., vol. 34, p. 147.

Gypsina globulus (Brady) var. *pilaris* (Brady), Cushman, 1919, Carnegie Inst. Washington, Publ. 291, p. 44, pl. 9, figs. 1, 2.

Gypsina pilaris (Brady) Rutten, 1940, Mem. Soc. Cubana Hist. Nat., vol. 14, No. 2, p. 165, pl. 24.

Sphærogypsina pilaris (Brady), Galloway and Heminway, 1941, New York Acad. Sci., Sci. Survey Porto Rico and Virgin Islands, vol. 3, pt. 4, p. 406, pl. 27, fig. 8.

This is one of the most distinctive species in the Bowden formation. It is moderately common in the material examined. The specimens agree closely with the figures given by Cushman (1919) and Rutten (1940).

Family **HOMOTREMIDÆ**

Genus **HOMOTREMA** Hickson, 1911

Homotrema cf. H. rubrum (Lamarck)

Millepora rubra Lamarck, 1816, Hist. Nat. Anim. sans Vert., vol. 2, p. 202.

Homotrema rubrum Hickson, 1911, Trans. Linn. Soc. London, Zool., ser. 2, vol. 14, p. 445, pl. 30, fig. 2; pl. 31, fig. 9; pl. 32, figs. 19, 22, 28; Cushman, 1922, Carnegie Inst. Washington, Publ. 311, p. 53, pl. 14, figs. 6-8.

Several poorly preserved specimens have been doubtfully referred to this species. The largest specimen has a maximum diameter of 7.4 mm. Another specimen has a length of 5 mm. and the breadth at the outer end is 4.5 mm. The surface of the speci-

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mens is eroded and there is no trace of the perforated plate filling the meshwork. In size and shape the specimens closely resemble those common in shallow water off Cuba.

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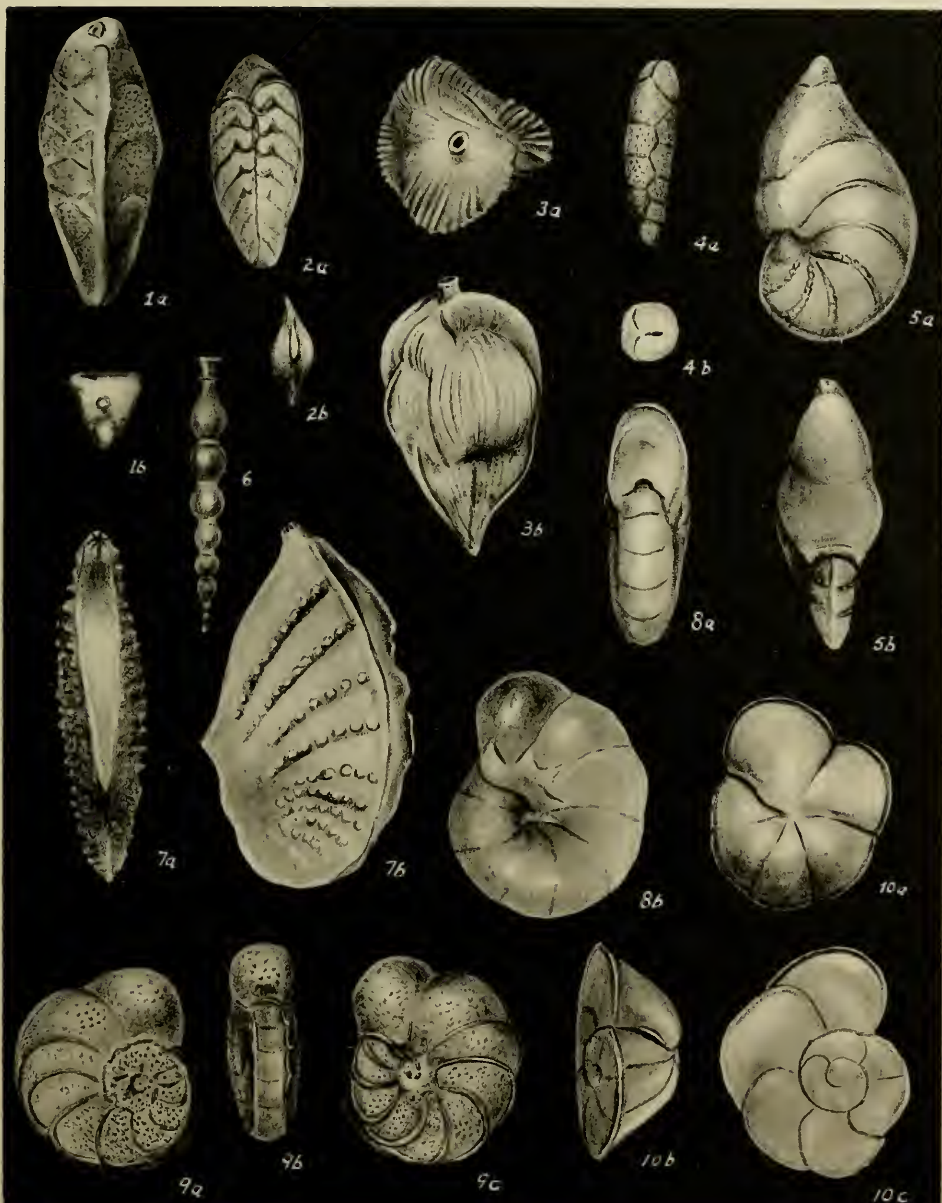
Figures drawn by Caridad Vidaurreta de Bermúdez.

All types and figured specimens are deposited in the Paleontological Research Institution.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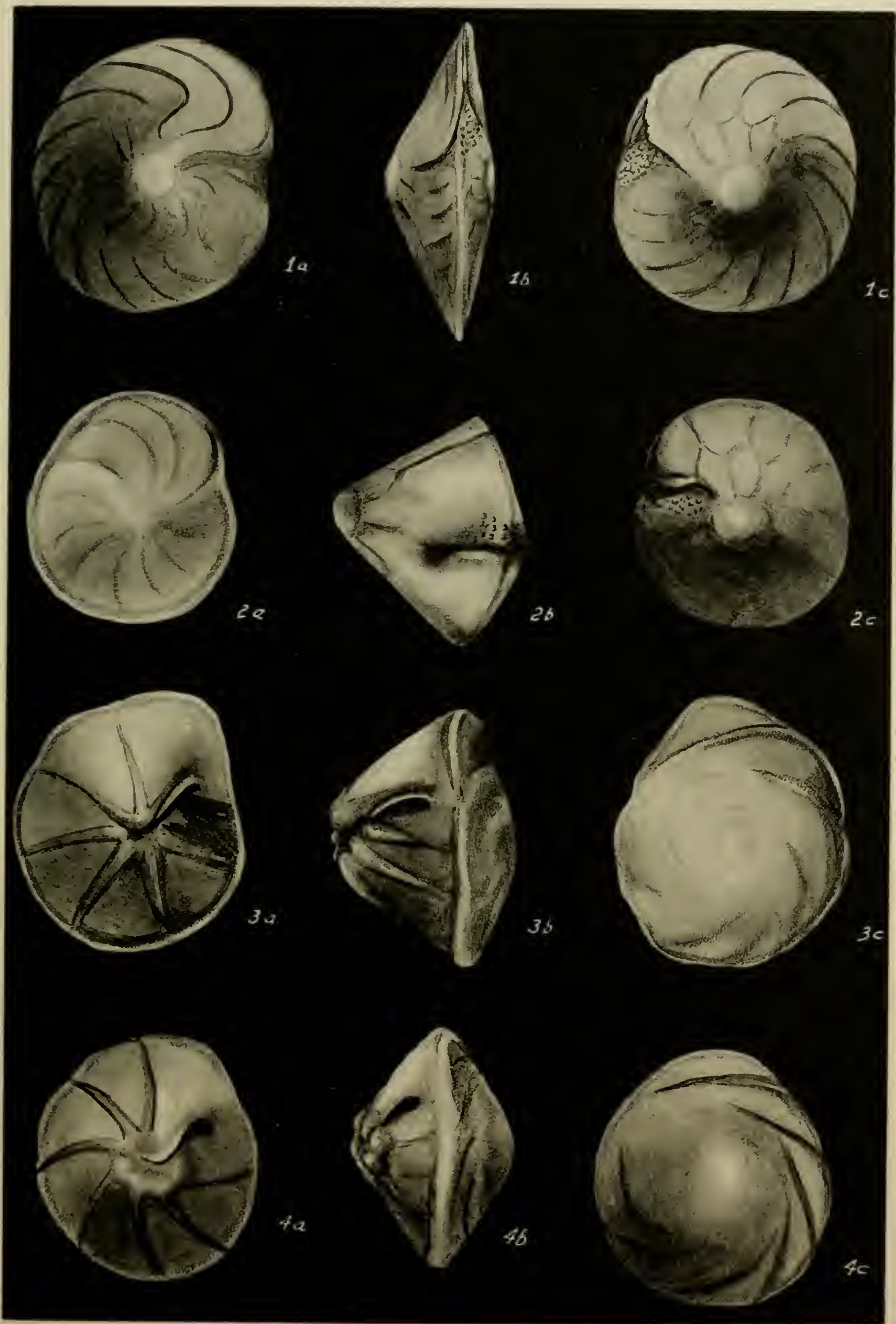
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ORDOVICIAN CEPHALOPODS OF THE CINCINNATI REGION
Part I

By

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March 21, 1946

Paleontological Research Institution
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ORDOVICIAN CEPHALOPODA OF THE CINCINNATI REGION

PART I

By

Rousseau H. Flower

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INTRODUCTION

The Cincinnati region furnishes the type section of the Upper Ordovician of America, and its assemblage of fossils is world famous, both for the prolific abundance of individuals and for excellence of preservation. Many, indeed most of the species of this region, have been made known through the efforts of those men in Cincinnati, amateurs in the best sense of the term, whose interest was captured by the remains of these ancient organisms. For those who have come after them, however, the problems of study and identification have become acute, for the original descriptions are so widely scattered in the geological literature that proper identification can be attempted only by those who have access to a well-stocked library. Further, many of the old descriptions are today too general to meet the exacting requirements of modern taxonomy, and revision of these species is badly needed. Likewise, the stratigrapher now desires precise information on the range of the Cincinnati species in terms of more than 18 members now recognized in the Cincinnati section. Likewise, much material representing undescribed species has accumulated. For these reasons a complete revision of the Cincinnatian faunas is needed. It has been the hope of the University of Cincinnati Museum for some years that such work could be undertaken, preferably by the individual treatment of the various systematic groups which comprise the Cincinnatian fauna as a whole.

In initiating this projected series, the Cephalopoda are a fitting beginning, since they are among the best known of the fossil groups in equivalent horizons, due to the work of Foerste (1925-33) in America, Teichert (1934) and Troedsson (1926) in the Arctic, and Strand (1934) and Teichert (1930) in northern Europe. On the other hand, the cephalopods of the Cincinnati region are perhaps the most neglected of the systematic units comprising the Cincinnatian fauna. This is shown by the fact that of the 50 species described from the Cincinnati region prior to 1935, only 24 are included in the 163 species discussed in Part I of this paper, the remainder being new. Of these 24 described species, three are unrecognizable. Twenty-six species already named, remain to be revised in the second part of this work. Four of these are certainly unrecognizable, and still others can be recognized only if the type specimens can be relocated and restudied. In addition, Cincinnati cephalopods have been identified in terms of 16 species described from other regions. In those cases in which the specimens forming the basis of these identifications have been relocated and restudied, the identifications have been found to be either erroneous or based upon material too poor for certain specific identification. The commonest species of Cincinnati cephalopods are the smooth orthoceracones. These are always fragmentary and frequently crushed. The identification of such forms from the extant descriptions and figures is virtually impossible. Recourse must be had to the type specimens in order to establish upon an adequate basis the species now described. No small part of the task has been an effort to relocate these types. One, the type of *Melia cincinatæ** is in Paris, if it is preserved. Those in America are widely scattered, literally from the Harvard Museum of Comparative Zoölogy to the University of California. Many have not been located.

The description and illustration of the species are the first requirement, and, where such a procedure is feasible, they are supplemented by keys. In many cases, however, the fragmentary nature of the remains makes the use of keys difficult if not impossible.

*Spelling as in text, D'Orbigny, Prodrome, 1850, p. 4; *M. Cincinnatæ* Index, D'Orbigny, Prodrome, p. 95.—*Eds.*

Illustrations and descriptions are the prime requisite for the student whose main interest lies in the identification of the fossils in the Cincinnati region. For the stratigrapher and the student of faunal relations, this information has not in itself great value. Practically all of the species of cephalopods of the Cincinnati region are confined to this area and do not extend far, if at all, into other regions. For this reason, the species as such have little value in settling the problems of correlation or the tracing of faunal migrations. Correlation on the basis of the genera gives some information on faunal relationships but is an unsafe guide to correlation. Foerste (1932, '33), found the same genera but different species inhabiting two distinct Middle Ordovician faunas, one now regarded by Kay as of Black River age, while the other, which is certainly slightly younger, he now regards as Rockland age, basal Trenton. However, some clues to such problems may be found by the examination of the genus as a unit. Where the factual information is adequate, it should be possible to trace a genus from the primitive generalized species by which it is first represented, through later variation and expansion of the stock, the possible development of distinguishable species groups, which often characterize its later development, to the appearance of phylogerontic forms, which sometimes characterize the last survivors of the stock. By drawing upon the published information, together with knowledge of such unpublished material, notably a large Chazyan fauna of over 70 species, which is still largely undescribed, and much Middle Ordovician material, notably from Quebec, submitted to the writer for study by Mr. G. Winston Sinclair, it has often been possible to trace fairly clearly the development of the genus. Further, some light is thrown upon the problem of the interpretations of the faunal changes in terms of the rather complex concept of alternating faunal invasions from the north and south. For example, the supposedly austral Cynthiana fauna has been found to contain elements strikingly similar to the supposedly boreal faunas of the Vaureal of Anticosti, the Whitehead formation of Gaspé, the Bighorn formation of Wyoming, and the Red River series of Manitoba. As an example of progressive evolution in a genus, Cynthiana species of *Faberoceras* present a marked contrast to the obviously more rugose, larger, and more complex species of the Leipers, while the crowded cameræ of the Corryville form marks it as phylogerontic in relation to the Leipers (Fairmount equivalent) forbears. Again, the youngest of the species of *Manitoulinoceras, M. ultimum* of the Elkhorn, is phylogerontic in relation to *M. moderatum* of the Whitewater and Saluda. On the other hand, the species of *Zitteloceras* are of less aid, for the Cincinnati species fall into species groups already well differentiated in Middle Ordovician time, which have showed little if any morphological advance which can be correlated definitely with the younger age of the Richmond species. The complex and bewilderingly large number of species in the Oncoceratidæ has yielded to some extent to the recognition of species groups, suggesting strongly the probable lines of descent among the various form genera which it is feared have little generic significance. However, these forms, on the basis of stratigraphic evidence, arose from generalized breviconic shells close to the tenuous boundary between *Oncoceras* and *Beloitoceras.* More form types became distinct in the Middle Ordovician, and in general, bizarre types, such as the group of *Beloitoceras amoenum, B. geniculatum, B. protractum,* and the genera *Neumatoceras, Winnipegoceras,* and *Digenuoceras* represent the last survivors of the stock in the Richmond. While it is felt that such investigations should have results which will aid materially in arriving at more accurate concepts of the intermingling migrations of faunas in the Ordovician, the problem has been approached with caution, largely because it was realized how much descriptive work remains to be done even in American Ordovician faunas. The cephalopods of the Ordovician formations of the Appalachian geosyncline south of New York are very largely undescribed. For this reason revisions of the concepts suggested here based upon new evidence will be gladly welcomed.

Yet another problem has been the tracing of phylogeny and classification. Many of the genera now employed for Ordovician cephalopods have never received family designation. Morphological study has made possible the placing in families of all except a few of the genera employed in the present work, which embraces the greater number of genera occuring in the American Ordovician, and in many cases indications of the relationship of families has been found. The final section of the study of American Ozarkian and Canadian faunas appeared when this investigation had reached its final stages. While further study of these forms will doubtless add materially to the present concepts of both cephalopod development and faunal relations in the early Paleozoic, it must be confessed that in the present state of knowledge of many of these pre-Chazyan genera, most of which are known from chert-replaced internal molds, there is not enough information in relation to internal structure to demonstrate the relationships between these older genera and those of the post-Canadian.

There has developed in recent years a need for more precise information concerning the range of the species throughout the Cincinnatian. This was brought out clearly in the discussions of Ulrich and Schuchert in relation to Ulrich's proposed removal of the Richmond group to the Silurian system. Many of the previously described species of the Cincinnatian are listed as only "Hudson River group, Cincinnati, Ohio". This is partly because many of the species were described at a time when this information was considered sufficient. It was also partly due to the keen rivalry which existed among the Cincinnati collectors, many of whom regarded localities and horizons which yielded their rarer treasures as carefully guarded secrets. In order to rectify this, both at the University of Cincinnati and at Miami University, large collections were accumulated, with an emphasis on material accompanied by careful horizon and locality data. During the several years which the writer spent at Cincinnati, a special effort was made to accumulate cephalopods accompanied by such data for the present study. Several thousand specimens of orthoceracones were accumulated, the study of which must be reserved for Part II of the present work. It is believed that these will supply data on variation and the recurrence of species in the column, thereby making these, the most abundant of the Cincinnati cephalopods, a useful stratigraphic tool. Likewise, such collecting has added materially to the rarer forms, which are largely included in the present section.

Because of the possibility that this work might suffer many interruptions, it was decided at an early stage that the descripions should be done in small sections, sometimes a genus, and sometimes a family. In order that the work could be prepared for publication in an incomplete form at almost any stage, it was necessary that preparation of the plates should keep pace with the descriptions. While the descriptions in this section of the work have been rearranged slightly in order to comply as closely as possible with the phylogeny and classification, the plates necessarily follow an order of their own. The first plates (1-5) are devoted to the annulated orthoceracones, which are followed by the Mixochoanites (Pls. 5-7). The next plates (8-17) are devoted primarily to the Discosoroidea. However, most of these forms were large, and in order to conserve plate space the smaller brevicones of the Cynthiana and Covington were combined with them. They are followed by the Valcouroceratidæ (Pls. 18-25), then by the characteristic genera *Shidelceroceras, Zitteloceras,* and *Cyrtocerina.* Plates 31-43 are devoted largely to the Richmond Onoceratidæ, Distoceratidæ, and Apsidoceratidæ. The remainder of the plates illustrate such of the Actinoceroidea as are included in the present part of the work.

Because of the writer's departure from Cincinnati, and of uncertainty as to how soon the investigation could be resumed, it was felt wisest to divide the work into two parts. Part II is expected to include (1) the family Trocholitidæ (2) the smooth orthochoanitic orthoceracones, the Michelinoceratidæ (3) the remainder of the Actinoceroidea, which comprises insofar as now known, only the prolific genus *Treptoceras* Flower (1942) and (4) the Endoceroidea. These comprise groups which involve special problems. Proper treatment of some requires the examination of types which it has not yet been possible to locate in any institution. The endoceroids involve special problems because of the fragmentary nature and poor preservation of most of the Cincinnatian specimens.

Part II will also contain such general remarks as the description of supposed nautiloid trails and impressions in the Cincinnatian, revised faunal lists, and a discussion of the faunal relationships of the Cincinnati cephalopods and their bearing upon broader aspects of Ordovician stratigraphy and paleogeography, together with a more thorough analysis of Upper Ordovician faunas as a whole. Because Part II may be long delayed, incomplete faunal lists are included together with some remarks upon the faunal and stratigraphic problems. These subjects are expected to receive more adequate treatment in the uncompleted part of the work.

Rousseau H. Flower

New York State Museum
January 31, 1945.

Formerly of the University of Cincinnati Museum.

ACKNOWLEDGMENTS

The revision of the Cincinnatian cephalopods has been based upon two major collections, that of the University of Cincinnati Museum and the collection of Dr. W. H. Shideler, to which have been added much supplementary material. The collections of the University of Cincinnati Museum had their real beginning in the gift of the second fossil collection of Charles L. Faber, to which was added some material from the collections of many of his contemporaries, including S. A. Miller, James, and Schlemmer. A number of types were found among his material. More recently, this has been supplemented by two noteworthy additions, the gift of a very fine collection by the late Mr. Charles E. Vaupel and the deposit of the fossil collection of the Cincinnati Society of Natural History. Much of this early material was of particular value because of the determinations, made in some instances by the describers of the species involved. However, some of it lacked all data on horizon and locality. Within recent years additional collecting on the part of members of the museum and Geology Department, both staff and students, has brought together a large amount of material labeled with careful regard to horizon and locality, and since the writer's arrival at Cincinnati in 1938, a particular effort has been made to bring together cephalopod material in preparation for this study.

Professor W. H. Shideler of Miami University submitted the cephalopods from his extensive and carefully made collection of Cincinnatian fossils. Not only did this material supply many species which would otherwise have remained unknown, but it presented in every case material accompanied by detailed information concerning its origin and horizon. A part of Dr. Shideler's material consisted of several drawers of specimens which had been submitted to Dr. A. F. Foerste for study. Dr. Foerste had laid this material aside in order to work with Dr. Ulrich on the cephalopods of the Ozarkian and Canadian and died before he could return to the Cincinnatian study. This material was sent from the U. S. National Museum accompanied by Dr. Foerste's labels and an incompleted manuscript consisting of the descriptions of about a dozen species. In the following pages these de-

scriptions are largely quoted intact, and the species described are attributed to Foerste. The fairest course seemed to be to treat this manuscript as though it had been published material. However, in some cases this proved impossible. One species was described without generic reference, save the indication that it belonged to a new genus. It was found to be congeneric with *Faberoceras*, a genus which existed then only in my own manuscript. *Shideleroceras* is a generic name proposed by Foerste in his manuscript, but the description of the genus was lacking. In some cases additional material has made it seem best to present a revised description of the species, while in a few instances such material has necessitated a revised concept of the species boundaries and sometimes of their generic position. These cases are noted in the discussions of the species concerned. It has seemed wisest in every instance to indicate clearly what part of the work was that of Dr. Foerste and which part has been contributed by the present writer, thereby eliminating possible confusion resulting from somewhat different viewpoints which are largely the result of further progress in the investigation of nautiloid structure in an interval of eight years, since Foerste abandoned this investigation.

Significant additions to these large collections consist in selected cephalopod material from the collections of Earlham College, loaned through the courtesy of Dr. Francis D. Hole and Dr. Millard Markle. Additional material was loaned by the U. S. National Museum through the courtesy of Dr. Ray S. Bassler and Dr. G. A. Cooper. Material from the collections of Ohio State University was loaned through the kindness of Dr. J. W. Wells and Dr. Grace A. Stewart. Also relevant to this problem is a large collection of Ordovician material from Canada, sent by Mr. G. Winston Sinclair of Sir George Williams College. This has been of inestimable aid in the tracing of faunal relationships.

It is impossible to mention all of those in Cincinnati who have contributed to this work by submitting specimens or by assisting in collecting. Practically every member of the Geology Department has aided in the accumulation of material used in this study. I wish to express my indebtedness to Miss Helen Duncan, Dr.

A. T. Cross and Mr. Robert Kosanke, for assistance in collecting. Dr. K. E. Caster and Mr. Robert T. Russell have made very significant contributions to our cephalopod material used in this study.

There has recently come into existence an organization of amateur geologists in Cincinnati known as the Dry Dredgers. So many of my friends in this organization have contributed material, that I can mention only a few. Mr. H. J. Seibert has made valuable contributions, particularly of cephalopods of the lower Maysville. Mr. Sarles and Mr. and Mrs. J. A. Dalve have contributed material from around Cincinnati. Miss Carrie Williams has presented material which has served mainly as the basis of our knowledge of the varied cephalopods of the *Orthoceras duseri* beds of the lower Waynesville. Dr. Kelly Hale of Wilmington, Ohio, has contributed some exceedingly significant specimens from his collection.

In the search for types of Cincinnatian cephalopods, practically all of the major institutions in eastern North America have been consulted. Dr. Ray S. Bassler has supplied information in relation to the types of the U. S. National Museum, many of which could not be consulted inasmuch as they were in storage for the duration of the war. Dr. Carey Croneis and Mr. M. S. Chappars have supplied information concerning the specimens in the collections of the University of Chicago. Dr. Bruce L. Clarke has supplied information concerning material in the collections of the University of California, and loaned the holotype of *Orthoceras duseri* for study. For other information I am indebted to Dr. J. W. Wells, Dr. Harold W. Scott, Dr. A. H. Sutton, Dr. W. H. Easton, Dr. J. Marvin Weller, and Professor P. E. Raymond.

Much information relevant to localities, horizons, and early collections, as well as the pursuit of many of the types, has been supplied by Dr. R. S. Bassler and Prof. W. H. Shideler, to both of whom I am deeply grateful for their assistance and their steadfast interest.

In the completion of this work at Cincinnati I have had the support and encouragement of Dr. John L. Rich and Dr. K. E.

Caster. The Department of Geology supplied the cutting and photographic equipment so necessary to this investigation. The expense of photographic supplies and a large part of the cost of illustration were met by the Faber Publication Fund of the University of Cincinnati Museum. This proved inadequate for the large number of plates necessary for the proper illustration of the cephalopods, and was materially supplemented by other grants as noted hereafter under "Plates".

Many have aided in the completion of this work. For discussion of many of the problems I am indebted to Dr. K. E. Caster, Dr. W. H. Shideler, Dr. R. S. Bassler, Dr. Winifred Goldring, and Dr. Rudolph Ruedemann. Miss Jane Forsythe has aided in the checking and cataloguing of the types. Mrs. J. A. Dalve has assisted in the completion of some of the illustrations. Mr. Clinton Kilfoyle has prepared several of the figures representing the phylogeny of the suborthochoanitic cephalopods and the Discosoroidea. I wish also to thank Dr. Winifred Goldring who generously assisted in rechecking the manuscript in the final stages. For stenographic assistance I am indebted to the New York State Museum.

Lastly, I wish to express my indebtedness to Professor G. D. Harris and Dr. Katherine V. W. Palmer for the thankless task of editing and also assistance in reading proof.

NAUTILOID MORPHOLOGY

In the last 15 years great advances have been made in the knowledge of nautiloid structure, and advantage has been taken of hitherto neglected features both in the description and in the tracing of phylogeny. For this reason, the study of nautiloids has progressed rapidly from a point at which only the gross features of the shell were taken into consideration to one at which the structures are examined to a detailed extent which is almost histological rather than morphological. The general knowledge of these exceedingly complex creatures has lagged far behind the outposts of research, and the structures, as well as the rather formidable system of nomenclature which is employed in their description, is a matter which is unfortunately known to relatively few paleontologists. Further, even the more recent text books in English have not kept pace with the recent investigations; indeed, most of them rely upon Hyatt's (1900) concept of morphology and classification, which has since been greatly elaborated and strongly modified. European texts are in an even worse state, and Hyatt's classification has there been rejected for a much more primitive classification built in general upon the form of the shell and ignoring internal structural differences. (See Zittel, Grundzüge der Palæontologie, 1910, Schmidt, 1910, and Schindewolf, 1942.)

In order that this work may find a greater sphere of usefulness, and the information contained within it may be made more readily available to both the paleontologist and to the amateur, a brief survey of the essential morphological features of the Nautiloidea is presented here together with such diagrams as are necessary for the portrayal of the essential structures. Some general discussions of morphology have prefaced various of the earlier studies of cephalopod faunas, in particular, Ruedemann (1906) and Troedsson (1926). Miller, Dunbar, and Condra (1933) have presented a brief and very lucid discussion of the anatomy of *Nautilus* together with a description of general shell terms, in which several points of shell terminology have received treatment. Their nomenclature is adopted here insofar as it pertains to the shell features under discussion. It does not, however, take into account the more recent advances into the knowledge of internal structure, the first of which (Teichert, 1933) appeared in the same year. Teichert presented a thorough and detailed investigation of the internal structure of the actinoceroids with special reference to the deposits of the cameræ and the siphuncle, which will rightly take its place as a classic in nautiloid investigation. It is the first work in which the deposits were considered with reference to their growth relations and their function. Flower (1939) presented a similar investigation of the Pseudorthoceratidæ, in which particular attention was given to the tissues which were responsible for their secretion. In this work Teichert's nomenclature is followed in the main, but in several instances it has been shortened and simplified. Kobayashi (1935, 1935A,

1936) has brought to light previously unsuspected variations in the structure of the endosiphuncle of endoceroids, based largely upon a study of the rich cephalopod faunas of the Ordovician of Manchuria. Flower (1941) has dealt with the details of the structure of the siphuncle wall in endoceroids and related types, while the study of the older cephalopods of America (Ulrich and Foerste, 1933, 1935; Ulrich, Foerste, Miller, and Furnish, 1942; Ulrich, Foerste, and Miller, 1943) have brought to light additional structural variations not all of which are as yet fully understood.

The following discussion of morphology is largely general. Each group within the nautiloids has developed its own special structures within the siphuncle and cameræ, and it has seemed best to treat these in the prefatory remarks of the groups to which they apply.

GENERAL SHELL PATTERN

The nautiloid shell is a cone in its simplest, though not necessarily its most primitive form. It differs from the cone of the gastropod shell in that it is not filled by the body mass throughout life. Instead, the shell grew so rapidly at the aperture that the visceral mass of the animal could not fill it. The animal moved forward in the shell at periodic intervals, each time shutting off the earlier part of the shell incompletely by a septum. In time a series of septa was built up in this way but always a nonseptate *living chamber* remained at the adoral end of the shell. Thus the cephalopod shell has come to be divided into two main regions, the *living chamber* and the *phragmocone* (fig. 1). In the earliest growth stage there is, of course, only a living chamber. However, once the phragmocone was developed, its growth continued in such a way that the living chamber maintained about the same proportions throughout life, except where as in the ascoceroids and the brevicones, modifications of either the shell wall or the septa interfered with this relationship.

Many of the older works have insisted upon a primary division of the cephalopod shell into two regions: a protoconch and a conch. It has been generally believed that the cephalopod appeared in a small ovoid protoconch (fig. 1), open at one end, and that this protoconch later had the true conch added onto its adoral end. In later growth stages the protoconch was frequently lost, either because it was originally chitinous or else very poorly calcified, or because it was resorbed. Further, it was held that the fragile and presumably noncalcareous protoconch was one of the features which characterized the Nautiloidea and distinguished it from the Ammonoidea, in which the shell began

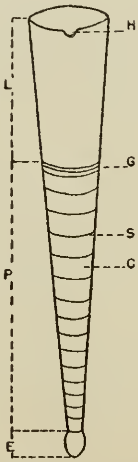

Figure 1. Internal mold of a generalized orthoceracone, viewed from the ventral side. H. Hyponomic sinus. L. Living chamber. P. Phragmocone. E. Protoconch, embryonal shell. G. Gerontic cameræ. S. Suture. C. Camera.

with a well calcified more or less spherical protoconch. However, subsequently some protoconchs have been found in the Nautiloidea (Clarke, 1893; 1897, pl. 9, figs. 23-25; Ruedemann, 1912, p. 8, figs. 4, 16), while on the other hand the evidence at the present time suggests overwhelmingly that in the Actinoceroidea and the Endoceroidea no protoconch as such was developed. The occurrence and phylogenetic significance of the protoconch in Nautiloidea is still an unsettled problem, particularly as there is even a difference of opinion as to whether *Nautilus* has a protoconch.

VISCERAL MASS

There is no direct evidence as to the structure of the visceral mass or the main part of the body of the fossil nautiloids. All of the direct evidence bearing upon this problem is found in what is known of the only living genus of the Nautiloidea, *Nautilus* itself. As the last survivor of a group of nautiloids which have remained coiled throughout the Mesozoic and Cenozoic, we may suspect that *Nautilus* may have undergone specializations in tissue organization and that the present body pattern may be quite different from that of the orthoceracones which dominated the

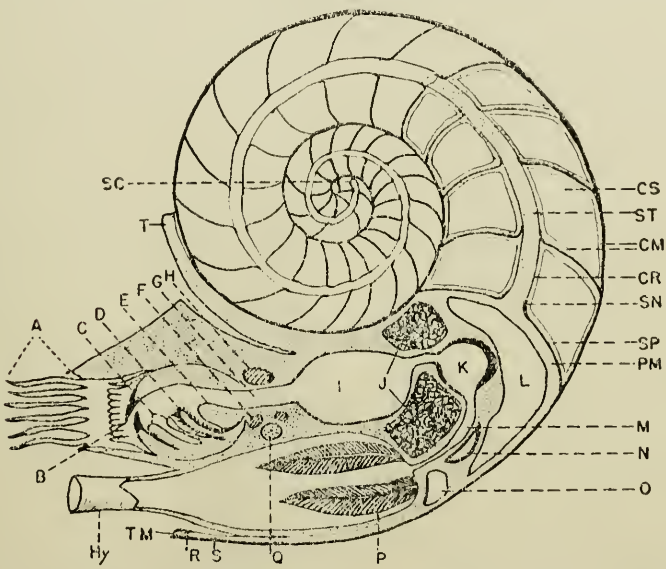

Figure 2. Diagrammatic sagittal section of *Nautilus* showing location of main organs and relation of soft parts to shell. A. Tentacles, surrounding the mouth. B. Beak. C. Prelingual processes. D. Radula. E. Tongue. F. First subœsophageal ganglion. G. Oesophagus. H. Supraœsophageal ganglion. F and G are a part of a circumoral nerve ring, essentially the brain. I. Crop. J. Portions of the liver. K. Gizzard. L. Space occupied by reproductive organs. M. Intestine. N. Heart. O. Nephridia. P. Ctenidia. Q. Portion of cartilage, incompletely represented, forming a capsule in the cephalic region. R. Shell wall. S. Mantle lobe. T. Dorsal mantle lobe. Hy. Hyponome, opening of gill chamber. TM. Terminal mantle. PM. Posterior mantle. SP. Septum. SN. Septal neck. CR. Connecting ring. CM. Cameral mantle. ST. Siphonal tissue. CS. Cameral space, occupied by liquid or gas. The tissues of the phragmocone are shown only on the four adoral cameræ. SC. Siphonal cæcum, termination of siphuncle in apex of shell.

Paleozoic. Some indirect evidence, bearing upon the problem in the form of trails and resting places attributed to orthoceracones, has been found in the Cincinnatian, which will be discussed in Part II of this work.

Figure 2 shows a diagrammatic sagittal section of *Nautilus,* designed to show first, the general body plan of the animal, and second, the relation of the soft parts to the shell.

Dean (1901) has presented one of the very few accounts of living *Nautilus* in its natural habitat. The animal is essentially benthonic, though capable both of crawling on the bottom or of swimming. This may be done either by movement of the tentacles or by the forcible extrusion of water from the gill chamber through the hyponome, which exerts sufficient force to propel the animal backward through the water. The whole animal is made lighter and therefore more motile by the presence of gas in the cameræ. Pruvot-Fol (1935) has argued, probably correctly, that the chambers of the phragmocone are only partially filled with gas. The gas is similar to air, but has a somewhat higher nitrogen content. As *Nautilus* inhabits relatively deep waters this is easy to understand, when one remembers the "bends" which affect divers and which are due to the greater solubility of nitrogen in the blood under the pressure of depth.

The protruding head of *Nautilus* consists of an elaborate system of tentacles surrounding the mouth, a pair of eyes which are simpler than those of the squids, in that they lack a crystalline lens. Beneath the head lies the foot, consisting of a rolled funnel or hyponome through which water is extruded in swimming. When the animal retracts into the shell, the aperture is protected by a thick fleshy dorsal fold, the hood.

The mouth is equipped with a horny or calcareous beak (fig. 2 B), consisting of an upper and an under process, the whole looking much like the beak of a parrot. Behind this lie two prelingual processes (C), a well-developed radula (D), and a tongue (E). There follows a short tubular œsophagus, which is surrounded by a complex ring of nerve tissue, the dorsal portion of which is essentially a brain (H), while the remaining parts are a fusion of the visceral ganglia. The relationship between this nerve ring and the usual paired dorsal ganglia which form a brain in most molluscs, with several pairs of ventral ganglia, is strongly paralleled by the development of a similar nerve ring in the Arachnoidea from paired ganglia which predominate in the simpler mandibulate line of the arthropods.

The œsophagus gives way to a large crop (fig. 2,I) which is followed by a stomach with thick muscular walls. Behind the stomach, the digestive glands enter into the alimentary canal. The most significant of these is a large "liver" (J) which occupies a considerable amount of space in the posterior part of the animal. There follows a tubular intestine (M) and a simple anus opening into a large anal chamber. Close to the intestine lie the heart (N) and the nephridia (O). The anal chamber contains the openings of the anus, the nephridia, the reproductive system, and in addition, is occupied by four large ctenidia or gills (P). The reproductive organs differ in the two sexes but lie in the posterior part of the animal. This is significant in view of the theory proposed by Ruedemann (1905) that the forward migration of the visceral mass and the disposition of a new septum might correlate with the periodic voiding of the sexual elements of the organism, a theory which it is unfortunately not possible to investigate except through studies of *Nautilus* which have not yet been made.

The anal chamber serves also as a breathing chamber, and water must be taken in and expelled periodically. Its aperture is a funnel-like structure, the hyponome (Hy). According to the primitive molluscan pattern, the dorsal part of the animal was covered with a mantle, while the foot and head were ventral. In *Nautilus*, the head and foot, here modified into the hyponome and tentacles, judging from the embryology of the squid, are anterior, while the mantle enclosed the dorsal, ventral, and posterior parts of the animal. In the mantle it has been convenient to recognize several secreting regions (Flower, 1939) as the (1) terminal mantle, responsible for the growth of the shell at the aperture, and which is therefore a ring around the edge of the mantle (2) the posterior mantle which secretes the septa, and, in fossil nautiloids, (3) the siphonal mantle, responsible for the secretion of any true shell structures in the siphon, and (4) the cameral mantle which is responsible for the secretion of further shell material in the cameræ. (See fig. 2, TM, PM, CM.).

When *Nautilus* moves forward in its shell to form a new septum it leaves behind a fleshy strand, once referred to as the siphon and later renamed the siphuncle. This pierces the septa and ends adapically in a small rounded siphonal cæcum. The septa turn slightly apicad about the siphon forming septal necks. Little attention has been given the siphonal tissues of *Nautilus,* but it is evident that they are liberally supplied with blood. Further, it is supplied by one of the main branches of the posterior branch of the aorta, which suggests that in older cephalopods with larger and more elaborate siphuncles the blood system may have been more extensive and more elaborate. The connecting ring is thin in *Nautilus* and fragile, consisting of spicular calcite secreted within the wall of the siphonal tissues. Within the cameræ this tissue is continuous outside of the connecting ring with a thin layer of tissue which lines the cameræ. Although in *Nautilus* this tissue is no longer active as a source of cameral deposits, it is clearly the homologue of the cameral mantle (Flower, 1939) as established on the basis of fossil cephalopods, which apparently secreted gas in the past from its inner free surface as it does today.

Nautilus is reported to be attached to the shell by a median girdle, which leaves a pair of lateral muscle impressions on the sides of the interior of the shell. In addition, three aponeurotic bands are reported, which are longitudinal structures. The ventral two are close together and form the boundary of the region which in fossil nautiloids has been termed the conchial furrow. The dorsal band is a structure which the writer has never succeeded in identifying with certainty, but which may be only that structure in the dorsal part of the mural part of the septum known as the septal furrow.

In some respects *Nautilus* is clearly primitive, and such features as can be regarded as primitive may be assumed to have been developed in the Paleozoic nautiloids. I should include under this general heading such general features of body plan as the organization of the alimentary canal, the development of a gill chamber, and a hyponome. The hyponomic sinus is a persistent though far from universal feature in Nautiloidea, and indicates that the hyponome was developed and probably played a role in the locomotion of the organism close to that supplied by the same organ in *Nautilus*. More conjectural is the condition of the tentacles. Some have assumed the numerous tentacles of *Nautilus* to be primitive, while other evidence leads one to believe that a system of fewer and perhaps longer tentacles may have obtained. In the Corryville beds a few layers have been found characterized by a horseshoe-shaped series of discrete impressions. These cannot be interpreted as the markings of any other known marine organism, and in spite of the absence of any such impressions centering about the aperture of a nautiloid shell, seem to be most logically interpreted as the impressions caused by the tentacles of a *Treptoceras* which was either at rest on the bottom or was strongly attached by tentacles to the substratum, a condition in which *Nautilus* has been reported. If these markings are the tentacular impressions of *Treptoceras*, then it is evident that the tentacles were relatively large, and relatively few in number. Some impressions suggest as few as 10 arms. Others suggest more, but in any one resting position it is perfectly natural that one or more of the tentacles may have been moved, thereby creating the impression of more arms than actually existed. The opinion that fossil cephalopods had relatively few arms has not often been ventured in print, but is found reflected in many reconstructions, that of *Goldringia cyclops* (Hall) in the New York Museum being equipped with only eight arms, a condition which is not improbable, for fossil coleoids are known with fewer arms.

On other questions of internal anatomy no light can be thrown. It seems probable that the two gills of the Dibranchiata represent a reduced condition and that the four gills of the Tetrabranchiata are primitive. However, where in the long and somewhat obscure evolution of the belemnites this change occurred is unknown, and therefore the question has been neatly avoided by those paleontologists who, instead of recognizing the Dibranchiata and Tetrabranchiata as the main divisions of the Cephalopoda, have substituted the Coleoidea for the Dibranchiata (Bather, 1892, 1892a), comprising all cephalopods in which the shell is internal or secondarily lost. In this classification the Nautiloidea and Ammonoidea are considered as major divisions of the Cephalopoda equal to the Coleoidea. This scheme has its advantages in the present state of our knowledge inasmuch as it is not yet certain whether the belemnites are to be traced to a simple orthoceracone in the Nautiloidea or whether, as is suggested by the presence of a protoconch and the structure of the siphuncle, they may have been derived from *Bactrites* of the simpler Ammonoidea.

SHELL FORM

Sixty years ago the genera of Nautiloidea which were widely recognized were distinguished mainly by the shape of the shell. The system of classification was simple, but the genera were so wide ranging as to have little stratigraphic significance. Straight shells were placed in *Orthoceras*, slightly curved ones in *Cyrtoceras*. If a shell was loosely coiled it was placed in *Gyroceras*, if tightly coiled, in *Nautilus*. Shells coiled eccentrically so as to develop more or less of a spire were put in *Trochoceras*, while gibbous shells, contracted at the aperture, were generally placed together in *Gomphoceras*. Only a few other genera were recognized widely. Some, such as *Hercoceras*, depended upon specializations of the ornament of the shell. Others, such as *Gonioceras* and *Ascoceras* were admitted as convenient receptacles for rare and bizarre types. However, one finds that even as late as 1910 (Schmidt, 1910, p. 103) *Endoceras*, *Ormoceras*, and *Actinoceras* were sometimes regarded as subgenera of *Orthoceras*.

Hyatt suspected that nature might not be quite so simple as all that. His researches (1884, 1894, 1900) culminated in a classification built upon the premise that the fundamental development of the Nautiloidea began with the straight shell and terminated in the coiled one. However, he recognized and succeeded in demonstrating that the progressive coiling of the shell had occurred not once, but many times in the development of the nautiloids, and that each line could be characterized by other, and usually internal, features. Further, he recognized other byways of development, the development of trochoceroids, the secondary derivation of straight shells from coiled ancestral types, and the development of endogastric curvature, commonest among the "inflati" of older authors, formerly lumped under *Gomphoceras.*

The concept of the gradual coiling of the shell and also in part, the concept of uncoiling have been severely attacked in recent years, and various other proposals have been put forward. However, Hyatt's contribution showed that the shape of the shell was not of primary importance, and that internal structures showed that externally similar forms might be only distantly related. The present stratigraphic evidence as well as common sense indicate that the "simple" orthoceracone of circular section—and in which the fundamental bilateral symmetry of the cephalopod is not always evident—is not primitive. Instead, the oldest cephalopods are small cyrtoceracones with marginal siphuncles, as in *Plectronoceras*, from the Cambrian of China.

The older generic names have been greatly restricted, but have given rise to a series of descriptive terms. It is convenient to recognize two sets, one series which may be applied to the shell as a whole, and another which may be applied only to a portion of a

Shell form	*Portion of shell*	*Entire shell*
straight	orthocone orthoconic	orthoceracone orthoceraconic orthoceran
curved	cyrtocone cyrtoconic	cyrtoceracone cyrtoceraconic cyrtoceran
loosely coiled	gyrocone gyroconic	gyroceracone gyroceraconic gyroceran
whorls in contact	tarphycone tarphyconic	tarphyceracone tarphyceraconic tarphyceran
involute coil	————	nautilicone nautiliconic nautilian
eccentric coil	————	trochoceracone trochoceroid trochoceran
short gibbous shells	————	brevicone breviconic gomphoceroid

shell.

Except for the terms brevicone and breviconic, which came into use long before the appearance of such a generic name as *Brevicoceras* Flower (1938), these terms are derived from generic names of long standing. Hyatt used the -an adjectival ending but this has been abandoned by most recent writers in favor of the longer -conic.

The need for terms descriptive of the entire shell is at once evident, since this feature is characteristic always of the species, usually of the genus, and not infrequently through higher categories. Study of the various stages of the shells will show the necessity for the other terms, those primarily applicable to portions of the shell. The early stages of many coiled shells show definite regional differences in the development of the spiral. *Lituites*

Figure 3. Shell forms in Nautiloidea. A. Orthoceracone. B. Cyrtoceracone. C. Gyroceracone. D. Tarphyceracone. E. Cross section of *Tarphyceras,* showing slight development of impressed zone for the reception of the earlier whorl. F. Nautilicone. G. Trochoceroid. H. Brevicone. I. Lituiticone, nautiliconic in young, the later part orthoconic. J. Adult shell of a cyrtoceracone which is breviconic ephebically. K. Cyrtoconic young stage of the same form. L. Cross section of whorl of a tarphyceracone with no true impressed zone but only a slight flattening of the dorsum.

(fig. 3I) began life as a gyroceracone or cyrtoceracone, but later became tarphyconic for a period. The last part of the shell, however, is orthoconic. Many shells are cyrtoconic in early stages, but later reduce their curvature so that the adoral parts are essentially orthoconic. Figs. 3J and K show two growth stages of the same species, the adult of which would be classed as a brevicone, while the young would be a cyrtoceracone. Yet other breviconic shells are essentially straight as in fig. 3H.

When the shell is so tightly coiled that the outer whorl is excavated for the reception of the inner whorl, an *impressed zone* is developed. This may begin as only a slight flattening of the dorsum (fig. 3L) and develop to a definite concavity (fig. 3E). Strongly involute shells (fig. 3F) may develop a very considerable impressed zone. In general, the impressed zone is more prevalent among the younger nautiloids, and in the Ordovician is rarely half the height of the outer whorl.

The main types of shell form are illustrated in fig. 3. Since the shape of the shell has changed many times in the evolution of the nautiloids, it is not surprising that these types actually intergrade and cannot be separated by hard and fast boundaries. The form of the shell is constant within the species and is generally regarded as an adequate basis for the recognition of genera. However, there are some cases in which obviously closely related species differ in little besides the shape of the shell. Thus in *Bickmorites* the genotype is a typical gyroceracone with the whorls free, but *B. marshi* is a tarphyceracone until the latest growth stage, in which the shell becomes nearly straight producing a lituiticone (fig. 3I). *Anomaloceras* Hyatt is based upon a nautilicone with a good impressed zone. Yet closely related to this and associated with it are two other species *Trochoceras transiens* and *Gyroceras minusculum*, one of which is a gyroceracone and another a cyrtoceracone properly included in the same genus, which is unique in combining a symmetrical coil with a broadly depressed section, and simple sutures with a siphuncle markedly displaced to one side of the plane of symmetry.

We cannot dispose of the old names applied to the once widely employed form genera without some mention of their present scope. *Orthoceras* was originally applied not to a cephalopod but to a rudistid and cannot properly be used for cephalopods (Teichert and Miller, 1936). Cephalopods which were placed in *Orthoceras* as defined by Hyatt (1900) are now properly placed in *Michelinoceras* Foerste or *Orthoceros* Brunnich. The latter generic name is discussed by Teichert and Miller who recommend its use but refrain from designating a genotype.

Cyrtoceras Goldfuss, which should be known as *Cyrtoceratites* Goldfuss, since that spelling is the older, is a valid genus of Middle Devonian nautiloids known only from Europe. (Foerste, 1924, p. 337; Miller, Dunbar, and Condra, 1933, p. 47; Teichert, 1939, p. 107, footnote).

Gyroceras de Koninck, 1844, is an emended spelling of *Gyroceratites* von Meyer, 1831, and the older spelling should be retained. The genus *Gyroceratites* is based upon loosely coiled Devonian ammonoids closely allied to the better known *Mimoceras* (see Miller, Dunbar, and Condra, 1933, p. 58).

Tarphyceras Hyatt is a valid nautiloid genus of the Canadian, based upon *Tarphyceras praematurum* Hyatt. Until recently subdivided (Ulrich, Foerste, Miller, and Furnish, 1942), it was perhaps the most characteristic single cephalopod genus of the Canadian in America.

Nautilus Linnæus, formerly used for all nautilicones, and sometimes tarphyceracones as well, is known only from the three recognized Recent species.

Trochoceras Barrande is today a small genus containing shells in which the coiling is only slightly eccentric, and which is known only from the Middle Silurian of Bohemia.

Gomphoceras, which strangely enough, did not yield to a cognate descriptive term for short rapidly expanding gibbous shells which contract to the aperture, is a valid genus recognized in England, America, and Bohemia in the Middle Silurian (see Foerste, 1924, p. 353).

Most cephalopod shells are curved with the venter on the outside of the curve. Such shells are called *exogastric.* A considerable number of genera are described which are known or believed to have curved their shells in the opposite direction. None are known to be true nautilicones, but many are cyrtoceraconic.

Orientation of these supposedly endogastric genera has depended upon various criteria. Perhaps the most reliable is the presence of a hyponomic sinus on the concave side of the shell. On this basis *Phragmoceras* and its allies of the Silurian are considered to be endogastric. It has been found that in these cephalopods the siphuncle is close to the concave side. As a consequence, many cyrtoceracones which have the siphuncles on the concave side of the shell have been classed as endogastric without further evidence. In one case at least, that of *Archiacoceras* of the Devonian of Germany (Flower, 1943), the discovery of a septal furrow on the concave siphonal side showed that the shell was curved exogastrically, but that the siphuncle was dorsal in position. This at once raises the question as to how many of the other genera which have been classed as endogastric may actually be exogastric.

The problem is of particular interest in that the oldest of the known cephalopods, *Plectronoceras,* as well as a very considerable group of genera in the Ozarkian and Canadian, are endogastric on the basis of the position of the siphuncle. In a few cases this orientation is suggested by a hyponomic sinus. In other cases the sinus is either unknown or definitely absent. The sinus is present in *Burenoceras,* which attains a living chamber remarkably reminiscent of that of *Phragmoceras,* and appears to be present in *Buehleroceras*, but is not known in any of the other genera. No conchial or septal furrows have been observed in these forms. Analogy of the siphuncles with those of endoceroids make the endogastric condition fairly certain, although perhaps the ventral position of the siphuncle in endoceroids might even be questioned. However, if the siphuncle is correctly oriented as ventral in endoceroids, the piloceroids at least are endogastric. Likewise, the ventral position of the siphuncle in cyrtoconic cephalopods presumably of the general organization of *Ellesmeroceras* becomes if not certain, at least highly probable.

SHELL MORPHOLOGY

THE CONCH

The conch is, in its simplest form, a cone composed of shell material. It grows by addition of material to its adoral surface by secretion of the terminal mantle. The aperture is in general straight and transverse to the axis of the shell. However, many apertures are more or less undulate, having some regions which swing apicad, known as sinuses, and regions which project orad, known as crests. Most significant of these is the hyponomic sinus, which is always ventral in position, and marks an emargination of the aperture to allow greater activity of the hyponome in swimming.

The shell is composed of three layers in *Nautilus*, but the layers of the conch are not well known in fossil nautiloids. Quite probably when more forms have been studied there will be found considerable variation in the thickness and composition of the layers, somewhat comparable to that already known for Recent pelecypods and gastropods. At the present time the layers are not significant taxonomically in nautiloids, because only rarely are specimens encountered which show even faint traces of the various shell layers in thin section, any original differentiation having been lost in replacement of the original shell material. (Blake, 1882, p. 20; Miller, Dunbar, and Condra, 1933, p. 21; Flower, 1939, p. 9.)

The surface is variously ornamented. Prominent among the surface markings are the lines of growth which indicate former apertures. They are significant, for sometimes they show that the hyponomic sinus was developed late in life, while in other cases they show that it was present from the early growth stages. In general, the elaborate lobation of the aperture found in such phragmoceroids as *Hexameroceras* is a gerontic feature, while the lobation which characterizes the Lituitidæ is present from early youth.

In the simplest cases growth lines are evenly spaced. Ruedemann (1921, p. 319) noted a correlation between alternating regions of widely spaced growth lines and closely spaced growth lines and the spacing of the septa, from which he suggested that possibly growth of the shell was retarded at the aperture while septa were being secreted at the base of the living chamber in some species. Again, other nautiloids show distinct varices of growth, resting stages in the growth of the aperture, which are marked by prominences in the growth lines themselves, and may be further marked by frills and spines as in the Devonian Kutoceratidæ.

Surface markings other than lines of growth have received much the same terminology as that employed for other organisms and need not be treated here. The commonly used terms are defined in the accompanying glossary.

The inside of the conch is primarily marked only by the conchial furrow (Flower, 1939, p. 12) which is always mid-ventral in position (fig. 4, CF). This and the hyponomic sinus are important guides in the orientation of cephalopod shells, for although the simpler shells may appear to be simple cones, the underlying pattern is always one of bilateral symmetry, and it is important to distinguish the dorsum from the venter.

Secondary deposits on the inside of the shell wall are found only in the living chambers of gerontic shells. Most commonly the shell is thickened close to the aperture in gerontic brevicones. In orthoceracones, the mature living chamber is frequently constricted by an annular thickening of the shell wall a short distance before the aperture is attained. In nautilicones and orthoceracones where such deposition has occurred, there may be left clear or obscure impressions of the shell muscles already noted in connection with the soft parts. These are generally obscure in orthoceracones. In *Orthoceros*, as emended by Teichert and Miller (1936), the mature living chamber bears three linear projections of the shell wall near the basal part of the living chamber, a feature also reported in the little known *Ctenoceras* Noetling (see Hyatt, 1900). Blake (1882) noted folds at the base of the body chamber, best developed in the brevicones (*inflati* of Blake and his contemporaries). These characteristic gerontic features have been given the name of basal zone (Flower, 1938, p. 171).

Impressed lines on internal molds have been termed *runzelschicht* by Schroeder and epidermids by Barrande. Neither term is employed here since these authors have included under them a variety of structures, the basal zone, incipient cameral deposits, and sometimes structures of the mantle surface reflected upon the thickened wall of the living chamber, which are neither.

THE SEPTA

The septa are secreted by a specialized part of the mantle known as the *posterior mantle* (fig. 2, PM), their formation following the movement of the visceral mass forward in the shell. The septum consists of three main regions (Teichert, 1933; Teichert, 1935; Flower, 1939): the mural part of the septum (fig. 4, M) which extends forward into the living chamber when first secreted, and later often, though not always, comes to be equal to the length of a camera; the free part of the septum (fig. 4, F) which functions as a partition, shutting off the living chamber from the cameræ, and the cameræ from each other; the septal neck (fig. 4, N) which extends apicad about the siphuncle. The septum is pierced by a *septal foramen* through which the siphonal tissues pass.

The mural part of the septum is not always simple. In *Nautilus,* it can be readily seen that the adoral termination of this part of the septum is approximate to the length of the wall of a camera on the dorsum, but on the venter the septum thins orad, and while its tip cannot always be made out, it clearly does not extend the whole length of the camera. This may be seen quite plainly in some specimens of *Nautilus,* particularly in the later whorls. It is a matter often hard to determine from fossil remains, but in some Devonian orthoceracones, a banding of the interior of the cameræ shows clearly that the mural part of the septum extended about half the length of an air chamber.

The *septal furrow* (Flower, 1939) sometimes referred to in the older literature under the more noncommittal term of normal line (*ligne normale* of Barrande) is an area on the dorsum of the shell in which no mural part of the septum is developed (fig. 4, SF; fig. 6 E). This is shown clearly in *Nautilus,* where it is better developed in the young stages of the shell than in the adult. The ways in which this structure can be preserved in fossils are variable (Flower, 1939), but it may be clearly recognized by its appearance on every septum. Often it extends the length of the mural part of the septum, and when well preserved, is an excellent guide to the adoral extent of the mural part of the septum. Often, however, it does not extend apicad to the position of the suture, where the septum swings free from the shell wall to form the free part of the septum. The functional and morphological significance of this structure is not known. All discussions of *Nautilus*, which might be expected to yield some information, fail to take the structure into account or confuse it with the anoneurotic bands, which it does not resemble in the least. The septal furrow is probably the best criterion of orientation in nautiloids and is always dorsal. In contrast, the conchial furrow, which is a continuous line on the interior, is always ventral in position. Some amazing interpretations of nautiloid orientation have resulted in the past from a confusion of these utterly unrelated structures. There has also been some confusion between the septal furrow and the marginal siphuncle in supposed Bactritidæ.

The free part of the septum shows no special structures and needs no discussion, save as it may come to be incorporated in part with the siphuncle, as noted below.

The septal neck is a funnel-like projection of the septum around the siphuncle. Its form varies among the various groups of cephalopods, and upon its form and structure depended the major divisions of the nautiloids proposed by Hyatt (1900). (Fig. 4, N.)

In most internal molds the most conspicuous feature is the line formed where the free part of the septum joins the shell wall. This is the suture (fig. 4, S). Its form has been taken as one of the important criteria of classification in both nautiloids and ammonoids. The simplest sutures are straight and normal to the axis of the shell. However, sutures are not infrequently lobed. Portions of the suture which project orad are known as *saddles,* while portions which project apicad are known as *lobes.* In general, the suture pattern is much simpler in nautiloids than in ammonoids, though in some of the more specialized coiled nautiloids a complex suture pattern is attained which exceeds that of the older and simpler of the ammonoids.

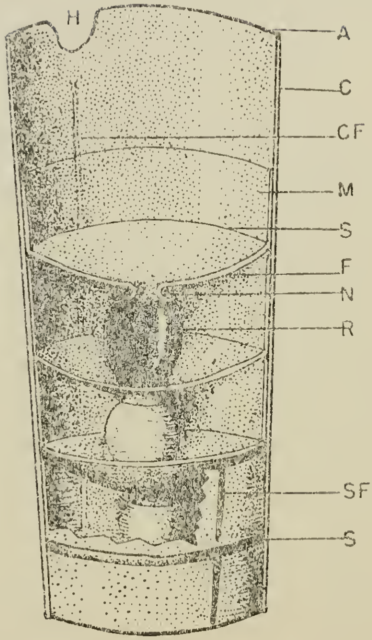

Figure 4. A dissected shell of a generalized orthoceracone showing essential parts. The hyponomic sinus (H) and the conchial furrow (CF) mark the mid-ventral part of the shell. Adorally the shell is cut to the center, showing the wall of the conch (C) and the three parts of the septa, the free part (F) the mural part (M) and the septal neck (N) which is cyrtochoanitic in this form. The first segment of the siphuncle is cut to the center and is formed by the neck supplemented by the connecting ring (R). The next segment of the siphuncle is entire and its exterior is shown. At its base, the entire free part of the septum is retained. In the next camera, part of the mural part of the septum is preserved on the nearer side. This is complete adorally on the right side, showing the septal furrow (SF). The entire mural part of the septum is retained in the last camera, obscuring the interior. CF. Conchial furrow.

Variations in the suture pattern may be attributed to various causes. Some are the direct result of a discordance between the section of the shell and the curvature of the free part of the septum. A simple orthoceracone has a straight suture. The septum curves gently apicad from the suture, like a portion of the surface of a sphere, attaining the greatest depth typically at the siphuncle. If the internal mold of such a shell is carved in such a way as to modify the section from circular to compressed, lateral lobes will result. Likewise, if instead the dorsum and venter are carved away, dorsal and ventral lobes will result separated by lateral saddles. Assuming such a simple septum in a coiled shell, if an impressed zone is carved on the dorsum, the sutures will immediately assume lobes there as a result. Many of the older nautiloids show these simple variations in pattern which may be correlated perfectly with the section. Further, wherever the siphuncle is shown to be marginal, the sutures will be expected to slope apicad on the siphonal side of the shell. This is true to a greater or lesser extent in many endoceroids.

However, inspection of septa shows that this simple ideal condition, while not uncommon, is often more or less modified. In most cyrtoconic cephalopods the siphuncle does not lie at the point of greatest depth of the free part of the septum as judged by its suture. Further, as might be expected, there are modifications of section which are accompanied by variations in the curvature of the septum in vertical and horizontal planes, so that depressed and compressed shells may both have simple transverse unlobed sutures.

Again, lobation of the sutures may be the direct result of specializations of the septum itself which develops definite irregularities so that it is no longer a portion of the surface of a sphere. Such modifications often involve a definite folding of the free part of the septum, particularly in ammonoids. This type of specialization is found in few of the older nautiloids and is only very slightly developed in those of the Ordovician. However, these different groups of septa and sutures are characteristic of various groups of nautiloids and promise to be of some value in tracing relationship.

The stable septum, in which the curvature becomes fixed, as though the shells were carved from internal molds of a simpler section, and the suture pattern, will show a constant accord between the lobation and the cross section of the shell. This is developed in many oncoceroids.

The stable suture, on the other hand, requires an increase or decrease of the horizontal curve of the septum in relation to the curvature in the dorso-ventral plane, in order to stabilize the suture. This appears to prevail in fewer cephalopods but is developed in *Anomaloceras.*

A third type is the functional suture, in which the lobes and saddles are the direct reflection of modifications of the septum from a simple curved surface, in its most generalized state, the surface of a portion of a sphere. Sometimes, as in the older Ammonoidea, there are definite crenulations of the septum as it approaches the shell wall. Sometimes the modifications are less marked, and the septum represents the portion of the surface of an ellipsoid rather than a sphere. In either case, the details of the lobation may either behave as stable septa, in the presence of a series showing variations in cross section, or may develop stable sutures at the expense of stability of the septal pattern. Again, a compromise may be effected between these two extremes. The stability of the suture is high in the ammonites and low in the nautiloids, where in general, the septum tends to be stable, particularly in the older and simpler types.

THE CONNECTING RING

The septal neck which bends apicad in most nautiloids at the septal foramen, fails in most cases to extend very far toward the next adapical septum. The remainder of the length of the siphuncle in the camera is marked by a structure to which Hyatt gave the name of connecting ring (see fig. 4, R; fig. 2, CR).

The connecting ring is a tubular structure which typically passes from the tip of one septal neck to the tip of the next one. Its variations in form will be discussed in the next section dealing with the siphuncle as a whole.

Unlike most other parts found in the fossil and Recent tetrabranchiate cephalopods, the connecting ring is not a true shell part. It is not, as are true shell parts, secreted from a specialized area of ectodermal epithelium, such parts as are considered here as functional mantles in a physiological sense. Instead it is a structure which is secreted within the walls of the tissues of the siphuncle, to which the term *siphonal tissues* is applied. In *Nautilus* the connecting ring is composed of minute calcareous spicules held together by organic matter. It is a relatively fragile structure, and it is not uncommon to find upon cutting into a shell of *Nautilus* that the connecting rings have been partly destroyed. If they were equally fragile structures in fossil cephalopods, the hazards of preservation there must be even greater. However, the strength and to some degree, the structure of the connecting ring may vary greatly among different genera and even species of the Nautiloidea. Thus, the orthoconic genus, *Leurocycloceras*, never developed this calcareous structure in the outer portion of the siphonal tissues, and large blood vessels were, therefore, permitted to pass direct from the siphonal to the cameral tissues where they left their impression (Flower, 1941C). In some genera connecting rings have never been found, as in the Silurian species currently assigned to *Heracloceras* (=*Gigantoceras*) of the east-central United States. In most of the cephalopods found from the Chazyan onward the connecting ring is thin, generally failing to show upon examination at high magnifications any structure other than a rather spongy texture. There are, however, several groups of cephalopods in which the connecting ring came to be quite highly specialized. Many among the oldest of our cephalopods show relatively thick connecting rings (fig. 5 A-C), so thick and so dense that they were long not recognized as connecting-rings but were considered as portions of the septal necks. In some cases these connecting rings show a succession of layers suggesting that they grew by the addition of material to the inner and outer surfaces of an originally very thin layer. Again there may be regional differentation of the structure of a connecting ring, such as the eyelet, an area of dense fine-grained material found at the adapical tip of the ring in *Tarphyceras* and its allies, and also in most and perhaps all endoceroids, and may have been present in more primitive cephalopods where it is undetected as yet. However, many of the genera in which it may be expected and which are regarded as probable common ancestors of the Endoceroidea and the Tarphyceratidæ, have not yet been studied from thin sections made from well-preserved material, and indeed, thin section examination of the older of our nautiloids has not progressed nearly as far as is necessary for the clarification of many of these matters. The thickening of the connecting ring in these older cephalopods which are regarded as constituting the Eurysiphonata, has been illustrated and discussed by the writer (Flower, 1941) on the basis of ellesmeroceroids, and tarphyceracones. A strikingly similar though bizarre type of thickening of the connecting ring has been found in *Cyrtocerina* (Flower, 1943) (fig. 5 A), an Ordovician genus, regarded as a last survival of some of the endogastric cyrtoceracones which predominated in the first (Ozarkian, or lowermost Canadian) widespread development of the nautiloids in North America.

Thickening of the connecting ring has developed in two other groups of cephalopods. It characterized the older of the Discosoroidea (fig. 5 G) where it sometimes is thickened in an annular manner within the septal neck and may simulate very closely annulosiphonate deposits of quite distinct origin and structure. Again, in the vast and almost certainly polyphyletic group of cephalopods characterized by actinosiphonate structure (fig. 5 F), the connecting ring is greatly thickened throughout its length, and the processes which extend from the main body of the connecting ring into the cavity of the siphuncle are morphologically merely extensions of the ring itself in which certain differentiations of structures may or may not have taken place. Holm (1899) has shown another modification of the ring in *Bathmoceras* (fig. 5 C) which may mark the origin of the annulosiphonate deposits of the actinoceroids.

Although the fundamental fact that the connecting ring, which is usually the greater part of the "wall" of the siphuncle, may be greatly thickened and may be responsible for many bizarre struc-

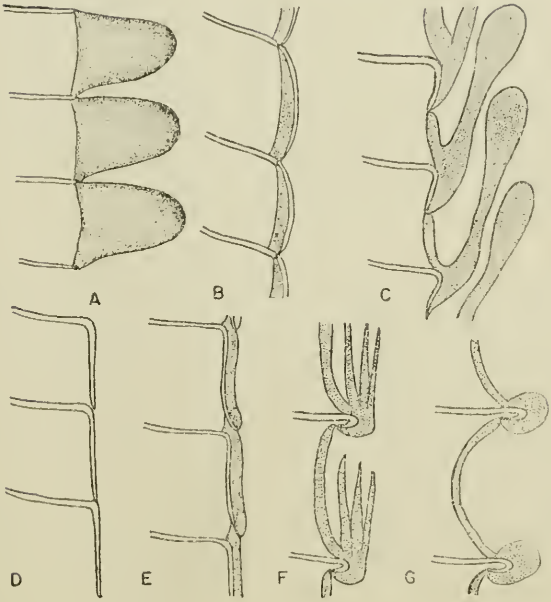

Figure 5. Siphuncles, showing role and modifications of the connecting ring. A. *Cyrtocerina madisonensis* with aneuchoanitic necks and thickened rings with obscure marginal layers. B. Condition found in *Proterocameroceras* and some Tarphyceratidæ, with aneuchoanitic neck and a connecting ring thickened, simulating a continuation of the neck in opaque section, but in thin section showing two layers. C. *Bathmoceras*, redrawn from Holm, showing thickening of the connecting ring and its development into forward projecting lobose processes. D. Holochoanitic siphuncle wall, consisting only of septal necks, formerly believed to characterize the endoceroids. E. Actual condition found in holochoanitic endoceroids with thick connecting rings, each terminating in an eyelet. F. Actinosiphonate structure from *Augustoceras*, showing the development of the deposit as a thickening of the connecting ring. G. Thickened connecting rings found in the Westonoceratidæ, from *Faberoceras.*

tures, was pointed out by Holm long ago, the concept has not come to be generally realized. Ulrich, Foerste, Miller, and Furnish in treating the Tarphyceratidæ and their allies, see in the outer layers of the thickened ring only cameral deposits. Actually cameral deposits are completely foreign to the ring in origin, being the true mantle secretions, and when well preserved, show strikingly different microstructure and optical properties. However, extensive replacement has occurred in many nautiloids, particularly in those species of the older rocks which show the maximum development of these thickened rings. In such instances the evidence from a single thin section may be exceedingly ambiguous, and more study will be necessary before the modifications of the connecting ring and true cameral deposits can be distinguished with certainty in a few cases.

THE SIPHUNCLE

The siphuncle, composed of the septal necks and usually with the connecting ring, and frequently other accessory structures, may best be defined as the calcareous remnant left by the siphon. In former years it has been customary to consider the siphuncle as consisting of two distinct structures: the ectosiphuncle, consisting of the outer wall, made up of septal necks and connecting rings; and the endosiphuncle, consisting of all structures within the ectosiphuncle. These may consist of cones, dissepiments, annuli, vertical dissepiments converging toward the center of the siphonal cavity, or rodlike or irregular processes. Further study of these structures has shown that the distinction between the ecto- and endosiphuncles is not always a natural one. In some cases secretion of the elements of the endosiphuncle is greatly delayed, and a definite resting period follows the secretion of the ectosiphuncle and continues while as many as 15 or even 50 (in some endoceroids) cameræ may be added to the phragmocone, which is the only criterion available for the lapse of time between the development of various parts of the "shell" in any given camera. When it is necessary to make this time distinction, the terms are useful. However, in some cephalopods the endosiphuncle may be formed either very late in life and very rapidly, as is the case with some actinosiphonate deposits, or it may be formed by a gradual growth of materials from the septal neck or from the connecting ring in which case no true time distinction is possible. This clearly applies to many although not all of the cases in which the endosiphuncle is built up by the development of processes of the connecting ring, as in *Cyrtocerina* (fig. 5 A), some Eurysiphonata (fig. 5 B), in particular *Bathmoceras* (fig. 5 C), and some actinosiphonate cephalopods. In some cases it is more important to distinguish those deposits which arise from the connecting ring and those which are the result of the secretion of a functional siphonal mantle, which is a very necessary distinction between the various deposits within the siphuncles of the Discosoroidea, and is especially important in the Westonoceratidæ where both may be developed in the same siphuncle.

According to Hyatt, various types of ectosiphuncles characterized the major divisions of the Nautiloidea. In his earlier works (1884), Hyatt differentiated between holochoanitic and ellipochoanitic siphuncles. Holochoanitic siphuncles were regarded as consisting only of septal necks which extended for the length of at least one segment of the siphuncle, and which were presumably without the adjunct of connecting rings (fig. 5 D). In contrast, another type of siphuncle has short septal necks supplemented by connecting rings, to which the term ellipochoanitic was applied (fig. 5 F, G). It was generally supposed that the holochoanitic condition was primitive and widespread among the older cephalopods. Ruedemann (1905) suggested how connecting rings might have developed from the endosipholining. But surprisingly enough, thin sections showed that many of the older cephalopods which had long been regarded as holochoanitic were actually characterized by very short septal necks and thick connecting rings which in opaque section looked deceptively like septal necks (fig. 5 B). Further, when septal necks finally did develop which extended for the length of a segment of the siphuncle, there still remained connecting rings which were also attenuated, so that they lay along the inside of the septal neck in the next adapical segment (fig. 5 E).

This shows clearly that the holochoanitic condition is not only a feature possessed by only a small minority of those genera which have in the past been regarded as holochoanitic, but also that where the holochoanitic condition is attained, it is clearly a case of specialization in which the connecting rings are retained in most cases.[1] (Flower, 1941).

The Schistochoanites of Hyatt need not concern us here. The group is one in which the siphuncle is supposed to be incomplete on the venter, which is certainly not true of the better known genera of the group, in particular *Bathmoceras.* Actually the genera of the Schistochoanites are probably largely ellipochoanitic eurysiphonate cephalopods.

In ellipochoanitic cephalopods some confusion seems to surround the relative distribution of the septal neck and the connecting ring. Miller, Dunbar, and Condra state: "The adoral portion of each connecting ring fits over the outside of the adapical portion of the septal neck orad of it, but its adapical end invaginates into the funnel of the septum apicad of it. Inside the septal necks the spicular deposits (of the connecting ring) become obsolete (or essentially so) so that the fleshy siphon can be said to be encased in a calcareous tube that is composed of alternating septal necks and connecting rings." While this seems to be the case in *Nautilus,* as can be seen by the external aspect of the siphuncle, it does not seem to be true of most fossil cephalopods which have been examined from opaque or thin sections. Possibly the position of the connecting ring outside the adapical end of the septal neck is one of several manifestations of the extension of the true connecting ring outward into the cameræ, which is widespread in the Eurysiphonata, and which also occurs, though more irregularly and sparingly, in the Stenosiphonata. It may or may not be the explanation of certain irregular structures commonly found outside of the siphuncles of Pseudorthoceratidæ, and indeed many other cephalopods, which everyone including the writer, had formerly regarded as inorganic.

Teichert (1933) has represented the connecting ring as arising from the tip of the septal neck, invaginating into the next

[1] Some Middle and Upper Ordovician endoceroids seem to lack the connecting ring, which may in these cases be lost secondarily. However, subsequent examination of more material suggests that the absence of the connecting ring in those cases which led to this proposal may be adventitious and merely the result of poor preservation. Such structure as shown in fig. 5 D is not known to exist.

neck, and continuing as far as the tip of the second neck (fig. 6 A). This is certainly borne out by all subsequent observations of the Actinoceroidea and is also true of the endoceroid complex, the Tarphyceratidæ, and many, perhaps most, stenosiphonate cephalopods. In cases where the connecting ring is so thin that it appears only as a thin line even under relatively high magnification, it is impossible to determine the exact termination of the ring. In such cases, as in the Pseudorthoceratidæ, it may be shorter. This is a very important question, as it involves the origin of the annulosiphonate and also certain other types of deposits within the siphuncle. If the septal neck is in contact with the cavity of the siphuncle, it is quite possible that siphonal deposits which appear to be attached to the neck, and which show traces of the prismatic structure of true shell parts, may be derived from the primary mantle indirectly since they may develop by expansion and proliferation from a small part of the posterior mantle. If, however, these deposits are actually attached to a thin connecting ring, the problem of the origin of the mantle which secretes them becomes infinitely more complex. The writer has suggested that the annulosiphonate deposits of the Actinoceroidea, which are clearly attached to the connecting ring, may be a highly specialized modification of the eyelet of the more primitive Eurysiphonata. The evidence for a similar origin of annulosiphonate deposits in orthochoanitic orthoceracones and in the secondarily cyrtochoanitic Pseudorthoceratidæ, is less conclusive. There is no good indication of the eyelet in the ancestry of these groups. It is possible that here the mantle may be a rejuvenation of a part of the posterior mantle left behind attached to the septum when the animal moved forward in the shell, and which certainly was modified in the cameræ into the cameral mantle. That cameral and siphonal deposits sometimes function as a unit in such a way that a continuous secreting surface is formed throughout a considerable interval of the phragmocone (see *Geisonoceras teicherti*, Flower, 1939, also Flower, 1939, pp. 53, 55-65), suggests a common mantle in the siphonal and cameral tissues. However, shellls exhibiting such a continuous secreting surface do not appear prior to the Middle Silurian. Their late appearance suggests that their continuous secreting surface may be specialized instead of primitive and is consistent with the belief that annulosiphonate deposits in the siphuncle may be derived not from a siphonal mantle, but from the connecting ring.

Siphuncles which have short septal necks and connecting rings were divided by Hyatt into orthochoanitic and cyrtochoanitic. Cephalopods which showed in different parts of the phragmocone a marked change from one to the other, were called mixochoanitic. The orthochoanitic siphuncle is characterized, as the name implies, by straight septal necks (fig. 6 B). The siphuncle itself is tubular or may be faintly expanded within the cameræ. The necks should lie parallel to the axis of the siphuncle. In cyrtochoanitic segments the necks are curved so as to point outward away from the center of the siphuncle, and the segment is more or less expanded within the cameræ (fig. 5 F, G; fig. 6 A). Teichert has found occasion to contrast the length of the neck, which he measures as the "neck" with the extent of the recurved portion, which constitutes the brim (fig. 6 A). Sometimes the neck is recumbent, lying back in contact with the free part of the septum. In such cases, the connecting ring may be adnate to the septum outside the tip of the neck before it becomes free and turns toward the adapical septum. When it joins the adapical septum, it may again form an area of adnation on the adoral surface of the adapical septum. In this way, a considerable portion of the free part of the septum may be incorporated into the organization of a siphuncle. This sort of development is best exemplified in the Actinoceroidea, and particularly in the Armenoceratidæ, Gonioceratidæ, and Huroniidæ, though it is also to be found in a less advanced condition in the Pseudorthoceratidæ and in many other cyrtochoanitic cephalopods.

Naturally, the distinction between orthochoanitic and cyrtochoanitic siphuncles becomes in some cases a very difficult matter. The writer attempted to solve this perplexity by the adoption of a term "suborthochoanitic" for such borderline cases. The term is a highly useful one, first of all for descriptive purposes, and second, because its use does much to eliminate the strong

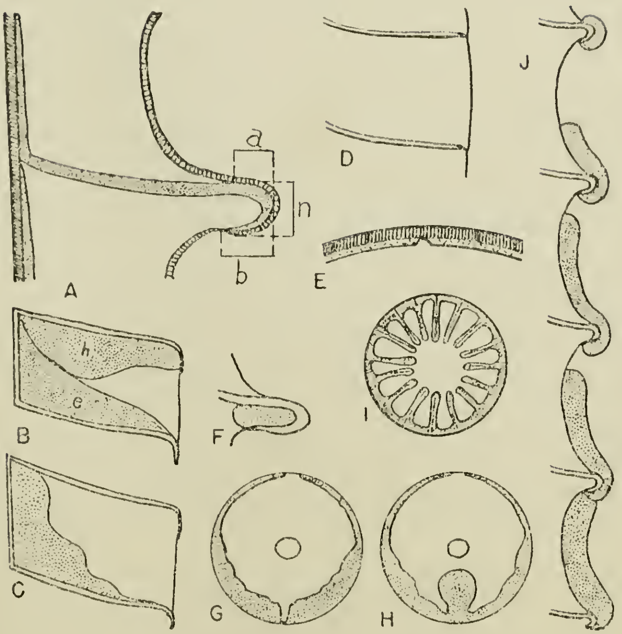

Figure 6. Structural details of nautiloid phragmocones. A. Portion of phragmocone showing wall of conch, the septum, and connecting ring: (n) neck (b) brim (a) area of adnation. Note continuity of mural part of septum, free part of septum and septal neck. B. Portion of a camera showing orthochoanitic septal neck, episeptal deposit (e) and hyposeptal deposit (h) in section. C. Portion of camera showing orthochoanitic siphuncle, with mural deposit in the camera. D. Aneuchoanitic siphuncle from *Shideleroceras.* E. Restored section through the dorsal wall of the phragmocone showing the wall of the conch, the mural part of the septum, which is interrupted on the mid-dorsal area forming the septal furrow. (See also fig. 4.) F. Cyrtochoanitic septal neck of an actinoceroid reinforced by the annulus. G. Cross section through a camera of a *Pseudorthoceras,* showing circumferential variation in the cameral deposit, the ventral sinus, the ventro-lateral masses, the dorso-lateral bands, and the dorsal hiatus. H. Circumferential distribution of cameral deposits in *Michelinoceras ludlowense.* I. Cross section of a typical actinosiphonate siphuncle. J. Longitudinal section through one side of a pseudorthoceroid siphuncle, showing the simple annulus adorally, while deposits farther apicad show successive growth stages of the parietal deposits to the point at which a continuous lining of the siphuncle is developed.

taxonomic implication of the dichotomous division of orthochoanitic and cyrtochoanitic.

One other term has been employed for septal necks. Cephalopods are found, particularly in the earliest strata, which have no true adapical bend of the septum (fig. 6 D). For such structures Ulrich and Foerste proposed the term *aneuchoanitic*. "Ozarkian" and some Canadian genera display this type of structure. It is to be found in two Cincinnatian genera, both of which are regarded as relics of the Canadian and Ozarkian types, *Cyrtocerina* (fig. 5 A) and *Shideleroceras* (fig. 6 D) but aside from these genera, no Chazyan or younger cases of this type of structure are yet known.

Hyatt used the terms holochoanite, orthochoanitic, and cyrtochoanitic not only as descriptive terms but made from them taxonomic divisions characterized only by the particular type of siphuncle involved in each. It is now evident that these terms are misleading. The Holochoanites of Hyatt as subsequently expanded are only holochoanitic in a very small part. The history of the Orthochoanites is as yet uncertain. The Cyrtochoanites have evidently developed three times at least in the history of nautiloids. The Actinoceroidea represent an early development of cyrtochoanitic structure in the eurysiphonate line, a development which is foreshadowed in *Bathmoceras*. In the Chazyan the oncoceroids, Valcouroceratidæ, and Allumettoceratidæ represent three divergent but perhaps closely related lines in which cyrtochoanitic segments developed in a group of cephalopods characterized by thin connecting rings. This is indicated first by the suborthochoanitic early stages of these cephalopods, and second by the absence of similar cyrtochoanitic forms and the presence instead of suborthochoanitic cyrtocones in older strata. Whether the contemporaneous Discosoroidea are closely related to these forms in origin, or whether they represent another independent development of cyrtochoanitic structure, is uncertain.

The Pseudorthoceratidæ represent a separate line which developed from Middle Silurian orthochoanitic orthoceracones and attained cyrtochoanitic siphuncles by Lower Devonian time. A few isolated examples of cyrtochoanitic or nearly cyrtochoanitic segments are known in younger nautiliconic genera.

The Ordovician Apsidoceratidæ, which do not seem to be related to any known cyrtoconic cephalopods of the Ordovician, may represent yet another attainment of cyrtochoanitic siphuncles. Unfortunately no orthochoanitic cephalopod is known which appears to be a likely ancestor. The Rhadinoceratidæ of the Devonian are another cyrtochoanitic family, and the origin of this group is clearly to be found in the orthochoanitic Silurian genus *Bickmorites*. The writer has treated the development of this family elsewhere (New York State Museum Bulletin, still in press).

Thus, the form of the siphuncle is a matter of primary importance in the classification of the nautiloids and must be known for certain identification. Happily, many cases exist in which fairly certain identifications can be made on the basis of the analogy of other parts, for siphuncles are often not well preserved.

SIPHONAL DEPOSITS

Siphonal deposits or endosiphoncular deposits are categories which embrace a variety of structures which are not always closely related. Briefly, the form types are as follows:

I. Partitions and dissepiments which cross the cavity of the siphuncle as tabulæ or diaphragms. This is an early Paleozoic feature, not found in any Cincinnatian cephalopods. The true nature of the structures concerned is not at present well understood. They have not been observed in any post-Canadian cephalopods.

II. Endocones. A series of solid cones filling the siphuncle, one within another, and characteristic of the Endoceroidea as restricted by the writer. The tips of the cones continue in flat or circular tubes, and in some cases these tubes may be divided by minute tabulæ. The structure of the endocones is treated more thoroughly in connection with the endoceroids. Endocones developed independently in the Discosoroidea and probably again in *Troedsonella* Kobayashi.

III. Annulosiphonate deposits (figs. 6 D, 7). These consist of doughnutlike rings formed at the septal foramina. In extreme cases the rings may become so enlarged as to occupy most

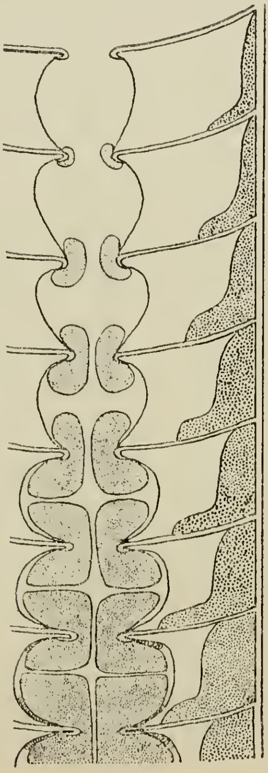

Figure 7. Idealized section of a *Treptoceras* showing the spatial relationships of the various cameral structures. The siphuncle is wide initially having the type of segment characteristic of *Armenoceras*. Farther orad the spherical segments of *Ormoceras* occur, and adorally the segments of *Deiroceras,* which are longer than wide, appear. Annulosiphonate deposits appear as simple annuli, shown in the adoral segments, and grow into pendant deposits which fill the siphuncle in the apical portion except for the siphonal vascular system. The apical two segments show the secondary perispatial deposit in the perispatium. Cameral deposits are mural and show an ontogenetic progression from the adoral to the adapical part of the figure. This is slightly idealized in that such changes in the form of the siphuncle and the cameral and siphonal deposits would ordinarily occupy a longer series of cameræ.

of the cavity of the siphuncle, as in the Actinoceroidea, and in such cases the only spaces remaining are the cavities of the original vascular tubes (fig. 7).

Annulosiphonate deposits may hang within the siphuncle, not coming in contact with the free part of the connecting ring (fig. 7, pendant deposits, Flower, 1939) or may form close against the connecting ring (fig. 6 J, parietal deposits, Flower, 1939) but both types begin as a simple annulus as shown in the upper portion of both figures. Some, but not all, annulosiphonate deposits show the rows of aragonitic prisms which are so generally characteristic of true shell structures and are indicative of secretion by true mantles. Others fail to show such structure, and may be derived from the connecting ring, from the eyelet of the connecting ring, or may even be independent of either the original mantle or the connecting ring in origin. Their origin requires much further investigation. At the present time all that can be said is that these structures have developed at least twice, and probably oftener in the history of the Nautiloidea, and may not always have been composed of the same sort of material.

IV. Actinosiphonate deposits (fig. 5 F; fig. 6 I) consist primarily of vertical rays extending from the wall of the siphuncle toward its center. Sometimes the rays are segmental structures and sometimes they appear to continue unbroken from segment to segment. The writer (Flower, 1943) has reviewed some of the types most readily available for morphological study and has come to the belief that these structures are developed as simple outgrowths of the connecting ring proper, and that they have developed independently in different lines of descent, a few of which can be traced back to ancestral types which are clearly free from any actinosiphonate structures. These structures are treated in greater detail in relation to the Valcouroceratidæ, and to a lesser extent, the Diestoceratidæ, the only families in the Cincinnatian in which actinosiphonate deposits are known.

Hyatt (1900) believed that the cyrtochoanitic cephalopods could be divided into two groups in none of which annulosiphonate deposits were at length perfected, while in the other, actinosiphonate deposits developed. Logical as this conclusion was in view of the relatively meagre morphological data available to Hyatt, these categories of the Cyrtochoanites must be abandoned. Further, even the Cyrtochoanites themselves must be split up since that group is remonstrably polyphyletic.

There is much variation in the type of "deposit" formed within the siphuncle. Except for annulosiphonate and actinosiphonate deposits, which are rather too broad generalizations to be useful in more than the most general descriptive sense, there is a characteristic pattern of the deposits in each group of cephalopods where deposits are developed. It has been considered best to confine the discussion of these special structures to the general discussions of the groups to which they pertain. All technical and special terms are, however, included in the glossary which accompanies this discussion of morphology.

CAMERAL DEPOSITS

Deposits within the cameræ of nautiloids are true shell secretions and are laid down by the cameral mantle (Flower, 1930), which is kept in contact with the remainder of the organism by the exchange of materials with the blood system of the siphon through the porous connecting ring. I do not include in this term all deposits found within the cameræ. Upon occasion deposits arising from the connecting ring and secreted on the outside of the original connecting ring may be said to be cameral deposits in the broadest possible sense of the term. However, I exclude these structures because they are properly part of the connecting ring and are so utterly alien in form and composition to the true cameral deposits that to identify them as such is greatly misleading. Further, inorganic deposits of the cameræ are not properly included in this term, which is significant only in relation to original natural organic structures of the cephalopod.

The various types of cameral deposits were classified by

Teichert on the basis of their distribution against the various walls of the cameræ. The writer (1936, 1939) attempted to find English equivalents which would retain the functional or descriptive significance of the original German terms proposed by Teichert, but which would have the additional advantage of brevity. Briefly, the following types have been recognized:

1. Episeptal deposits. Formed mainly on the adoral face of the septum and largely against the free part of the septum (fig. 6 B, e).

2. Hyposeptal deposits. Formed on the adapicad side of the septum (fig. 6 B, h).

3. Mural deposits. A variant of the episeptal deposit, but one which is formed mainly against the mural part of the septum, and which encroaches extensively on the episeptal parts largely in the later stages of growth (fig. 6 C).

4. Pseudoseptum. The line of junction of episeptal and hyposeptal deposits in advanced stages of growth (fig. 6 B).

5. Circulus. This term was proposed to substitute for Teichert's *Stützring,* a ring of deposits formed outside of cyrtochoanitic septal necks (fig. 6 F).

In addition, the surfaces of growing and mature deposits have been found to show significant features. Terms were proposed for the different regions found in the Pseudorthoceratidæ (fig. 6 G). In general, similar patterns are found in many ellipochoanitic cephalopods with mural or episeptal deposits. They consist of:

1. A ventral sinus.

2. Ventro-lateral lobes, often marked by complex ridges and bosses.

3. Dorso-lateral bands, thinner areas, often with ridges and striæ.

4. A dorsal hiatus, an area roughly corresponding to the septal furrow in which no deposits are formed.

Somewhat similar patterns are found in the Actinoceroidea, but there is rarely a clear division between the dorso-lateral bands and the ventro-lateral masses. Pitting of the surface is more frequent and slightly less regular.

The peculiar type of deposit found in *Michelinoceras ludlowense* (fig. 6 H) is without a parallel in other known nautiloids, the main feature being a conspicuous boss on the mid-ventral area instead of the usual sinus. Mid-ventral projections, though of quite a different shape, have been found in *Leurocycloceras* (Flower, 1941) but here the projections are essentially linear, extending from the wall of the camera toward the siphuncle and extending vertically through the entire cameral space.

One other type of cameral deposit remains to be considered, that consisting of low numerous linear projections, commonly seen as longitudinal impressions on the internal molds and resembling superficially the fluting of some kionoceroid shells. Such deposits I have observed in a variety of brevicones where they are clearly gerontic features. They are well developed in many phragmoceroid shells, but are by no means confined to them. They are particularly characteristic of the Ordovician *Westonoceras,* and indeed some shell fragments have been assigned to that genus on the basis of these structures alone. However, they are also to be found in the allied genus *Faberoceras,* described below, and are characteristic of the Westonoceratidæ rather than of *Westonoceras* itself.

Data are meagre for the surface patterns of cameral deposits. Such structures are best studied from internal molds, which show the surface features of the deposits with exceptional clarity. The types outlined above are the main ones found in nautiloids. Special variations are discussed in connection with the genera and species in which they occur.

GROWTH RELATIONSHIPS OF SHELL PARTS

The distribution of various structures in the shells of nautiloids presents problems which may lead the unwary astray, particularly in relationship to the deposits of the siphuncle and cameræ. Deposition of shell parts begins in almost every case at the apex of the shell and extends forward. The first shell part to appear is of course the wall of the conch. After this has developed to a certain extent, the visceral mass moves forward for the first time and behind it is secreted the first septum. Thereafter, the body mass of the animal continues to move forward forming septa behind it at regular rhythmic intervals. In this way the proportions of the living chamber retain a definite relationship throughout life, which is commonly expressed in simple conical shells by the relationship between its length and its basal diameter. On the other hand, the phragmocone is constantly increased until growth ceases.

The septa are fixed once they are secreted and are not further modified. They exemplify the serial repetition of unalterable parts, and the oldest and most apical of the septa shows the most primitive features. In most nautiloids there is little ontogenetic progression of the septa, except in a few of the younger coiled genera and the Mixochoanites, but in ammonoids where a complex suture pattern is developed the ontogeny of the suture has provided clues for identification and for phylogeny. The connecting ring is secreted at the same time as the septum which lies orad of it and may or may not be subsequently modified.

The deposits of the cameræ appear some time after the deposition of the septa. Their growth orad in the shell is in general about equal to the rate of deposition of the septa, so that within a species there is a constant relationship between the two. Thus in *Striacoceras typus* (Saemann) about 12 cameræ at the adoral end of the phragmocone show no cameral deposits regardless of the growth stage of the organism.

The deposits of the cameræ illustrate the ontogenetic progression as found in a serial repetition of alterable parts, and the spatial relationship of ontogenetic stages here is exactly the reverse of that found in the septa which are not alterable after they are originally deposited. Each cameral deposit undergoes an ontogeny of its own from the time when it is deposited until the time when, owing to varying factors, its growth ceases. As the apical deposits are older, they are more advanced in their growth stages than the adoral deposits, and an ontogenetic series may be found in which the youngest, smallest and most adorally located deposit represents the youngest stage, and apicad from this is arranged a series showing successively later growth stages and more massive deposits. Sometimes this series extends as far apicad as the material—nearly always incomplete apically—permits observation. Again, a growing series of deposits undergoing ontogeny may terminate adapically in a mature series exhibiting a uniform condition of mass and surface features. Sometimes this is found where the deposits nearly or completely fill the cameræ. Again, maturity may be attained owing to purely physiological factors, or to a mechanical control, as is the case in the Pseudorthoceratidæ even when the deposits are not very thick. Normally, the phragmocone may be divided into three regions in reference to the cameral deposits: 1. An adoral region free from cameral deposits. 2. A region showing ontogenetic stages of the cameral deposits, which increase in mass, and often also in complexity of the surface pattern as they are traced apicad. 3. A region in which the cameral deposits are mature and do not undergo further growth. Sometimes the last two regions cannot be differentiated clearly. In some cases the axial gradient appears to function, and the growth rate of deposits seems to decrease apicad. Part of the difficulty is practical in estimating the relative growth of deposits in cameræ when the cameræ themselves decrease in size apically. But there are cases, notably in the Pseudorthoceratidæ and Actinoceroidea, as well as some Michelinoceratidæ, in which a definite mature region is attained. When there is such a region, it grows with the shell and increases while the first two regions of the phragmocone may remain the same.[2]

[2] This is a generalization. With growth infinitely more complex relationships may exist, the first two regions increasing very slightly or even rarely, decreasing as the shell progresses to maturity.

Siphonal deposits may show similar developments. This is particularly true of annulosiphonate deposits. These may precede cameral deposits in their appearance in ontogeny, as in some Michelinoceratidæ and most Actinoceroidea, or may follow them as in the Pseudorthoceratidæ, some Michelinoceratidæ, and commonly in the Sactoceratidæ of the Actinoceroidea. Some siphonal deposits seem to show no ontogenetic progression. The endocones of the Endoceroidea are fixed after deposition and consequently the endosiphuncle of some endoceroids shows no region in which ontogeny of the deposits can be observed by examining a series of deposits from the adoral to the adapical end. However, even in the endoceroids further modification of the siphonal deposits is possible. In tracing the endoceroid siphuncle from its adoral to its adapical end, first an endosiphocylinder is found in which no deposits are present. Second, there occurs the endosiphocone, which is of no functional importance as a growth stage, but marks the margin of the last endocone. Third, there will appear a series of similar endocones. Sometimes this continues to the apex. At other times the endosiphotube is subjected to further modifications, which appear some distance, and apparently a constant one, apicad of the tip of the endosiphocone. These may consist of tabulæ or diaphragms, as in many piloceroids, and again may consist of a partial filling of the tube as in *Proterocameroceras*.

It may be readily seen that both cameral and siphonal deposits might by greatly delayed in appearance and then grow very rapidly, so as to soon develop over the entire phragmocone. Cameral deposits which are delayed until the gerontic stage in many brevicones show this phenomenon. They are essentially vestigial and form a series of longitudinal grooves on the inside of the phragmocone. They are best known in *Westonoceras* but are also developed in many other forms, some of which are not closely related to *Westonoceras*. This same relationship may occasionally apply to siphonal deposits as well. Direct proof is lacking, but the available evidence suggests very strongly that a similar growth pattern is to be found in many, but certainly not all actinosiphonate deposits. These are apparently absent in many shells until at or near to maturity, when they grow so rapidly as to appear at almost the same time throughout the entire siphuncle. Where such an ontogenetic pattern is formed, the deposits fail to show a clear ontogenetic progression from young adoral deposits to mature adapical deposits.

Two other complications are possible. It is, of course, distinctly possible that the ontogeny of all of the members of such serially repeated structures may not undergo a similar ontogeny. No case is known as yet in which this applies to the deposits of the phragmocone or siphuncle in nautiloids, but as much is yet to be learned about these structures, the possibility is one which must be kept in mind in their study.

Or, though these parts are alterable, there may remain definite differences in the mature condition of those first secreted and those secreted later. When such a series is found, the progression may, theoretically, be either palingenetic or proterogenetic. The Pseudorthoceratidæ show one such modification. Apical mature deposits may fail to line the siphuncle completely but may leave the connecting ring exposed to siphonal tissues on the dorsal side. Such a modification has been interpreted as cœnogenetic (Flower, 1939). This interpretation was reached since no such stage was found in any pseudorthoceroid prior to late Middle Devonian (Hamilton) time, is not well developed before the Upper Devonian, and attains its fullest expression in the Pennsylvanian. The stratigraphic evidence suggests that it is a feature which appears relatively late in the family. Further, except for one Hamilton *Dolorthoceras,* regarded as probably ancestral to *Pseudorthoceras,* this specialization is perfected only in the Pseudorthoceratinæ and is not known in the greater part of the Dolorthoceratinæ, nor has it been observed in the ancestral orthochoanitic genus *Virgoceras.* Since material of these older and simpler types was ample, and both the ontogeny of *Pseudorthoceras* and the stratigraphic relationship of the first appearance of the genera suggest the same conclusion, the phylogeny may be safely interpreted in terms of a palingenetic progression of the form of the segments of the siphuncle.[3]

Still another modification of the ontogenetic progression is found in the actinosiphonate deposits, which the writer has fully observed only in the family Valcouroceratidæ. In extremely apical segments the connecting ring is simple. Farther orad, the ring is thickened. Still farther orad actinosiphonate rays develop from the thickened ring, and these increase in number to the ephebic part of the phragmocone, where they remain fairly constant. Here the oldest deposits when mature are simpler, and probably also more primitive, than those which are developed in later segments. The pattern is further complicated by the fact that there is a very slight series, usually only the last two or three segments, in which immature deposits appear to be developed. In *Valcouroceras*, and clearly in *Manitoulinoceras*, the actinosiphonate deposits do not appear until the shell as a whole attains a late ephebic or gerontic stage of development. In *Augustoceras* the same may be true, but it is also possible that the development of the connecting ring to maturity takes place in each segment very early, so that at any growth stage immature deposits may be seen in the first two or three segments of the siphuncle, but are mature in all segments apicad of these. This is suggested by the presence of such deposits in nearly every specimen examined. Most shells were exceedingly fragmentary, the living chamber and perhaps adoral cameræ being brok-

[3] Schindewolf (1942, p. 342, fig. 2 b) has figured a *Pseudorthoceras* (*sensu lato*) *hagenowii* (Boll) from the Upper Silurian (Gotlandian) which would seem to dispute this conclusion. While the writer has not seen the specimen concerned, Schindewolf's figure agrees perfectly with numerous sections of the Cincinnatian *Treptoceras*, properly an actinoceroid, with the annulosiphonate deposits greatly delayed and therefore confined to the extreme apex of the shell. Adoral parts of such shells commonly show what appears to be an organic lining of the siphuncle. This is actually inorganic and is the infiltrated material which complements an incomplete internal mold, formed in this case by incomplete penetration of the siphuncle by sediment from the adoral end. Similar structures are common in *Ormoceras* and *Armenoceras* in the Silurian and Devonian in America, where the siphonal deposits are also greatly retarded and do not show on many incomplete specimens. Schindewolf's specimen is certainly neither a *Pseudorthoceras* nor a member of the Pseudorthoceratidæ.

en off, so it is uncertain whether they are mature or immature individuals. With about 50 specimens from one locality, however, it is exceedingly improbable that all of them represented fully grown shells with adorally contracted cameræ, which is the only certain criterion of maturity in these forms.

The time interval which may elapse between the completion of a segment of the phragmocone, as formed by the septum and connecting ring, and the development there of siphonal and cameral deposits, is a constant source of confusion. Because of this lag, an appreciable series of adoral cameræ in a cephalopod may lack any trace of such deposits. Specimens of the common Cincinnatian genus, *Treptoceras,* lacking adapical parts of the phragmocone may show no evidence in themselves by which the student could determine whether the specimen should be placed in the Actinoceroidea, the Steroplasmoceratidæ, or the Pseudorthoceratidæ. Yet these three groups have developed cyrtochoanitic siphuncles of similar aspect completely independently of one another. Likewise, it is now quite certain that the perplexing occurrence of actinosiphonate deposits in some but not in all members of a species may be due also to the peculiar growth relationships and to the delay secreting these structures until a late ephebic or gerontic stage. Certainly some such explanation seems necessary in view of the presence of such deposits in only two out of perhaps 50 specimens of Cincinnatian *Manitoulinoceras.*

Perplexities exist which suggest that much remains to be learned concerning the growth relationships of the various nautiloids in addition to the generalizations included here. Unhappily a proper study of the phenomena requires the sort of materials which are rarely available, a considerable suite of reasonably complete specimens of a single species, which should, further, represent various stages of growth. Suites of such material well enough preserved for study by sections are very difficult to find. The writer had an opportunity to study such a suite of specimens of *Striacoceras typus* (Saemann) of the Cherry Valley limestone, but internal structure was not always good in these specimens. In the present work a large suite of *Augustoceras* was available, but most specimens consisted of broken phragmocones, so that it is uncertain at what growth stage many of the individuals died. Likewise, in the suites of abundant specimens of *Treptoceras,* much of the material was made worthless through either crushing or loss of internal structure, while nearly all specimens were exceedingly fragmentary. Further study of actinosiphonate cephalopods in particular is to be urged, while further study is needed to show whether there is any relationship between ontogenetic stages and the features of the blades and tubes within the siphuncles of the Endoceroidea.

GLOSSARY

actinoceroid.—Of or pertaining to the Actinoceroidea, involving a cyrtochoanitic siphuncle with complex structure, in which pendant annulosiphonate deposits may nearly fill the siphuncle in advanced stages of growth, leaving only the vascular spaces which consist of a central canal, a system of radial canals, and a perispatium.

Actinosiphonata.—One of the two major divisions of the Cyrtochoanites, formerly including all actinosiphonate cephalopods as well as primitive vacuosiphonate types believed to be ancestral to the actinosiphonate genera. As actinosiphonate structure is polyphyletic, the Actinosiphonata may be considered obsolete as a taxonomic unit.

actinosiphonate.—A type of siphonal deposit consisting of longitudinal lamellæ which arise from the wall of the siphuncle and converge, but do not meet, near the center. The deposit, derived from the connecting ring, at least in most instances, is polyphyletic and varies greatly in form among the various cephalopods known to possess it.

adapertural.—Toward the aperture of the shell, or toward the anterior end of the animal. (Adoral is preferred.)

adapical.—Toward the apex or initial portion of the shell.

adoral.—Literally toward the mouth, or in cephalopods toward the mouth or aperture of the shell. Preferred to adapertural as shorter.

adnation, area of.—The region at which the connecting ring lies in contact with the free part of the septum.

air chamber.—The space between the septa; camera is a preferable term.

aneuchoanitic.—A term applied to siphuncles at which the septum forms only a vestigal neck, being scarcely bent apicad.

annular.—Ringlike.

annular lobe.—A lobe of the suture in the plane of symmetry.

annulation.—A ringlike structure. Generally confined in cephalopods to ringlike expansions of the shell wall.

annulated.—Marked by or bearing rings. Generally applied to surface features of the shell. Rarely used to describe deposits within the siphuncle.

Annulosiphonata.—One of two divisions of the Cyrtochoanites (Hyatt, 1900) now obsolete, containing those Cyrtochoanites bearing annulosiphonate deposits.

annulosiphonate.—Deposits within the siphuncle consisting of doughnutlike rings formed at the septal foramen and attached to the wall of the siphuncle. A general term, involving polyphyletic structures.

annulus, simple.—The simplest type of annulosiphonate deposit, the free surface of which is everywhere approximately equidistant from the center of deposition.

aperture.—The opening of the shell through which the head and foot are protruded.

aponeurotic bands.—Linear bands, usually three, of attachment of the animal to the shell. See conchial furrow.

asceroid.—A naturally truncated cephalopod with sigmoid septa; also often applied to the septa alone.

basal zone.—A region in the basal portion of the living chamber in which the shell is gerontically thickened, often producing a pitted or banded surface. Best developed in breviconic cephalopods.

blade.—A structure of uncertain nature and function running the length of the endocones in an endoceroid. Two or more blades are usually present, the form and position of which are highly characteristic of certain genera. More properly, endosiphoblades, but for brevity the term blade is more often used.

brevicone.—A cephalopod shell which is short and rapidly expanding. Used to include forms with open apertures (as *Rizoceras*) and also gomphoceroids in which the shell contracts toward the mature aperture. A descriptive but not a classificatory term.

breviconic.—Adjectival form applied to brevicones.

bulette.—A term proposed by Strand (1934) for annulosiphonate deposits of most ellipochoanitic cephalopods except the Actinoceroidea. It is applied here only to the annulosiphonate or early stage of actinosiphonate deposits, or to deposits known to be derived from the generalized connecting ring.

brim.—The portion of the septal neck which extends away from the axis of the siphuncle.

cæcum.—See siphonal cæcum.

camera.—The space enclosed between two adjacent septa, but not including the space set off from this by the walls of the siphuncle.

cameral.—Of or pertaining to the cameræ.

cameral deposits.—Calcareous deposits, true shell structures, secreted against the original walls of the cameræ by a living tissue. Does not include growths on the outside of the siphuncle which are formed within instead of upon the surface of tissues.

cameral gas.—Gas secreted within the cameræ. In *Nautilus* this differs from air only in the relatively high nitrogen content, a condition which may be explained by the relatively high solubility of nitrogen in the blood under such pressure as supplied by the deep water environment of *Nautilus.*

cameral mantle.—The tissue lining the cameræ in cephalopods, responsible for the secretion of cameral deposits and gas. Connected through the porous connecting ring with the tissues of the siphon, and thence to the remainder of the organism.

centrad.—Toward the center. Usually used in connection with the siphuncle which for descriptive purposes may be assumed to be a more or less modified cylinder, the center of which is a straight line or axis.

central canal.—A canal or cavity in or near the center of the siphuncle of Actinoceroidea, sometimes apparent as consisting of two parallel tubes. It connects the radial canals with the visceral mass, and as seen in fossil forms represents the cavity formerly occupied by large blood tubes. In rare cases, the walls of the blood tubes themselves may be calcified.

circulus.—A cameral deposit forming a ring around a cyrtochoanitic septal neck; the *Stützring* of Teichert (1933).

conch.—A general term applied to the entire shell.

conchial furrow.—A shallow furrow or groove on the inside of the shell wall located mid-ventrally. Comparable to the space between two aponeurotic bands in *Nautilus.* Usually a single structure, although a few species, notably in the Devonian *Striacoceras* Flower, three grooves are developed on the venter. (Flower, 1939, pp. 12-13.)

concavosiphonate.—A form of siphuncle concave in section between the septa. (Foerste, 1926.)

connecting ring.—A calcareous structure secreted within the tissues of the original siphonal strand. and forming an important part of the siphuncle. This structure, unlike other parts of the shell except those derived from the connecting ring itself, is mesodermal and is not secreted by the surface of a specialized tissue, a mantle. In generalized forms the connecting ring is often spicular, but may appear massive and amorphous, or may be differentiated into specialized layers or regions.

crest.—An adoral projection of the aperture, or, in early parts of the shell, of growth lines reflecting the condition of former apertures. The opposite of a sinus.

cyrto.—Prefix indicating curvature.

Cyrtoceras.—A generic name once applied to all slightly curved nautiloids. Now a synonym of *Cyrtoceratites,* a genus known only from the Middle Devonian of Europe.

cyrtoceracone.—A nautiloid shell in which the entire conch is slightly curved.

cyrtoceraconic.—Adjectival form of cyrtoceracone.

Cyrtochoanites.—A major division of the Nautiloidea (Hyatt, 1900) now obsolete, containing all cephalopods with expanded siphuncles and septal necks which bend outward or distad at their tips.

cyrtochoanitic.—A form type of siphuncle in which a segment expands within the cameræ and the septal necks are bent outward or distad at their tips. (Also, cyrtochoanoidal.)

cyrtocone.—A shell or fragment of a shell of a nautiloid which is slightly curved. Properly confined to portions of shells, in contrast to cyrtoceraconic, but in actual usage this term has often been used synonymously with cyrtoceracone.

cyrtoconic.—Adjectival form of cyrtocone.

distad.—Toward the periphery or tip, as of appendages or processes; also, away from the base or center.

dorsal.—Of or pertaining to the dorsum, the back, or top of an animal. In nautiloids, used arbitrarily for the side opposite the hyponome, although properly the primitive dorsal surface of a nautiloid may be considered to be extended so as to embrace all except the portion protruding from the shell. Also often used for the concave and/or the siphonal side of the shell in shells in which no better criteria or orientation are available.

dorsal furrow.—A linear dorsal marking on each chamber of the phragmocone representing a region in which the mural part of the septum is not developed. Septal furrow is preferred as a more descriptive term. The normal line, the *ligne normale* of Barrande is synonymous.

dorsum.—Properly the back or upper side of an organism, as opposed to the venter. In nautiloids, the dorsum has properly been expanded to cover all except the adoral surface of the animal, and the dorsal side is arbitrarily considered, in descriptions to be the top side, as oriented in *Nautilus* in life, that is the side which is on the inside of the coil of the shell. Often used loosely and sometimes incorrectly for (1) the concave side of a shell where no sure guide to orientation is known, and (2) for the convex side in cases where the siphuncle is close to the concave side, on the theory, sometimes mistaken, that the siphuncle is generally ventral when it is marginal.

ellipochoanitic.—A descriptive term applied to siphuncles having relatively short septal necks supplemented by connecting rings, as opposed to the old concept of holochoanitic, in which connecting rings are supposed to be absent.

Ellipochoanites.—(Also Ellipochoanoidea) an obsolete group of cephalopods (Hyatt, 1884) characterized by siphuncles composed of septal necks supplemented by connecting rings. Abandoned by Hyatt (1900) for Orthochoanites, Cyrtochoanites, Holochoanites, Schistochoanites, and Mixochoanites.

ellesmeroceroid.—A descriptive term for cephalopods with large tubular or faintly annular siphuncles, the wall composed of short necks and strong connecting rings, and formerly regarded erroneously as holochoanitic. The interior lacks endocones, and no organic deposits have been demonstrated within the siphuncles of the group. Such cephalopods are particularly characteristic of the Cambro-Ordovician (Ozarkian and Canadian).

endoceroid.—A descriptive term for cephalopods with large tubular or faintly annular siphuncles containing endocones. Formerly loosely applied (1) to Holochoanites or supposed holochoanitic shells (2) to slender shells with the above features in contrast to the short rapidly expanding piloceroid. (Restricted, Flower, 1941.)

Endoceroidea.—A superfamily grouping for endoceroids as emended above, including both holochoanitic and ellipochoanitic forms, and piloceroids as well as endoceroids in the old sense.

endocone.—One of a series of cones formed in the adapical portion of the siphuncle of an endoceroid. The cones are arranged with the apex pointing apicad, and new cones are formed orad of the old ones.

endogastric.—A term applied to cephalopods which are curved with the venter on the inside instead of the outside of the whorl. Also, cephalopod shells believed to be coiled in this way on the basis of a siphuncle which is marginal and close to the concave side of the shell. This interpretation has been found to be incorrect in some cases, as in *Archiacoceras*.

endosiphoblade.—See blade. (Ruedemann, 1905.)

endosiphocoleon.—A flat tube connecting the apices of successive endocones and eventually filled in laterally to form the endosiphotube. (Ruedemann, 1905.)

endosiphocone.—The conical space orad of the last endocone.

endosiphocylinder.—The adoral cylindrical cavity of an endoceroid siphuncle, where no endocones are developed, terminating apically in the endosiphocone with which it is continuous.

endosipholining.—A continuous lining of the endoceroid siphuncle separating the ectosiphuncle from the endocones and attendant structures. (Ruedemann, 1905.)

endosiphotube.—(1) The circular tube formed by the adapical thickening of the lateral walls of the endosiphocoleon in some endoceroids. (2) Also applied to simple tubes connecting the apices of endocones where no differentiation of coleon and tube is possible.

endosiphuncle.—By original definition, all siphuncular structures within the ectosiphuncle. The distinction is artificial in many cases but not in the Endoceroidea where the term was originally used.

Eurysiphonata.—A major division of the cephalopods proposed by Teichert (1933) but subsequently used for Nautiloidea embracing the Endoceroidea, Actinoceroidea, and their allies. Characterized in general by long septal necks, and/or thickened connecting rings.

eurysiphonate.—Descriptive term used here to denote the type of siphuncular organization of the Eurysiphonata, thick complex rings, long necks, or both.

exogastric.—Descriptive term applied to curved or coiled cephalopods in which the gaster, *i. e.*, the ventral side, is on the outside of the coil. The prevailing mode of coiling in the Nautiloidea.

eyelet.—A specialized region in the tip of the connecting ring in many eurysiphonate cephalopods characterized by dense fine-grained or amorphous material.

foramen, septal.—The opening in the septum for the passage of the siphonal tissues through the phragmocone.

free part of septum.—The portion of the septum which traverses the cameræ, and which is not, primitively, a part of the siphuncle.

funnel.—The septal neck. Not widely used currently.

Gomphoceras.—A generic name formerly applied to all breviconic cephalopods with contracted apertures. *Gomphoceras* as restricted is a valid genus of the Middle Silurian.

gomphoceroid.—A descriptive term, applied to shells of the general aspect of *Gomphoceras* in the older and broader sense. Gomphoceroids are a special type of brevicone.

Holochoanites.—A division of the Nautiloidea (Hyatt, 1900) with "funnels of siphuncular segments reaching from the septum of origination to the plane of the next septum apicad or beyond this, or in some genera even to the plane of the second septum." Holochoanites were formerly believed to lack connecting rings. Their presence has, however, been demonstrated. As a taxonomic group, the Holochoanites is no longer valid in the sense it was used by Hyatt, for a large number of the genera included in it are elliphochoanitic. The term would now embrace only a small part of the Endoceroidea.

holochoanitic.—(1) Formerly supposed to apply to siphuncles the walls of which are composed of septal necks which extend apicad at least the length of one segment, and which were supposedly without connecting rings, (2) as restricted (Flower, 1941) the term is applied to cephalopods in which the septal neck extends apicad for the length of one camera. Connecting rings are generally, perhaps always, present. Known only in certain Endoceroidea.

impressed zone.—(1)The concavity on one side, usually dorsal, of a coiled shell for the reception of the preceding whorl, (2) zone at base of living chamber of many gerontic nautiloids with impressions of various sorts (Flower, 1936). The term basal zone has been substituted for this usage to avoid confusion. (Flower, 1939.)

intracameral deposits.—Organic deposits formed in the cameræ. The term cameral deposits has been substituted, since there is no need to distinguish between these and intercameral or extracameral deposits.

lateral angle.—A special term for the angular bend in the lateral part of the suture of ascoceroids, separating the main part of the suture from the dorsal saddle. (Mixochoanites.)

ligne normale.—The normal line (Barrande) here termed the septal furrow.

liræ.—Following the usage of Miller, Dunbar, and Condra (1933) liræ are here employed as raised lines, large or small, transverse or longitudinal.

living chamber.—The adoral aseptate part of the shell occupied in life by the visceral mass, or main part of the organism.

lobe.—A part of the suture which bends apicad. Opposite of saddle.

lunette.—Annulosiphonate deposits which are large and massive, as in the Actinoceroidea. Employed as the opposite of bulettes. Not employed here inasmuch as a natural distinction based on size alone is dubious. Originally confined to the annulosiphonate deposits of the Actinoceroidea.

mural part of septum.—The portion of the septum which extends orad from the free part of the septum along the inside of the wall of the shell.

mural deposits.—Deposits of the cameræ which are formed mainly against the outside, that is, against the mural part of the septum and the wall of the conch, rather than against the free part of the septum.

nautilicone.—(1) Any coiled cephalopod in which the whorls are in contact. Later restricted to coiled shells which are more or less involute, as opposed to tarphyceracone.

nautiliconic.—Adjectival form of the above.

neck.—(1) Commonly the septal neck, (2) in specialized brevicones, as *Ascoceras* the contracted adoral part of the living chamber between the aperture and the basal inflated portion (rare).

neck, septal.—The portion of the septum which is produced apicad about the siphonal tissues at the septal foramen and forms a part of the siphuncle.

nepionic bulb.—The apically swollen part of the siphuncle in many endoceroids.

oncoceroid.—A descriptive term for small compressed brevicones with small empty ventral siphuncles. Essentially, (1) a shell of the general shape of the Oncoceratidæ and (2) a cephalopod belonging to or descended from the Oncoceratidæ.

orthocone.—A shell or better, a portion of a cephalopod shell which is essentially straight.

orthoconic.—Adjectival form of the above.

orthoceracone.—A complete shell which is essentially straight in the Nautiloidea.

orthoceraconic.—Adjectival form of the above.

Orthochoanites.—(Hyatt, 1900). Ellipochoanitic cephalopods with straight septal necks and cylindrical or nearly cylindrical siphuncles. Restricted here to stenosiphonate cephalopods, to eliminate orthochoanitic endoceroids with thick complex rings.

orthochoanitic.—Adjectival form of the above.

parietal deposits.—Annulosiphonate deposits which grow close against the connecting ring and which do not normally project markedly into the cavity of the siphuncle.

pendant deposits.—Annulosiphonate deposits which are in contact with the wall of the siphuncle only at their point of origin, and which otherwise hang free within the siphonal cavity.

perispatial deposits.—Carbonaceous lamellar deposits which develop in the perispatium in the Actinoceroidea.

perispatium.—A vacant space between the annulosiphonate deposits and the free part of the connecting ring characteristic of the Actinoceroidea. Regarded as a space in which the radial canals ultimately divide to form capillaries, which pass through the ring into the cameral deposits.

phragmoceroid.—Compressed endogastric cephalopods with strongly contracted and strongly lobed apertures.

phragmocone.—The chambered portion of the shell, in contrast to the aseptate living chamber.

piloceroid.—A short breviconic shell, with aperture uncontracted, a ventral siphuncle, large and rapidly expanding, and containing endocones.

pre-basal segments.—Confined to the Mixochoanites. Segments of the siphuncle lying between the septum of truncation and the basal septum.

protoconch.—The initial portion of the shell, rarely found in Nautiloidea.

proximad.—Toward the base, as of an appendage or process.

radial canal.—Tubes running from the central canal to the perispatium. Confined largely to the Actinoceroidea.

saddle.—The portion of the suture which is bent orad.

septal furrow.—A narrow mid-dorsal region in which the mural part of the septum is lacking. Often prominent on internal molds of Nautiloidea.

septal neck.—The portion of the septum which is extended apicad at the septal foramen, and which forms part of the siphuncle.

septum.—One of the series of partitions which set off the cameræ.

septum, free part of.—The part of the septum traversing the cavity of the shell.

septum, mural part of.—The portion of the septum which extends orad from the free portion and lies in contact with the wall of the shell.

septum of truncation.—The septum which forms the base of the mature shell of an ascoceroid, and more primitive Mixochoanites, apicad of which earlier parts of the shell have been lost during the life of the organism.

sigmoid suture.—A special term for the sutures developed in the late growth stages of ascoceroid shells (Mixochoanites) characterized by a prominent dorsal saddle and more or less S-shaped in lateral aspect.

sinus.—A portion of the aperture which swings apicad, in contrast to a crest. Also applied to growth lines which indicate earlier apertures.

siphon.—The tissues which extend the length of the phragmocone. Largely vascular in function.

siphonal.—Adjectival form of the above.

siphonal cæcum.—The adapical portion of the siphuncle which in many nautiloids terminates in a rounded closed sac.

siphonal mantle.—The specialized surface of the siphon which secretes true shell structures in the siphuncle, as some annulosiphonate deposits.

siphonal vascular system.—The system of blood tubes in the siphonal tissues. Well known only in the Actinoceroidea, where the system of few and large tubes represents the only part of the siphuncle not filled in by excessive growth of the annulosiphonate deposits.

suture.—The line along which the septum leaves the wall of the shell, therefore, the point of transition from the mural to the free part of the septum.

tarphyceracone.—A coiled shell in which the whorls are in contact, but in which they are not strongly involute, though the dorsum may be flattened or slightly excavated to receive the earlier whorl.

trochoceroid.—A nautiloid shell with an eccentric coil, developing more or less of a spire.

truncation.—The natural loss, in life, of the adapical portion of the shell. (Largely in the Mixochoanites.) See also septum of truncation.

venter.—The under side of the organism. In Nautiloidea this applies to the side commonly oriented downward in life as in *Nautilus* and is distinguished generally by a hyponomic sinus and also by the conchial furrow.

vacuosiphonate.—A descriptive term applied to siphuncles lacking any internal deposits of organic nature. (New.)

PHYLOGENY AND CLASSIFICATION

Fifty years ago all except a few bizarre types of nautiloids were placed in the genera *Orthoceras, Endoceras, Cyrtoceras, Gyroceras, Trochoceras, Nautilus,* and *Gomphoceras.* One look at the outside of the shell was sufficient for the identification of the genus. However, these genera were highly artificial, and Hyatt (1900) presented a detailed classification based upon the reasonable premise that the internal features of the shell were a better guide to relationship than was the exterior. His classification is still the only one which goes into sufficient detail to indicate the position of the various genera then known, and is the one still outlined in most textbooks. He divided the Nautiloidea into five groups. The Holochoanites contained forms in which the siphuncle was supposedly composed only of septal necks. The Schistochoanites, a small and little understood group, was erected for cephalopods in which the septal necks were apparently incomplete on the venter, where the siphuncle lay in contact with the wall of the shell. Mixochoanites was erected for the reception of the ascoceroids, which were characterized by slender segments in the early part of the shell, but in which these were abruptly succeeded by rounded globular segments in the adult. Cephalopods which had short necks supplemented by connecting rings were termed ellipochoanitic. Those which had necks parallel to the axis of the shell and essentially tubular segments were placed in the Orthochoanites, those in which the necks were recurved so that their tips pointed outward and in which the segments were more or less nummuloidal, were placed in the Cyrtochoanites.

While no comprehensive and detailed classification has yet appeared to replace Hyatt's scheme, subsequent study has shown certain objections, some of which are so strong that it is no longer possible to use this classification. The Holochoanites were placed first in the scheme, because it was believed that they were the most primitive, having the simplest siphuncle walls. However, it is now apparent that the endoceroids, which constitute the nucleus of the Holochoanites, are not all holochoanitic. Properly speaking, the endoceroids are not a part of the Holochoanites, rather the Holochoanites constitute a part of the Endoceroidea. Further, the holochoanitic endoceroids are specialized from older and simpler ellipochoanitic endoceroids and retain connecting rings as a heritage from their ellipochoanitic ancestors. (Flower, 1941.)

The Schistochoanites are not recognized today. The genera which constituted the group represent primitive types but are too diverse in the structure of the siphuncle to be united. The Mixochoanites (Flower, 1941) have been traced to an origin in orthochoanitic orthoceracones, and Chazyan types, unknown in Hyatt's day, serve to lessen the morphological gap which separated these singular cephalopods from more generalized types.

Little progress has yet been made in the tracing of relationships in the Orthochoanites of Hyatt, beyond the point to which Hyatt (1894) carried his investigations, which were concerned primarily with the coiled genera. Subsequently the writer (Flower, 1941) has noted a grave discrepancy between the thick complex connecting rings of most coiled Canadian cephalopods on one hand, and the thin simple rings of post-Canadian genera on the other, which suggests that two independent stocks may be represented among the older coiled cephalopods. Ulrich, Foerste, Miller, and Furnish (1942) have failed to recognize these structures as thickened connecting rings and have apparently not even suspected the possibility of homeomorphy which the anomalous condition of the siphuncles suggest.

The Cyrtochoanites, as already noted in the discussion of the morphology of the siphuncle (p. 44) constitute several morphologically convergent stocks, and developed independently at least four times in the history of the nautiloids, and probably oftener.

The last 20 years of nautiloid investigation have resulted in the recognition of many genera which have never been assigned to families or groups of higher rank. Foerste rarely if ever discussed relationship. The impression which one gets from his work is that he realized that he was dealing with uncertainties in relationship, and that progress would be best served by the illustration and description in terms of form genera. If this was his view, his results show that it was a sound one, for he succeeded in making available information on many of the earlier Paleozoic species, in a form in which it could be later assimilated into a classification, the main obstacle being at present lack of adequate information on internal structures. This, more often than not, is the fault of the material not of the investigator. Foerste arranged his genera in an artificial scheme, based in general upon the shape of the shell.

Meanwhile morphological investigations were serving to show the necessity of either revising Hyatt's scheme of classification radically, or replacing it by a completely new one. It has been impossible to assign genera to the families now proposed. As pointed out in the discussion of the morphology of the shell, grave difficulties are encountered in the use of his major categories. The endoceroids are only in part holochoanitic. The Cyrtochoanites embrace the actinoceroids, the secondarily cyrtochoanitic cephalopods, as here treated, the Pseudorthoceratidæ and the Rhadinoceratidæ, each of which attained this structure independently of the others. Probably other cases of independent attainment of cyrtochoanitic structure will be found.

Meanwhile new proposals concerning the classification and phylogeny of cephalopods were appearing. Grabau's concept of the endoceroid siphuncle as the homologue of the orthoceran shell must be rejected in the light of subsequent research on endoceroids, which show that the holochoanitic condition is derived from an orthochoanitic one.

Hyatt's classification of nautiloids was based fundamentally upon internal structures. In Europe this classification has not been widely accepted, and what little progress has been made there has involved a concept of classification based primarily upon the form of the shell. However, Teichert (1933) in his study of the actinoceroids proposed a division of the cephalopods as a whole into the Eurysiphonata and the Stenosiphonata, the Eurysiphonata including the Endoceroidea and the Actinoceroidea, the Stenosiphonata including all other cephalopods. Schindewolf (1934) rejected this scheme partly because of the union of the Dibranchiata, Ammonoidea, and most of the Nautiloidea under the Stenosiphonata, and partly because he rejected what seems to be the main thesis of Teichert's scheme, the close relationship of the endoceroids and the actinoceroids. Kobayashi (1935, 1935A. 1936, 1937) developed a concept of the development of the cephalopods in which the actinoceroids were derived from orthochoanitic orthoceracones, as is the family Stereoplasmoceratidæ. Yet curiously, the morphological features which he reported from the apical end of the siphuncle of the actinoceroids were quite different from those which Schindewolf reported; the two authors came to the same phyletic conclusions from diametrically opposed morphological facts, as was pointed out by Flower (1940, 1941, pp. 8, 26-7). Flower (1941) substantiated Teichert's proposal of the relatively close relationship of the actinoceroid and the endoceroid by tracing a connection between these two groups. However, by the time this work was undertaken the term endoceroid has come to be restricted and did not have the broad scope attributed to it generally at the time of Teichert's work. The Ellesmeroceratidæ, probably the ancestral radicle of the Eurysiphonata, are here regarded as the common ancestor of the Bathmoceratidæ and the Endoceroidea. The Actinoceroidea are traced to *Bathmoceras* through the genus *Polydesmia.*

Schindewolf (1942) published subsequently a rather general paper the main purpose of which seems to be to apply his concept (by adoption) of proterogenesis to the Cephalopoda as a whole and to show that a normal palingenetic sequence has no phyletic significance. Unfortunately his scheme of nautiloid phylogeny is hardly a classification. He maintains that *Volborthella* should be a cephalopod but is unable to unite it to any other cephalopod stock. Therefore, in his diagram of the phylogeny, this genus is placed by itself. *Plectronoceras* is regarded as the point of origin of the various major groups, the large group of forms which he unites under the term Endoceracea on one hand; on the other the Orthoceracea and the Actinoceracea. From the Orthoceracea are derived the Ascoceracea, the Cyrtoceracea and the Nautilicea, while confusion of nomenclature surrounds his treatment of the Lituitidæ, which he regards, and probably correctly, as an independent derivative of the more primitive orthoconic stock. Unfortunately his scheme involves several misconceptions of morphology. He regards the genera *Plectronoceras, Diphragmoceras,* and *Ellesmeroceras* as three stages in the development of holochoanitic structure. Actually *Ellesmeroceras* is orthochoanitic, or better, aneuchoanitic (Flower, 1941A; Ulrich, Foerste, Miller, and Unklesbay, 1944, p. 66). From *Ellesmeroceras* he derives five distinct endoceroid types, represented by *Nanno,* *Endoceras, Piloceras, Baltoceras, Cyrtendoceras,* and *Wolungoceras.* This scheme of phylogeny is simply a slightly different and less accurate statement of the views which Kobayashi published earlier, and seems to have been written in complete ignorance of the earlier (Flower, 1941, 1941A) investigations of the endoceroid complex by means of thin sections. Likewise he has failed to take notice of Swinnerton's (1938) masterly analysis of his earlier (1936) paper in which the weakness of most of the stratigraphic evidence invoked to support proterogenesis is brought out. Unfortunately, not only is Schindewolf's phylogeny built upon the basis of a preconceived theory, but his groups are so poorly delimited and involve such misconceptions of morphology that it is impossible to give them serious consideration.

It was long the hope of the writer that the completion of the study of the American Ozarkian and Canadian cephalopods, interrupted by the death of Dr. Foerste, might throw much light upon the problem of the relationships of the early cephalopods. Unfortunately the bulk of the material consisted of chert internal molds, unsuitable for sections, which leaves much doubt as to the structure of many, indeed, most of the genera. The classification employed in that work is clearly one of convenience and necessity, and one based upon gross features of the shell. The longicones are divided into the family Stentomoceratidæ for slender cyrtocones with a siphuncle on the concave side; the family Endocycloceratidæ for similar shells which are annulated externally, the Bassleroceratidæ for smooth cyrtoceracones with the siphuncle on the convex side, the Rudolphoceratidæ for similar annulated cyrtoceracones. The Orthoceratidæ is employed for smooth orthoceracones of supposed orthochoanitic structure, and *Ellesmeroceras* is included here. The family Robsonoceratidæ is correctly erected for the genus *Robsonoceras*, an orthoceracone with a tubular siphuncle of orthochoanitic structure, but characterized by diaphragms. Annulated orthoceracones are placed in the family Spyroceratidæ, the synthetic nature of which has already been demonstrated (Flower, 1943 G) while the Endoceratidæ, for supposed endoceroids, defined as holochoanitic, certainly contain at least three genera of aneuchoanitic structure. The family Suecoceratidæ is recognized for endoceroids in which the apical part of the siphuncle is inflated. The Bathmoceratidæ and Eothinoceratidæ are correctly monotypic families for anomalous structural types. The brevicones (Ulrich, Foerste, and Miller, 1943) have not fared much better. The Piloceratidæ is probably a natural or nearly natural group as there defined and delimited. Straight brevicones are placed in the Cyclostomiceratidæ, and endogastric forms in the Cyrtendoceratidæ, although both holochoanitic and ellipochoanitic cephalopods are included among the 14 genera placed in this family. The gyroconic *Cyrtendoceras priscum* Ruedemann is placed in a genus and family by itself, the Beekmanoceratidæ and the genus *Beekmanoceras.*

The immense labor involved in the description and illustration of the species in this work is not to be disregarded. The work shows clearly that further knowledge of these earlier cephalopods must depend upon the careful study by sections of favorably preserved material. It has been the good fortune of the writer to happen upon several such associations, which are now under the process of investigation. At present, we can hope to accomplish little more than to review previous views in the light of this new information. Unhappily, the structure, position, and relationship of many of the genera remain at present so uncertain that no genetic classification can be attempted.

The family Plectronoceratidæ is a convenient receptacle for the oldest of the endogastric cephalopods which have small marginal siphuncles of unstable form. Flower (1941) accepted Kobayashi's morphological conclusions as to the siphuncles of the genera as illustrated by Kobayashi (1933, 1935) but reserved opinion on the validity of some of the diaphragms and pseudodiaphragms which were so faint that it seemed possible that they might be adventitious structures. Miller (1943) suggested that the ontogenetic transition from orthochoanitic to "cyrtochoanitic" siphuncle outlines in *Plectronoceras* reported by Kobayashi (1935) might be based upon adventitious structures. Ulrich, Foerste, Miller, and Unklesbay (1944, p. 133) believe that the supposed adoral inflated siphuncular segment in this genus figured by Kobayashi is adventitious. *P. cambria* Walcott exhibits orthochoanitic necks and fails to show any connecting rings. Ulrich, Foerste, Miller, and Unklesbay (1944, p. 134) believe that their genus *Clelandoceras* may possibly be the same as *Plectronoceras*, if *Plectronoceras* does not have real adoral expanded segments. This is possible, but the distribution of *Plectronoceras* in the Upper Cambrian and *Clelandoceras* only in the Smithville, highest Canadian, suggests that there may be something wrong with this relationship. It is also, of course, possible that earlier *Clelandoceras* may have been overlooked, but in view of the large number of small cyrtoceracones found in intervening formations it is remarkable that it has not been found if it existed there.

With *Plectronoceras* the writer united *Wanwanoceras*, *Sinoeremoceras*, and *Multicameroceras*, other genera with variably constructed siphuncles (1941). It is doubtful whether any of these forms possess real transverse structures across the cavity of the siphuncle. Kobayashi's photographs of structures which he interprets as pseudodiaphragms show such vague outlines that the writer fears that they are only inorganic calcite.

Plectronoceras is itself an endogastric cyrtocone of compressed section, characterized by short septal necks. It seems logical to unite with this genus a large number of Ozarkian genera of similar form. The structure of the siphuncle wall is unknown in most cases. The wall of the siphuncle, as known from internal molds, may be smooth, or the segments may be faintly concave in outline. Thin section study is necessary to determine whether these are holochoanitic or orthochoanitic. If orthochoanitic, it must next be determined whether the ring is thin and structureless or whether it is relatively thick and perhaps equipped with an eyelet. Ulrich, Foerste, and Miller (1943, pp. 142-3) have figured thickened rings and diaphragms for a cyrtocone of this type referred with doubt to *Levisoceras*. For the most part, limestone material susceptible to study by thin sections has been lacking for this group, and until better material is found, the structure of the siphuncle can only be inferred.

The genera of supposed ellipochoanitic endogastric cephalopods which fall into this group may be roughly divided into those which agree with *Plectronoceras* in retaining a small siphuncle throughout life, and those in which the siphuncle is rapidly expanded orad. Those with a slender siphuncle are *Burenoceras*—to which the essentially straight *Buehleroceras* is probably allied—*Conocerina, Dakeoceras, Ectenoceras, Oncotoceras, Shelbyoceras,* and *Smithvilloceras.* In *Caseoceras, Clarkeoceras, Cumberloceras,* and *Levisoceras,* the siphuncle expands more rapidly, sometimes being commensurate with the vertical expansion of the conch, and sometimes independent of it and greater than the conchial expansion. *Eremoceras* is intermediate between the two groups. Ulrich, Foerste, and Miller have placed most of these genera in the family Cyrtendoceratidæ and state that if their suspicions on the morphology of *Plectronoceras* prove correct, that family should be suppressed in favor of Cyrtendoceratidæ. The writer objects to this view on the grounds that the connection between these Ozarkian genera and *Cyrtendoceras* is extremely dubious and cannot be established until a more thorough restudy of *Cyrtendoceras* is undertaken. These authors have perhaps gone to too great lengths in shaping the taxonomy to suit the limitations of the chert-replaced faunas with which they were largely concerned. We still do not know whether *Cyrtendoceras* is truly orthochoanitic or holochoanitic. Ulrich, Foerste, and Miller state that both conditions occur in the Cyrtendoceratidæ. If so, the family should probably be divided. They state that *Cyrtendoceras* is holochoanitic, *Oelandoceras* orthochoanitic. *Oelandoceras* certainly possesses endocones, and such structures are probably present in *Cyrtendoceras* (see Foerste, 1932, pl. 1, fig. 1a; pl. 2, fig. 3 B). If so, these two genera are properly endoceroids, and it may be that *Oelandoceras* was derived from one group the Canadian orthochoanitic endoceroids, while *Cyrtendoceras* was derived from the essentially Ordovician group. This is quite possible stratigraphically, for *Oelandoceras* is confined to the glauconitic layer of the Vaginatenkalk, apparently Canadian, while *Cyrtendoceras* occurs in the higher and presumably Ordovician (as restricted by the elimination of the Canadian) ranging from the gray *Lituites* limestone to the *Echinosphaerites* limestone. The writer is not so certain of the correlations with the American section as other writers seem to be but would suggest that the genus might possibly range into rocks as young as the Rockland of eastern North America.

Therefore it is proposed that until evidence is presented to the contrary, the family Cyrtendoceratidæ should be restricted to endogastrically coiled, and essentially gyroconic shells which have the holochoanitic siphuncles and the endocones which place them in the Endoceroidea. The Ozarkian endogastric genera may be consigned to the family Plectronoceratidæ with which they are more closely allied. *Oelandoceras,* on the other hand, should be grouped with the primitive (Canadian) ellipochoanitic endoceroids and will be treated with them.

The Wanwanian, that is, approximately the Gasconade equivalent, the upper Ozarkian of Ulrich, and possibly the equivalent in part of the lowermost Canadian, is dominated by such endogastric shells. There are others which merge into the orthoconic form, through such intermediate types as *Eremoceras* and *Ectenoceras.* Most of such forms have marginal siphuncles of uncertain structure, but such evidence as exists suggests that they have short septal necks. The nature of the connecting rings is not known. Orthoconic genera of this group are *Copiceras, Ellesmeroceras, Ogygoceras, Oxfordoceras, Albertoceras,* and *Walcottoceras.* The rings of *Ellesmeroceras* are thick. The rings of *Walcottoceras* are thin and structureless. Conditions in the other genera have not been established.

The Ellesmeroceratidæ were defined (Flower, 1941) as differing from the Plectronoceratidæ in two respects, the essentially straight form of the shell rather than the endogastric one and the thickened connecting ring. No sure division can be made on the basis of curvature. At present data fail to show where a division based upon the appearance of thick rings in this stock should be drawn.

Allied to the breviconic endogastric shells of the Ozarkian are the longiconic endogastric types, *Stemtonoceras, Woosteroceras, Endocycloceras,* and the essentially straight *Vassaroceras.* More remains to be learned concerning the structure of all of these genera.

Longiconic exogastric cyrtoceracones are rare in the Upper Ozarkian and Lower Canadian, but appear to be particularly characteristic of the Middle Canadian and the Upper Canadian. Compressed smooth-shelled genera vary in internal structure. *Bassleroceras* has aneuchoanitic necks and a thin structureless connecting ring. *Dwightoceras* and *Dyscritoceras* on the other hand have thickened rings and larger siphuncles. Practically nothing is known of the internal structure of *Avaoceras, Diaphonoceras, Lawrensoceras, Leptocyrtoceras, Monogonoceras,* but the siphuncles are small as in *Bassleroceras.*

The depressed cyrtoceracone *Onychoceras,* has thickened rings, as does the essentially orthoconic *Rudolfoceras* Information is inadequate for *Seelyoceras,* apparently close to these two in other features. and *Ectocycloceras.* The Canadiar annulated orthoceracones *Protocycloceras* and *Catoraphiceras* are apparently related to the ellipochoanitic stock. The connecting rings of *Protocycloceras* are somewhat thickened.

Cyclostomiceras has short necks and thick rings remarkably like those of *Proterocameroceras.* The structure of *Dresseroceras* and *Bridgeoceras* is not adequately known. *Buehleroceras,* an Ozarkian type, is regarded as not allied to *Cyclostomiceras,* but instead to *Burenoceras.* Both of these Ozarkian genera have apertures which simulate the specializations later found in the phragmoceroids, and it would be remarkable if they were not related.

Anomalous types exist, concerning the relationship of which there is much uncertainty. *Buttsoceras,* which should probably be placed in a family by itself, is an orthoceracone. The apparently orthochoanitic siphuncle possesses well-developed diaphragms. This feature is found to be duplicated in other genera of different form, *Stemtonoceras,* (?) *Levisoceras,* sp., and in *Clarkeoceras.* In spite of the differences in form, it may well be wise to unite these genera, and also others should they prove to be similarly constructed, into a single family.

Oxfordoceras is the only Ozarkian orthoceracone known to have a subcentral siphuncle.

Quebecoceras, a large endogastric shell, has a large siphuncle, by which it could be a plectronoceroid, an ellesmeroceroid, or, should it have endocones, an endoceroid.

Eothinoceras, by its anomalous thickened connecting rings, is placed in a family by itself. Miller believes that the resemblance to the Ordovician *Cyrtocerina* is adventitious. However, the internal structures are essentially identical, insofar as can be told without subjecting *Eothinoceras* to thin section examination, and the fundamental similarity of structure seems to outweigh the superficial difference in form. Nevertheless, since no connecting types have been found, *Cyrtocerina* is placed in a family by itself.

Bathmoceras was properly placed in a family by itself. No typical forms have been found in America.

It is extremely doubtful whether any true endoceroids existed as early as the Ozarkian. *Pachendoceras* is regarded as an endoceroid. However, there is no good evidence that its siphuncle wall is holochoanitic. More important, the only clear *spiess* figured for the genus is of such anomalous shape that it is probably adventitious. Certainly there is a very long interval of the siphuncle which lacks any trace of endocones.

The first undisputed endoceroids, by which I mean cephalopods with good endocones, are Canadian in age. From the *Lecanospira* zone upward true endoceroids occur. Three genera, *Cotteroceras, Cyptendoceras,* and *Clitendoceras,* intergrade enough to suggest very strongly that they are very closely related. Indeed, the writer would not always agree with Ulrich, Foerste, Miller, and Unklesbay as to the disposition of some of the species among these genera. Arbitrarily, *Cotteroceras* is used for compressed shells, *Cyptendoceras* for depressed shells with sutures forming more or less of a ventral lobe, and *Clitendoceras* for essentially circular shells. To these may be added the endogastric *Mcqueenoceras,* close to *Clitendoceras,* the genotype of which is also faintly endogastric, and *Paraendoceras,* erected for rather rapidly expanding shells. The writer has had opportunity to study in thin and also in satisfactory opaque sections typical *Clitendoceras,* and a fairly typical undescribed *Cyptendoceras.* Both are undoubtedly ellipochoanitic. To these ellipochoanitic endoceroids must be added *Proterocameroceras,* which is not strikingly distinct from the more generalized species assigned to *Cyptendoceras.* The Chazyan *Meniscoceras* Flower represents a survival of this ellipochoanitic group into the Chazyan.

Since these longiconic ellipochoanitic endoceroids represent a distinct, and I believe a very significant stage in endoceroid development, they are here set apart as the family Proterocameroceratidæ. *Proterocameroceras,* although its endosiphuncle is rather more specialized than is that of the other genera, is selected as the type of this family because it is probably the best known member of the group.

The Upper Canadian marks the next step in the development of the endoceroid stock. Here we find two distinct changes occurring simultaneously. First, the entire shell becomes rapidly expanding instead of slender; in short, we approach the piloceroid type in contrast to the endoceroid. Secondly, it is clearly in the piloceroid that we first find the septal necks lengthen so as to extend at least for the length of one segment of the siphuncle. The connecting rings are stretched for another segment. Such structure was suspected by the writer from an opaque section of *Cassinoceras explanator* in the New York State Museum. Ulrich, Foerste, and Miller (1943, p. 18) report identical structure, again in opaque section, for the genotype of *Piloceras* but failed to grasp the significance of this dark-colored "lining" of the siphuncle.

Already in the Canadian some piloceroids show signs of developing first a rapidly expanding portion of the shell, in which the siphuncle expands rapidly, but later also there develops a tendency for the adoral end of the siphuncle (we know nothing of the form of the conch here) to become more tubular. This is seen in some *Allopiloceras.* Reduce this in size, attach to the adoral end the natural logical continuation of the slender siphuncle within a slender conch, and the creature which is reconstructed is no longer a piloceroid, but an endoceroid proper such as is seen from the Chazyan to the Richmond. Apical ends of this type are variously termed *Nanno* and *Suecoceras,* but the adoral parts of the shell are placed in *Endoceras, Vaginoceras,* and *Cameroceras,* depending upon the paleontologist who is doing the describing. *Nanno noveboracum* Ruedemann is almost certainly the apex of *Vaginoceras oppletum* in the Chazyan. *Nanno* is supposed to show a nonseptate phase in development and Schindewolf has made various unwarranted statements about the significance of *Nanno* as a preseptal phase of the cephalopod, which harkens back beyond the cephalopod stage to a primitive molluscan condition. However, it must be remembered that the first of these swollen siphuncles is the Canadian *Mysticoceras.* They are more common and better developed in the Chazyan, Black River, Trenton, and Richmond. Further, the annulations on the exterior of such siphuncles have little significance, as I have found much to my surprise. Most endoceroids show some trace of annular marking on the siphuncle when its surface is exposed. However, typical *Vaginoceras* shows only the faintest trace of the junction of the septa with a perfectly tubular siphuncle. Yet in section the two types, the annulated and the smooth, possess essentially identical structure, and the annulated or smooth appearance is due to minute differences in the shape and thickness not so much of the septal neck, as of the connecting ring. Indeed, many specimens of *Nanno* fail to show annulations clearly on the adoral thin part of the siphuncle. However, in this respect there is much variation in the type species. More fundamental is the problem as to whether the first septum appears orad of the point at which the siphuncle begins to contract, or well apicad of this point. Such variation between the two extremes is found in a number of species including *Nanno noveboracum,* and it is to be feared that *Nanno* and *Suecoceras* are actually gradational.

The next problem which presents itself is the relation between these inflated apical ends and the smaller apices which are best typified by specimens commonly placed in *Cameroceras.* Apices, or rather specimens suspected of representing apices, of this general aspect occur in such ancient genera as the Gasconade *Pachendoceras,* which was not even an endoceroid. Is *Cameroceras* a relic of this stock? The answer can be found when better material of *Cameroceras* is sectioned, for if so, the siphuncle will certainly not be holochoanitic. It is suspected, however, that the significance of *Cameroceras* is quite different. Such ends are found in the Trenton and have never been found attached to very extensive phragmocones. It is very strongly suspected that *Cameroceras* is nothing more than the apical end of *Endoceras proteiforme*, and that *Endoceras* and *Cameroceras* have been based upon one and the same species, but the one upon early stages, and the other upon the mature shell. Sardesson (1930) proposed a similar idea, but strangely enough insisted upon identifying *Cameroceras* with the annulated *Endoceras annuliferum*, now the genotype of *Cyclendoceras* Grabau and Shimer (1915). This is extremely unlikely, as *Cameroceras* does not show any indication of true annuli on the surface of the phragmocone.

In summary, it is possible to recognize three stages in endoceroid development. The first, typified by the Proterocameroceratidæ, combines the ectosiphuncle of an *Ellesmeroceras* with endocones. These may sometimes become highly specialized. The second stage combines rapid expansion of the shell with the lengthening of the neck and is represented by those shells generally lumped as piloceroids. This does not mean, however, that the piloceroids are a sharply defined unit. Kobayashi has shown that some forms represent stages intermediate between the aneuchoanitic condition of the Proterocameroceratidæ and true holochoanitic structure. Also, these same forms may have siphuncles intermediate in the rate of expansion between the endoceroid and the piloceroid type. Yet certainly within the piloceroids, even incipient piloceroids on the basis of both of the criteria noted above, extraordinary specializations of the endosiphuncle could occur, as noted in *Manchuroceras*. However, much remains to be learned yet concerning the endosiphuncles of American piloceroids before we should accept the idea that these oriental types attained specializations far beyond anything reached in American forms.

The third step is the development of the Endoceratidæ, as the writer would restrict the term. These are the holochoanitic longiconic cephalopods. The apical part of the siphuncle is usually but not quite always, as can be seen from *Cameroceras*, inflated, and this inflation, together with the holochoanitic structure, serves to unite this group with the Piloceratidæ and to distinguish it from the Proterocameroceratidæ.

In America the last of the Ordovician endoceroids do not appear to have developed any startlingly new features. The Richmond contains internal molds of siphuncles strikingly reminiscent of Holm's figures of *Nanno belemnitiforme* from a much earlier horizon (gray *Lituites* limestone, probably Chazyan or Black River in age).

The development of curvature in the endoceroid line seems, from the present evidence, to have occurred several times. *Oelandoceras* might, from its reported ellipochoanitic structure, be a curved member of the Proterocameroceratidæ. Slight curvature in shells probably referable to the Endoceratidæ has been noted by Ruedemann (1906) and by Kobayashi (1934). Apparently the Baltic Ordovician *Cyclendoceras* represents an extreme of the development of coiling in the Endoceratidæ if the previously published illustrations are correct in suggesting holochoanitic necks and endocones.

Other developments sprang from the *Ellesmeroceras* stock, which is certainly the logical ancestor of the endoceroid, even though our knowledge of most Wanwanian cephalopods is insufficient to determine which genera should be placed in it by virtue of thick connecting rings that simulate a holochoanitic siphuncle and which ones have thin and structureless rings and should therefore be excluded. To this stock are traceable aneuchoanitic orthoceracones with thick rings, which differ from *Ellesmeroceras* and its allies in several relatively minor features. The siphuncle tends to become smaller and to migrate from a marginal position to a position closer to the center of the shell. These conchs lack endocones, and the presence of any organic deposit in the siphuncle is dubious. For want of a better name, the family Baltoceratidæ is employed for these cephalopods. The writer has had an opportunity to examine genotype material of *Baltoceras* which shows that the siphuncle is orthochoanitic, the necks are thickened, and no endocones are present within the siphuncle. Schindewolf (1942) has postulated such endocones which he finds asymmetrical. Study of a good suite of specimens shows that the calcite in the siphuncle identical with that figured by Schindewolf is not organic, but the complement to the filling of an internal mold. Sediment has entered the siphuncle from the adoral end and thins toward the apex. The side upon which the calcite extends farthest orad is the upper side of the shell as it lay in the sediments. I have seen specimens in which it is dorsal, ventral, lateral, and oblique. With this genus should be placed other orthoceracones with small siphuncles and thick rings. The only other one definitely known to the writer is *Protocycloceras*. Others will probably be found when Canadian siphuncles have been subjected to proper thin section examination. Possibly such cyrtoconic types in *Onychoceras* stem from the Baltoceratidæ. It is not impossible, and the hypothesis must be considered, that these forms and the Tarphyceratidæ may have developed thick rings independent of the Ellesmeroceratidæ. However, the preferance of external over the more static internal characters in classification should be based upon overwhelming similarities in other features before it should be accepted, in view of the known environmental influence upon evolutionary trends in regard to such features.

The writer previously proposed that Canadian coiled cephalopods might belong to the eurysiphonate line and might have arisen from the Ellesmeroceratidæ by the reduction in size of the siphuncle and the development of coiling. Ulrich, Foerste, Miller, and Furnish failed to even suspect this possibility from their study of Canadian coiled cephalopods.

The last of the several lines of descent traceable to the ancestral *Ellesmeroceras* is that comprising the Bathmoceratidæ and the Actinoceroidea. *Bathmoceras* combines a lengthening of the septal necks, which are already developing the faintest trace of cyrtochoanitic form, with inflation of the connecting ring and the projection of the process formed on the inner surface of the ring orad into the siphuncle. In the younger *Polydesmia*, the structures originally interpreted as annulosiphonate rings have much the same shape, but are less strongly projected orad, and less inflated at their forward projecting tips. Here for the first time there is a trace of the siphonal vascular system of the Actinoceroidea, not as a series of a few simple tubes in each segment of the siphuncle, but tubes which branch rapidly and irregularly as they approach the connecting ring. Reduction of the lobed extension of the connecting ring to a normal annulosiphonate structure is perfected in *Nybyoceras* and *Cyrtonybyoceras,* while further reduction of the siphonal vascular system attends the development of the Actinoceratidæ and Sactoceratidæ.

The line passing from *Plectronoceras* to *Ellesmeroceras* and then branching into the Endoceroidea on one hand, again into the Bathmoceratidæ and Actinoceroidea, and yet again into the Baltoceratidæ, and possibly again to produce the Tarphyceratidæ is here considered the Eurysiphonata. While the line is admittedly probably not very distinct from the Stenosiphonata at its point of origin, perhaps this is too much to expect if, as is believed, both stocks are traceable to *Plectronoceras.*

Lack of data on the structure of the siphuncle of most of the genera of Canadian and Ozarkian orthoceracones and cyrtoceracones makes it impossible to determine the status of the connecting ring in many of these genera. Indeed, the structure is so little known that many uncertainties of relationship still exist. It seems fairly evident, however, that if among these forms there lurk the ancestors of the stenosiphonate line, which, as characterized by a thin and homogeneous ring, is strikingly distinct from the Eurysiphonata by Chayzan time, we cannot yet recognize them with certainty. Nevertheless, there are some facts which are evident, in particular the secondary nature of the type of shell which has for so long been considered the generalized and perhaps also the archaic type—the orthoceracone with the central siphuncle. In the Ozarkian and Canadian most of the orthoceracones possess marginal siphuncles and are closely allied to curved genera. The endogastric genera which characterize the Ozarkian have practically disappeared by Canadian time; they persist only in strata regarded as Lower Canadian, and which are probably equivalent to the Upper Ozarkian or nearly so, as is the case of the Tribes Hill limestone of New York.

Few if any of the archaic types of cephalopods which characterize the Ozarkian and Canadian continue into Champlainian or younger rocks. The orthoconic genus *Murrayoceras* of the

Black River and higher beds, has a ventral aneuchoanitic siphuncle which suggests some of these forms. It is perhaps allied to the depressed, but unfortunately little known *Oxfordoceras,* and to a lesser degree to *Ogyoceras* and *Copiceras. Cyrtocerina* combines the internal structure of *Eothinoceras* with a shell form which is essentially that of *Levisoceras.* It is probably a descendant, though a highly modified one of the Eothinoceratidæ. Possibly when more is known of the older cephalopods from limestone material suitable for sections other relatives of *Eothinoceras* may be found. At present its origin and relationship are a puzzle. *Shideleroceras* of the Cincinnatian is unlike any other Ordovician cephalopod in combining a cyrtoconic form, the absence of a hyponomic sinus, and a subcentral aneuchoanitic siphuncle. The aneuchoanitic siphuncle suggests a relationship with these ancient cephalopods, but no genus has been described which appears to be very closely similar to it.

Flower (1941) proposed a morphological classification of ellipochoanitic cephalopods into five morphological groups. With the elimination of the Actinoceroidea, even then not regarded as related to the others, this serves as a tentative basis for an arrangement of the early Paleozoic Stenosiphonata.

The series of groups may be summarized as follows:

1. Cephalopods with tubular siphuncles.
2. Suborthochoanitic cephalopods.
3. Secondarily cyrtochoanitic cephalopods with suborthochoanitic early stages.
4. Cephalopods in which the above ontogenetic succession from suborthochoanitic is reversed, at least gerontically; the Stereoplasmoceratidae.
5. Apparently primitively cyrtochoanitic cephalopods, the Discosoroidea.

Further, in the same work, a series was postulated in the suborthochoanitic cephalopods leading from the generalized *Sactorthoceras,* through *Centroonoceras* to the Mixochoanites on one hand and suborthochoanitic cyrtoceracones with ventral siphuncles on the other. This system was retained as a working hypothesis pending new information. Now it seems that on the basis of stratigraphic evidence the series may possibly have developed in the other direction; that the ventral siphuncles are a primitive feature, and that orthoceracones with central siphuncles are secondary.

The stages in development of this stock are treated more fully in the discussion of the suborthochoanitic cephalopods in the systematic part of the present paper. In general, they may be summarized briefly as follows: The primitive radicle consists in compressed cyrtoceracones with ventral suborthochoanitic siphuncles. Such forms are represented in the Chazyan by *Graciloceras* and *Eorizoceras*. While detailed information on Canadian types of similar aspect is lacking, it seems that smooth compressed shells typified by *Bassleroceras* may be older members of the same general stock. The migration of the siphuncle toward the center will produce *Centroonoceras*, which is the logical source of three distinct radicles, the suborthochoanitic orthoceracones with central siphuncles, and two stocks having in common early planoconvex siphuncles, the Clinoceratidæ and the Mixochoanites. On the other hand, the appearance of cyrtochoanitic structure in such shells as the Bassleroceratidæ may have given rise to the secondarily cyrtochoanitic cephalopods as here defined. The Oncoceratidæ include compressed shells with empty siphuncles which agree with the Bassleroceratidæ in their compressed section. The Allumettoceratidæ are distinct in their depressed section. It is uncertain whether the cyrtochoanitic siphuncle indicates that they became distinct after the development of cyrtochoanitic structure, or whether their origin is yet to be sought among exogastric depressed genera of the Canadian. *Onychoceras*, the only such Canadian genus to be studied thoroughly up to the present, seems an unlikely ancestor of the stock because of its thickened connecting rings. Therefore the other hypothesis is tentatively adopted in our figure.

From the Oncoceratidæ developed a stock differing from it at first only in the development of actinosiphonate structure, the family Valcouroceratidæ. Closely allied internally and probably very closely related, is the family Diestoceratidæ, differing from it in departing from the exogastric pattern, for the shells of this family are sometimes straight brevicones, but more often faintly endogastric. These groups with the Discosoroidea, embrace all except a few inadequately known genera of the cyrtocones and brevicones of the Ordovician. Descendents of the Valcouroceratidæ and Diestoceratidæ of Silurian time are not definitely recognized. The Oncoceratidæ underwent a second period of expansion and produced probably the Lechritrochoceratidæ and certainly the Brevicoceratidæ.

The orthoconic family Stereoplasmoceratidæ, not present in the Cincinnatian, is still inadequately known. The siphuncles are modified from cyrtochoanitic to suborthochoanitic in the later stages of ontogeny. Recently discovered sections of Chazyan types suggest that these shells had early suborthochoanitic stages, and if so, were probably derived from the Sactorthoceratidæ.

The Discosoroidea are characterized by broadly expanded siphuncles throughout life. They differ from the actinoceroids in the small apical ends, the absence of a siphonal vascular system and perispatium, and in having a very different pattern of siphonal deposits. Further, while the actinoceroids are dominantly straight orthoceracones, the Discosoroidea are essentially cyrtoconic and often rather rapidly expanded. The origin of the group is uncertain, but no facts as yet discovered serve to suggest a eurysiphonate affinity for the group.

The Stenosiphonata, characterized by tubular siphuncles, evidently had a long pre-Chazyan history, for in the Chazyan they are represented by two strikingly different groups, the orthoceracones, and the coiled genera, including *Plectoceras*, *Trocholites*, *Barrandeoceras*, and at least one previously unnamed genus. The thin and homogenous rings of these Chazyan species contrast with complex and thick rings of the Canadian coiled cephalopods. The writer is still uncertain whether such early Paleozoic coiled cephalopods constitute a natural group, perhaps best divided into a series of families as was done by Hyatt, and also by Ulrich, Foerste, Miller, and Furnish, or whether as the internal differences suggest, two homeomorphic lines, one perhaps originating from the Eurysiphonata, are involved in this series of genera. It would seem unlikely that the interval between the close of the

Canadian and the beginning of the Chazyan could be marked by the complete extinction of one large and flourishing group of coiled cephalopods, and that by Chazyan time another group had developed from another origin and replaced them ecologically. However, even this is not impossible. Further, even such a hypothesis may be unnecessary. It may be that some of the Canadian coiled genera, all of which have not been studied closely, may not have the thick complex rings which characterize those forms thus far studied.

The orthoceracones with tubular siphuncles are equally hard to trace. Ordovician genera commonly have central siphuncles; most of the very few of their forbears in the Canadian are characterized by marginal siphuncles. Is there a connection here, or did the Chazyan types develop from the Sactorthoceratidæ? It seems unlikely, since the orthochoanitic and suborthochoanitic cephalopods of the Chazyan and Mohawkian are far more sharply set off from each other than are those of the Upper Ordovician or the Silurian or Devonian.

Three families of coiled cephalopods penetrated the Cincinnatian. The Trocholitidæ can be traced back to the Chazyan. Genera have been assigned to the family from the Canadian, but here is involved the problem of the evaluation of external versus internal differences in the tracing of phylogeny.

The Bickmoritidæ probably arose from Middle Ordovician coiled cephalopods, probably *Centrocyrtoceras*. Possibly *Barrandeoceras* is the ancestor of this genus in the Chazyan, but no likely ancestors of *Barrandeoceras* have come to the attention of the writer in earlier strata.

The Apsidoceratidæ, a family of cyrtochoanitic coiled cephalopods, is especially prevalent in the Upper Ordovician, although only *Charactoceras* and *Charactocerina* penetrated the Cincinnati region. This family is regarded as a late development of secondarily cyrtochoanitic structure, largely because it has not been possible to trace it to any cyrtochoanitic ancestors. However, the family is admittedly not closely connected to any orthochoanitic coiled stock. The orthochoanitic origin is suggested largely because throughout the Chazyan and Mohawkian there are practically no cyrtochoanitic curved cephalopods with subcentral siphuncles, such as prevail throughout the Apsidoceratidæ, nor is there any indication in the ontogeny of the Apsidoceratidæ of their origin from cephalopods with ventral siphuncles. On the other hand, the siphuncle segments are slender in the early stages of *Charactoceras* suggesting an origin in suborthochoanitic cephalopods.

PREVIOUS INVESTIGATIONS OF CINCINNATIAN CEPHALOPODS

The earlier citations dealing with the Cincinnatian cephalopods in the geological literature are concerned mainly with the description of species. These were largely named in terms of the broad form genera *Orthoceras, Cyrtoceras, Gomphoceras, Trochoceras,* and *Gyroceras.* Subsequently refinements of classification dating from Hyatt's investigations (1884, 1894, 1900) were only applied to the Cincinnatian forms much later by Foerste (1924, etc.) who found many modifications necessary in both the genera and the classification. Likewise, little was known at first concerning the range of the species. This was due in part to the gradual development of the stratigraphic refinements of the Cincinnatian sections. It was also due in part, and rather strangely, to the large rôle which the early amateur fossil collectors played in the study and description of these forms. Among these earlier collectors intense rivalry existed. The discovery of a locality which yielded new or rare species was a jealously guarded secret. It is not possible to say what relative rôles a failure to appreciate the faunal changes in the column and the necessity for accurate locality and horizon data on one hand, and a desire to keep secret various localities on the other, played in the absence of published data giving precise locality information from which the horizons may be determined. Doubtless both contributed. A third factor complicated the study of the cephalopods. The original descriptions were quite general and did not serve as good guides for identification of species. Consequently those who collected carefully from the Cincinnati area found it difficult to determine what their species were. This was a particularly perplexing problem in relation to the smooth-shelled species of orthoceracones which are far the commonest of the Cincinnatian cephalopods. Such information as has been published on the range of these forms is presented in the following pages. Some of it has a definite value because it consists of statements made by the describers of these species. Others, who were for the most part active members of the Cincinnati Society of Natural History, had seen determined specimens, sometimes the types, and their determinations also have a certain value. Nevertheless, the application of modern methods of study have necessitated sometimes drastic revisions in the concept of the species which are discussed in the systematic portion of this paper.

The first cephalopod described from the Cincinnati area cannot be recognized today. This was *Melia cincinatæ* d'Orbigny (1849 [1850]). D'Orbigny's description is brief and could apply to members of any one of three genera and perhaps a dozen of the species now recognized.

Meek and Worthen (1865) described *Orthoceras ortoni* and *Trochoceras baeri* in the Proceedings of the Philadelphia Academy of Natural Sciences. Meek (1872) later described and illustrated these forms in Part two of the first volume of the Geological Survey of Ohio.

In 1874 S. A. Miller described and illustrated in the Cincinnati Quarterly Journal, *Cyrtoceras vallandighami* and in 1875 described *Orthoceras mohri, O. dyeri, O. meeki, O. byrnesi, O. fosteri, O. cincinnatiensis, O. harperi, O. halli, O. transversa, Cyrtoceras ventricosa, C. obscura,* and identified other specimens in terms of *Endoceras proteiforme* Hall, and doubtfully, *Endoceras approximatum* Hall (both of which are typically developed in the Trenton limestone of New York) and the previously described Cincinnati species *Orthoceras ortoni* and *Trochoceras baeri*. Later in the same journal the name *Cyrtoceras magister* was proposed to replace *Cyrtoceras obscura,* since Barrande had used the same specific name for another species of *Cyrtoceras,* and the spelling of other names was corrected. *Cyrtoceras ventricosa* being changed to *C. ventricosum* and *Orthoceras transversa* to *O. transversum.*

Hall and Whitfield in the same year published in the second volume of the paleontology of the Ohio Survey, *Orthoceras turbidum, O. carleyi, O. duseri,* and *Gomphoceras eos.*

Miller (1877) in his first edition of his American Paleozoic Fossils proposd the name *Orthoceras hallianum* to replace *Orthoceras halli,* as that name had been used by Barrande for a Bohemian species.

Miller and Dyer (1878) in a privately published paper described and illustrated *Trocholites circularis* and *T. minusculus.* Miller in the same year described *Cyrtoceras amoenum* in volume 1 of the Journal of the Cincinnati Society of Natural History. U. P. James in the first number of the Paleontologist identified Cincinnati specimens as *Orthoceras olorus* Hall, *Ormoceras tenuifilum* (Hall), *Gomphoceras eos* Hall and Whitfield, *Trochoceras baeri* Meek and Worthen, and *Endoceras proteiforme* Hall.

Miller (1879) in the tenth report of the Geological Survey of Indiana presented a catalogue of the fossils of the "Hudson River, Utica, and Trenton groups" of Indiana, Ohio, and Kentucky, the first of several such lists. The species are listed here with general indications as to their horizon, recognizing the Trenton, Utica, and differentiating the lower middle and upper parts of the Hudson River group. His list together with the horizon data is reproduced here:

Cyrtoceras amoenum Miller. Upper part of Hudson River Group.
C. magister Miller. Lower part Hudson River Group.
C. vallandighami Miller. Middle part Hudson River Group.
C. ventricosum Miller. Lower part Hudson River Group.
Endoceras proteiforme Hall. Trenton and Hudson River Group.
Gomphoceras eos Hall and Whitfield. Upper part of Hudson River Group.
Orthoceras byrnesi Miller. Hudson River Group.
O. carleyi Hall and Whitfield. Hudson River Group.
O. cincinnatiense Miller. Hudson River Group.
O. duseri Hall and Whitfield. Upper part of Hudson River Group. (Probably a synonym of *O. fosteri*)
O. dyeri Miller. Hudson River Group.
O. fosteri Miller. Upper part Hudson River Group.
O. hallanum Miller. Upper part Hudson River Group.
O. harperi Miller. Hudson River Group.
O. meeki Miller. Hudson River Group.
O. mohri Miller. Upper part Hudson River Group.
O. ortoni Meek. Hudson River Group.
O. transversum Miller. Lower part Hudson River Group.
O. turbidum Hall and Whitfield. Hudson River Group.

Trochoceras baeri Meek and Worthen. Upper part Hudson River Group.
Trocholites ammonius Conrad. Trenton Group.
T. circularis Miller and Dyer. Upper part Hudson River Group.
T. minusculus Miller and Dyer. Utica Slate Group.

Ulrich (1880) published a catalogue of the fossils occurring in the Cincinnati group of Ohio, Indiana, and Kentucky. Here he indicated the horizon in terms of elevation at Cincinnati, following each species by a number indicative of its range in terms of hundreds of feet above the low water level of the Ohio River at Cincinnati. The essentials of his list are reproduced here.

Genus ORTHOCERAS	
O. annellum Conrad	near 4
O. amplicameratum Hall	near 1
O. carleyi Hall and Whitfield	near 3
O. cincinnatiensis Miller	
O. fosteri Miller	6-7
(Syn. O. duseri Hall and Whitfield)	
O. byrnesi Miller	?
O. dyeri Miller	?
O. halli Miller	6-7
O. harperi Miller	3-?
O. mohri Miller	6-8
O. junceum Hall	0-2
O. ortoni Meek	2-?
O. transversum Miller	0-3
O. turbidum Hall and Whitfield	3-5
Genus ORMOCERAS	
O. tenuifilum Hall	below 0
Genus ENDOCERAS	
E. annulatum Hall	?
E. approximatum Hall	?
E.	0-2
E. proteiforme Hall	07?
E. subcentrale Hall	?
Genus GOMPHOCERAS	
G. eos Hall and Whitfield	near 7
G. acceptum Ulrich	3-4
Genus PHRAGMOCERAS	
P. hector (?)	?
Genus TROCHOLITES	
T. ammonius Conrad	1-?
T. circularis Miller and Dyer	near 5
T. minusculus Miller and Dyer	below 2
Genus TROCHOCERAS	
T. baeri Meek and Worthen	6-7
Genus CYRTOCERAS	
C. amoenum Miller	near 7
C. magister Miller	near 2
C. ventricosum Miller	near 2
C. vallandighami Miller	near 4

This list is noteworthy, not only for the indication of range, but for the identification of several species originally described from the Trenton of New York and not previously recognized in the Cincinnati region. *Phragmoceras hector* is probably based upon a Silurian rather than an Ordovician specimen. *Gomphoceras acceptum* Ulrich was apparently never described.[4] I have not found the name elsewhere.

Miller (1880) p. 236, described and figured *Orthoceras dyeri* in volume 3 of the Journal of the Cincinnati Society of Natural History.

Miller (1881) in volume 4 of the same publication presented brief notes and figures of *Orthoceras cincinnatiense, O. harperi, O. fosteri,* and *O. byrnesi.*

Wetherby (1881) in the same volume described *Cyrtoceras irregulare, C. conoidale,* and *Colpoceras arcuatum.*

Miller (1884) described *Gomphoceras cincinnatiense* and *G. faberi* in volume 7 of the Journal of the Cincinnati Society of Natural History.

Joseph F. James (1886) in his Cephalopoda of the Cincinnati group presented keys and brief descriptions of the Cincinnatian cephalopods. His work shows a marked tendency toward generalization, and a number of species are reduced to synonymy. The species which he recognized are as follows:

Orthoceras amplicameratum Hall. Cincinnati and Lebanon, Ohio.
Orthoceras dyeri Miller (=O. meeki Miller, O. byrnesi Miller. O. fosteri Miller, O. cincinnatiense Miller, O. halli, Miller, O. harperi Miller). Widespread.
O. mohri Miller. Versailles, Indiana.
O. junceum Hall. Cincinnati, Lebanon, Ohio.
O. transversum Miller. Columbia Ave. and Eden Park, Cincinnati, 150 to 200 feet above low water.
O. ortoni Meek. Cincinnati.
O. anellum (annellus) Conrad. Versailles, Indiana.
O. annulatum Sowerby. Versailles, Indiana; Westboro, Ohio.
O. turbidum Hall and Whitfield. Cincinnati.
O. hindei James. Cincinnati.
O. duseri Hall and Whitfield. Waynesville, Ohio.
O. carleyi Hall and Whitfield. Fayettville, Brown County, Ohio; Covington, Kentucky; Lebanon, Ohio.
O. tenuifilum Hall. Cincinnati.
Colpoceras arcuatum James, n. sp. Cincinnati.

[4] Confirmed by R. S. Bassler, in correspondence.

Endoceras proteiforme Hall. Cincinnati.
E. annulatum Hall. No locality.
E. magniventrum Hall. Cincinnati.
E. approximatum Hall. No locality.
E. sub-centrale Hall. No locality.
Gomphoceras eos Hall and Whitfield. Dayton and Waynesville, Ohio and Weisburg, Indiana.
G. faberi Miller (=G. cincinnatiense Miller). Cincinnati; from middle to top of rocks.
Cyrtoceras vallandighami Miller (=C. conoidale Wetherby). Cincinnati, Ohio; Columbia, Tenn.; Garrad Co., Ky.; Westborough, Ohio.
C. faberi James, n. sp. Waynesville, Ohio, upper part of group.
C. ventricosum Miller. Columbia Ave., Cincinnati. 150 ft. above low water.
C. irregulare Wetherby. Freeport and Waynesville, Warren Co., Ohio, and Versailles, Indiana; upper part of group.
C. magister S. A. Miller (=C. obscurum Miller). 1st ward, Cincinnati, 130 ft. above low water.
C. amoenum Miller. Richmond, Indiana; Cincinnati.
Lituites planorbiformis Conrad. No Cincinnati locality.
L. circularis Miller and Dyer (=Trocholites minusculus Miller and Dyer). Morrow, Ohio, and Cincinnati.
L. baeri Meek and Worthen. Richmond, Indiana; upper part of group.
L. ammonius Conrad. Cincinnati.

Faber (1886) in volume 9 of the Cincinnati Society Journal described *Cyrtoceras tenuisceptum* from specimens from Waynesville, Ohio, and Versailles, Indiana.

Miller (1894) described *Tryblidium madisonense, Orthoceras gorbyi,* and *Cyrtoceras thompsoni* from the Cincinnatian rocks of Indiana in the 18th report of the Indiana Department of Geology and Natural Resources.

Miller and Faber (1894 adv. sheets, 1892) described *Gomphoceras indianense* from the upper part of the Cincinnatian in Indiana, and *Orthoceras ludlowense* and *O. albersi* from the Trenton of Kentucky, and changed *Tryblidium madisonense* to *Cyrtocerina madisonensis.*

Hyatt (1894) presented notes on *Trocholites circularis* and *T. minusculus* and described the new species, *T. dyeri.*

Harper and Bassler (1896) in their privately printed catalogue of the fossils of the Trenton and Cincinnati periods occuring in the vicinity of Cincinnati, Ohio, list the following cephalopods. Again the figures indicate height above low water mark of the Ohio River, as in Ulrich's lists.

Cyrtoceras amoenum Miller	near 6
C. conoidale Wetherby	5-6

C. faberi James	5-6
C. lysander Billings (=C. tenuiseptum Faber)	6-
C. magister Miller	near 2
C. ortoni (MMek)	2-3
C. vallandighami Miller	3-4
C. ventricosum Miller	2
Cyrtocerina madisonensis Miller	5-6
Endoceras magniventrum (?) Hall	0-2
E. proteiforme Hall	0-7
Gomphoceras cincinnatiense Miller	3-4
G. eos Hall and Whitfield	near 6
G. faberi Miller	5-6
G. indianense Miller	5-6
Gyroceras baeri Meek and Worthen	6-7?
Orthoceras albersi Miller	0-½
O. byrnesi Miller	3-4
O. carleyi Hall and Whitfield	near 3
O. cincinnatiense Miller	3-4
O. dyeri Miller	3-5
O. fosteri Miller	5-6
O. hallanum Miller	3-5
O. harperi Miller	3-5
O. junceum Hall	0-2
O. ludlowense Miller	0-½
O. meeki Miller	3-4
O. mohri Miller	4-5
O. transversum Miller	0-3
O. turbidum Hall and Whitfield	3-5
Trocholites ammonius (?) Conrad	0-½
T. circularis Miller and Dyer	3-4
T. minusculus Miller and Dyer	1-2

Nickles (1900) attempted to place the species of Cincinnati fossils in named units of the Cincinnatian for the first time. The cephalopods have been placed as follows:

TRENTON

Cameroceras proteiforme, Orthoceras albersi, O. junceum, Trocholites ammonius

UTICA (Entire)

Orthoceras transversum.

LOWER UTICA

O. junceum

MIDDLE UTICA

Cyrtoceras magister, C. ortoni, C. ventricosum, Trocholites minusculus

UPPER UTICA

No indigenous cephalopods reported

MT. HOPE

No indigenous forms reported

FAIRMOUNT

Cyrtoceras conoidale, C. vallandighami, Orthoceras byrnesi, O. cincinnatiense, O. meeki, O. turbidum

BELLEVUE

No cephalopods reported.

CORRYVILLE

Gomphoceras cincinnatiense, G. faberi, Orthoceras dyeri, Orthoceras harperi

MT. AUBURN

No indigenous forms reported

WARREN (ARNHEIM)

Orthoceras mohri

LOWER RICHMOND

Cyrtoceras faberi, C. irregulare, Gomphoceras indianense, Orthoceras carleyi, O. fosteri, O. hallianum, Trocholites circularis

MIDDLE RICHMOND

Cyrtoceras amoenum, Cyrtoceras lysander, Gomphoceras eos, Gyroceras baeri

UPPER RICHMOND

Cyrtocerina madisonensis

Cumings (1908) included the following cephalopods in his lists and presented descriptions and illustrations of a number of the forms.

Cyrtoceras amoenum Miller	Richmond
C. hallianum d'Orbigny	Saluda
C. tenuiseptum Faber	Richmond
C. thompsoni Miller	upper Richmond
Endoceras proteiforme Hall	whole Cincinnatian
Gomphoceras indianense Miller and Faber	Richmond
Gyroceras baeri (Meek and Worthen)	middle Richmond
Orthoceras bilineatum Hall	doubtful
O. byrnesi Miller	upper Maysville
O. carleyi Hall and Whitfield	Richmond
O. duseri Hall and Whitfield	lower Richmond
O. gorbyi Miller	?
O. junceum Hall	doubtful
O. mohri Miller	Waynesville (2)

Foerste (1910) identified *Suecoceras inæquabile* (Miller), a Maquoketa species, from the Waynesville of Ohio, and described *Orthoceras* (*Dawsonoceras*) *hammelli* from the Hitz bed at Madison, Indiana, *Orthoceras bilineatum frankfortense* and *Orthoceras* (*Loxoceras*) *milleri* from the Cynthiana limestone of Kentucky, *Orthoceras* (*Ormoceras?*) *hitzi* and *Cyrtoceras hitzi* from the Hitz layer at Madison, Indiana.

Bassler (1915) included the Cincinnatian species in his bibliographic index of Ordovician and Silurian fossils giving information as to the horizon which in general agrees with that of Nickles (1900).

Foerste (1917) in volume 20 of the Journal of the Cincinnati Society of Natural History described *Tripteroceras* (*Lambeoceras*) *richmondensis* from the Whitewater formation of Richmond, Indiana, and referred *Cyrtoceras hitzi* to *Zitteloceras.*

Foerste (1924, Denison Univ. Bull., vol. 20) in the first of his cephalopod papers, included the following Cincinnatian species:

Diestoceras indianense Miller and Faber. Whitewater beds.
Diestoceras eos (Hall and Whitfield). Whitewater beds.
Diestoceras shideleri Foerste, n. sp. Whitewater beds.
Charactoceras baeri (Meek and Worthen). Whitewater beds.

He also placed *Gomphoceras cincinnatiense* in *Oncoceras* and indicated that *G. faberi* may belong there, although in some respects it is suggestive of *Beloitoceras.*

Foerste (1926, p. 323) erected the genus *Wetherbyoceras* based upon *Cyrtoceras conoidale* Wetherby of the Leipers formation of Kentucky.

Foerste (1928, pp. 40, 41, pl. 6, fig. 2; pl. 23, fig. 9) based the new genus *Troedssonoceras* upon *Orthoceras turbidum* Hall and Whitfield and figured and described under this species a specimen from the Leipers of southern Kentucky.

Foerste (1929) figured a Richmond endoceroid as *Cameroceras,* sp., regarding the apex as representing the filling of an endocone, and described *Cameroceras (?) faberi* from the Hitz layer of Madison, Indiana, and *Trocholites faberi* from the Cynthiana limestone of Kentucky.

Foerste and Teichert (1930) described *Ormoceras covingtonense* from the Maysville of Kentucky, *Deiroceras nashvillense* from the Cathys of Tennessee, and *Armenoceras madisonense* from the Richmond, probably the Saluda, of Madison, Indiana.

Foerste (1933, p. 135) described the new genus, *Fayettoceras,* based upon *Cyrtoceras thompsoni* Miller of the Richmond of Indiana.

Two previous attempts at a revision of the Cincinnatian cephalopods have been made which did not result in any published works. Foerste (*fide, litt.,* 1926) writes of the first as follows: "Shortly before his death, S. A. Miller was engaged in a revision of the cephalopods of the Cincinnatian. A great number of the drawings had already been made when a dispute about payment for the same arose. The artist confiscated the types figured, and nothing has been heard of them since."

Foerste began a revision of these cephalopods, largely upon the basis of material from Dr. Shideler's collection. He put the work aside, however, in order to work with Dr. Ulrich on the Ozarkian and Canadian cephalopods. Foerste's incomplete manuscript, consisting of a number of descriptions, is incorporated in the present work, and such species as he had described appear with his name. In some cases his descriptions are quoted directly. In other instances they have been rewritten, as new material has made possible a more complete understanding of quite a number of the species.

NAMES APPLIED TO CINCINNATIAN CEPHALOPODS PRIOR TO 1935

The following list includes those scientific names which have been applied to cephalopods of the Cincinnatian. These are arranged alphabetically by genus, with the result that the same species sometimes appears more than once. After each species its present status is indicated insofar as the present progress of the work permits. The species may be divided as follows:

1. Species which have been restudied and have been found to be valid.

2. Species which cannot be recognized owing to inadequacy of the extant descriptions and figures and to our failure up to the present to relocate and study the type specimens. It is hoped that in the future this list can be shortened.

3. Species which are unrecognizable because they are based upon inadequate material.

4. Erroneous or dubious identifications. In this group are those species which were described from regions other than Cincinnati but which have been identified, usually in faunal lists, as occurring in the Cincinnatian proper. In some cases the identifications are patently erroneous, as in the recognition of the Middle Silurian European species, *Orthoceras annulatum* Sowerby, now the genotype of *Dawsonoceras*. Other species are not recognized in the present work because Cincinnatian forms have failed to prove identical with typical material. In some instances restudy of the original material is required before the species can be

recognized with certainty. In almost no instances have we been able to find the exact material from the Cincinnatian upon which these determinations have been based. Species described in preliminary papers by the writer (Flower 1939B, 1942, 1943) are not included.

Armenoceras madisonense Foerste and Teichert, 1903.	Armenoceras madisonense Foerste and Teichert
Cameroceras, sp. Foerste, 1929.*	
Cameroceras faberi Foerste, 1929.*	
Charactoceras baeri (Meek and Worthen, 1865).	Charactoceras baeri
Colpoceras arcuatum Wetherby, 1881.	Unrecognizable.
C. clarkii Wetherby, 1881.	Unrecognizable.
Cyrtoceras amoenum Miller, 1878.	Beloitoceras amoenum
C. conoidale Wetherby, 1881.	Unrecognizable. (Genotype of Wetherbyoceras Foerste 1926)
Cyrtoceras faberi James, 1886.	Charactocerina faberi
C. hitzi Foerste, 1910.	Zitteloceras hitzi
C. irregulare Wetherby, 1881.	Manitoulinoceras (?). Unrecognizable.
Cyrtoceras lysander Billings.	Not present in Cincinnati See Manitoulinoceras tenuiseptum Manitoulinoceras williamsæ
C. magister Miller, 1874.	Faberoceras magister
Cyrtoceras ortoni (Meek and Worthen, 1865).	Faberoceras magister
C. obscura Miller, 1874 (not Barrande).	Westonoceras (?) ortoni Westonoceras, sp,
C. tenuiseptum Faber, 1886.	Manitoulinoceras tenuiseptum
C. thompsoni Miller, 1894.	Fayettoceras thompsoni
C. vallandighami Miller, 1874.	Augustoceras, sp.
C. ventricosa Miller, 1874.	Westonoceras ventricosum
C. ventricosum Miller, 1874.	Westonoceras ventricosum
Cyrtocerina madisonense (Miller, 1894).	Cyrtocerina madisonensis
Dawsonoceras hammelli (Foerste, 1910).	Gorbyoceras hammelli
Diestoceras eos Hall and Whitfield, 1875.	Diestoceras eos
Diestoceras indianense (Miller and Faber, 1894).	Diestoceras indianense
Diestoceras shideleri Foerste, 1924.	Diestoceras shideleri
Endoceras proteiforme Hall.*	Dubious
Endoceras approximatum Hall.	Dubious
Endoceras annulatum Hall.	Dubious
Endoceras magniventrum Hall.	Dubious
Endoceras subcentrale Hall.	Dubious
Fayettoceras thompsoni (Miller,1894)	Fayettoceras thompsoni
Gomphoceras acceptum Ulrich, 1880.	Nomen nudum.
G. eos Hall and Whitfield, 1875.	Diestoceras eos

* Species to be treated in Part II, not thoroughly studied at present.

G. faberi Miller, 1884.	Oncoceras faberi
G. cincinnatiense Miller, 1884.	Oncoceras cincinnatiense
G. indianense Miller and Faber, 1894.	Diestoceras indianense
Gyroceras baeri (Meek and Worthen, 1865).	Charactoceras baeri
Lituites planorbiformis (Conrad), James, 1886.*	Trocholites, sp.
L. circularis (Miller and Dyer, 1878) James 1888.	Trocholites circularis
L. ammonius (Conrad) James, 1886.	Trocholites, sp.
L. baeri (Meek and Worthen, 1865) James, 1886.	Charactoceras baeri
Melia cincinatæ d'Orbigny. 1849.	Unrecognizable.
Oncoceras cincinnatiense (Miller, 1884), Foerste, 1924.	Oncoceras cincinnatiense
O. (?) faberi (Miller, 1884), Foerste, 1924.	Oncoceras faberi
Ormoceras covingtonense Foerste and Teichert, 1930.*	Treptoceras
Ormoceras hitzi (Foerste, 1910).*	Treptoceras
Orthoceras albersi Miller and Faber, 1894*	Treptoceras (?)
O. ampicameratum Hall. * Not at Cincinnati.	May be Michelinoceras ludlowense.
O. annellum Conrad.	Not at Cincinnati.
O. annulatum Sowerby.	Not at Cincinnati
O. bilineatum frankfortense Foerste, 1910.	''Spyroceras'' bilineatum frankfortense
O. byrnesi Miller, 1874.*	Treptoceras
O. carleyi Hall and Whitfield, 1874.	Not recognizable.
O. cincinnatiense Miller, 1874*	Treptoceras
O. duseri Hall and Whitfield, 1874*	Treptoceras duseri
O. dyeri Miller, 1874. *	Treptoceras
O. fosteri Miller, 1874.*	Not recognizable.
O. gorbyi Miller, 1894. *	Gorbyoceras gorbyi.
O. hallianum Miller *	Treptoceras hallianum
O. halli Miller, 1874 (not Barrande).	Treptoceras hallianum
O. harperi Miller, 1874.	Treptoceras
O. hindei James.	Probably a preservation phase of O. transversum. Unrecognizable.
Orthoceras hammelli Foerste, 1910.	Gorbyoceras hammelli
O. hitzi Foerste, 1910.	Treptoceras hitzi
O. junceum Hall.	Presence at Cincinnati very doubtful. Species not adequately known.
Orthoceras (Loxoceras) milleri Foerste, 1910.	Treptoceras milleri
Orthoceras ludlowense Miller and Faber, 1894.	Michelinoceras ludlowense
Orthoceras ortoni Meek and Worthen, 1865.	Westonoceras (?) ortoni
Orthoceras transversa Miller, 1874.	Treptoceras transversum
Orthoceras transversum Miller, 1874.	Treptoceras transversum

Orthoceras turbidum Hall and Whitfield, 1865.	Troedssonoceras turbidum
Phragmoceras hector Billings.	Not at Cincinnati.
Suecoceras inaequabile (Miller) Foerste, 1910.	Identity doubtful.
Tripteroceras (Lambeoceras) richmondense Foerste, 1917.	Lambeoceras richmondense.
Trochoceras baeri Meek and Worthen, 1865.	Charactoceras baeri
Trocholites ammonius Conrad. *	Trocholites, sp.
T. circularis Miller and Dyer, 1878.*	Trocholites
T. dyeri Hyatt, 1894.*	"
T. minusculus Miller and Dyer, 1878.*	"
Trocholites planorbiformis Conrad.*	"
Troedssonoceras turbidum (Hall and Whitfield, 1874)	Troedssonoceras turbidum
Wetherbyoceras conoidale (Wetherby)	Wetherbyoceras conoidale (Unrecognizable), Augustoceras, sp.
Zitteloceras hitzi (Foerste)	Zitteloceras hitzi

SPECIES ERRONEOUSLY IDENTIFIED IN THE CINCINNATI REGION

A considerable number of cephalopods of the Cincinnati region have been assigned to species typically developed in other regions, and usually in other horizons. I list these species, under the generic name first applied to them, in chronological order as they were reported from the Cincinnatian. In some cases it is quite evident what these species are; in others it is extremely uncertain.

Endoceras proteiforme Hall. This species is typically develed in the Trenton limestone of New York. It has been customary to refer almost any large endoceroid shell to this species. Fully nine-tenths of the Cincinnatian specimens of endoceroids are too poor for specific determination. The writer is frankly uncertain whether any of the Cincinnatian species are actually *E. proteiforme.* The matter requires a restudy of *E. proteiforme* as the extent of variation in typical Trenton specimens is uncertain.

Endoceras approximatum Hall (Miller, 1874; Ulrich, 1880). The species is inadequately known and may not be distinct from *E. proteiforme.*

Trocholites ammonius Conrad. This has been widely cited from both the Cynthiana and Covington. Most Cincinnatian specimens are too poor for proper comparison. (Miller, 1879; Ulrich, 1880; James, 1886).

Orthoceras anellus Conrad. Ulrich (1880) cites this from a 400 foot elevation; James (1886) lists it from Versailles, Indiana. The Versailles occurrence is probably *Gorbyoceras hammelli* or *G. crossi,* both of which are known to the writer from there, but it could be any of the annulated species treated here.

Orthoceras amplicameratum Hall. This Trenton species is not adequately known and its generic position is uncertain. Deeply camerate forms assigned to this species are apparently in part the deeply chambered *Michelinoceras ludlowense* of the Cynthiana limestone. Cited by Ulrich, 1880; James, 1886.

Orthoceras junceum Hall. This Trenton species has a sub-orthochoanitic siphuncle. The numerous citations of this form are based upon phases of preservation rather than on valid specific details. It is cited by Ulrich and James. Cumings (1908) expressed doubt as to the correctness of the identification.

Endoceras annulatum Hall. A Trenton species, the genotype of *Cyclendoceras* Grabau and Shimer. Cited by Ulrich, but without horizon data. No *Cyclendoceras* has been recognizable among the material available for the present study.

Endoceras magniventrum Hall. A Trenton species. Apparently Cincinnatian endoceroids with very large siphuncles have been placed under the name. Neither the typical New York form nor the Cincinnatian forms assigned to it are adequately known.

Endoceras subcentrale Hall. This is a Black River species known from a fragment of a siphuncle. The species is inadequately known and may be identical with *Vaginoceras longissimum* (Hall).

Phragmoceras hector (Billings). This is a Middle Silurian species, placed by Foerste (1929) in *Gomphoceras, sensu stricto.*

Lituites planorbiformis (Conrad). This is a Lorraine species of New York, properly placed in *Trocholites.* Cincinnati species may belong here, but the specimens studied are too poor for close comparison with the typical New York form.

Cyrtoceras hallianum d'Orbigny. This was cited from the upper Richmond at Madison, Indiana. The species is a *Zitteloceras* of the Trenton of New York. Foerste found the form which occurs at Madison distinct, and proposed for it the name *hitzi*.

Cyrtoceras lysander Billings. Foerste formerly regarded *C. tenuisceptum* Faber as a synonym of this species, which is typically developed in the Richmond Meaford formation of Ontario. The two forms are closely related species of *Manitoulinoceras*, but are here regarded as distinct.

Orthoceras annulatum Sowerby. This is a British Silurian species, the genotype of *Dawsonoceras*. Neither *Dawsonoceras* nor its genotype occur in the Ordovician.

Orthoceras olorus Hall. This species is typically developed in the Trenton of New York. Foerste (1928, p. 179, pl. 40, fig. 9) has placed it in *Spyroceras* using the genus very broadly. The Cincinnati forms might be almost any annulated orthoconic species.

RANGE OF CINCINNATIAN CEPHALOPODS

Although at the present time the cephalopods of the Cincinnatian have not been completely studied, the probability that the appearance of Part II of the present work may be delayed for some time makes it desirable to present such information on the stratigraphic range of the species as can be supplied now. This includes the species in the present portion of the work but also draws to some extent upon investigations which are reserved for the second part.

Two types of cephalopods range throughout the Cincinnatian, the endoceroids, which at present we can only class as *Endoceras*, and the smooth orthoceracones with nummuloidal siphuncles for which the genus *Treptoceras* was erected. These are the commonest of the Cincinnati cephalopods and unfortunately present special problems in identification which have not yet been overcome. It is impossible to treat the endoceroids properly because of the fragmentary nature of nine-tenths of the material. *Treptoceras* is typically more complete, but not only has it been impossible to treat properly the several thousand Cincinnatian specmens collected for this study, but also it has been impossible as yet to locate and restudy more than a small fraction of the types of described species of *"Orthoceras"*, most of which obviously belong to this genus.

Treptoceras and *Endoceras* are present in all members of the Cincinnatian, though I have not indicated them always in the faunal lists. In *Treptoceras,* the relationships have not yet been worked out in detail, but the observations made up to the present time indicate recurrence of general types. Whether the recurring types are sufficiently unmodified to be considered the same species in different horizons has not yet been determined, nor have investigations proceeded far enough to determine whether, as is suspected, the recurring types suggest the same conditions as the recurrence already noted time and again by other investigators of other fossil types in the Cincinnati column.

MOHAWKIAN SERIES

PRE-CYNTHIANA FAUNAS

Very little information is available concerning the cephalopods of the Middle Ordovician formations underlying the Cynthiana limestone in Kentucky and the equivalent Cathys limestone in Tennessee. In Kentucky cephalopods are not abundant in the underlying formations, at least down to the Tyrone formation of Black River age. In Tennessee the pre-Cathys beds carry several assemblages of cephalopods, which are, however, largely undescribed. Foerste and Teichert (1930) have redescribed a number of the actinoceroids. I do not reproduce these as the list is obviously very incomplete, and a proper evaluation of the faunas will require many more complete data. Nothing is known from these formations similar to the Cincinnatian *Treptoceras.*

Two forms included in the present work from the earlier Trenton of Kentucky are *"Spyroceras" bilineatum frankfortense* Foerste of the Curdsville horizon and *"Spyroceras" mcfarlani* Foerste of the Perryville member of the Trenton.

CYNTHIANA LIMESTONE

The Cynthiana limestone varies in both faunal and lithological characters. It is supposedly upper Trenton in age, but its correlation with the New York section presents difficulties which will not be discussed here. The cephalopods are largely from the typical Greendale limestone. the cephalopod-bearing lens in the Greendale limestone at the Poindexter quarry at Cynthiana, and the upper beds of the Cynthiana including the Bromley shale and the Point Pleasant beds, of northern Kentucky and southern Ohio. These faunas are distinct and are listed separately. *Treptoceras* and endoceroids occur, but only those which are already published or are at present in manuscript are included.

Greendale limestone (general).—

Troedssonoceras obscuroliratum Flower, n. sp.
Armenoceras vaupeli Flower, n. sp.
Danoceras cynthianense Flower, n. sp.
Faberoceras sonnenbergi Flower, n. sp.
Faberoceras saffordi Foerste, n. sp.
Faberoceras ooceriforme Flower, n. sp.
Oncoceras fossatum Flower, n. sp.
Oncoceras, sp.

Poindexter quarry lens.—This fauna was discovered in 1939 in a small lens in the Poindexter quarry. The fossil material is no longer obtainable due to quarrying. The cephalopods were previously described by the writer. The same lens contained abundant association of gastropods and pelecypods in its lower portion. An extensive collection of this unique association was made and deposited in the University of Cincinnati Museum by the writer in 1939, but only a small portion of it could be located when the cephalopods were studied (Flower, 1942). The nautiloid species have been previously described, no new material is available, and they are not redescribed or reillustrated in the present work.

Treptoceras persiphonatum Flower
T. prænuntium Flower
T. perseptatum Flower
Rizoceras graciliforme Flower
R. conicum Flower
Oncoceras carlsoni (Flower)
Oonoceras planiseptatum Flower
O. acutum Flower
O. (?) brevidomum Flower
O. multicameratum Flower
O. gracilicurvatum Flower
O. triangulatum Flower
O. triangulatum var. cylindratum Flower
O. suborthoforme Flower
Diestoceras, sp.

Bromley shale and Point Pleasant limestone.—This fauna is best known from quarries at Covington, Kentucky. Other localities are noted.

Michelinoceras ludlowense (Miller and Faber)
Michelinoceras (?) ivorense Flower, n. sp. Ivor, Ky.[5]
Treptoceras albersi (Miller and Faber)
Reedsoceras mcfarlani Flower, n. sp.
Oonoceras curviseptum Flower, n. sp.
Oonoceras covingtonense Flower, n. sp.
Trocholites faberi Foerste
Endoceras, n. sp.
''Succoceras'', n. sp.

CATHYS LIMESTONE

The Cathys is the equivalent of the Cynthiana limestone in Tennessee. Its cephalopod fauna is not adequately known, but such forms as have been described are listed because of the importance of this fauna in relation to the Cynthiana, and the relation of both of these earlier faunas to the Leipers.

Armenoceras brevicameratum Foerste and Teichert
(aff. Armenoceras vaupeli Flower.)
Deiroceras capitolense Foerste and Teichert
Deiroceras nashvillense Foerste and Teichert
Treptoceras troosti (Foerste and Teichert)
Saffordoceras nelsoni Foerste and Teichert
Probillingsites williamsportensis Foerste

In addition, material studied in the U. S. National Museum has shown the presence of a number of Oncoceratidæ. These specimens were finally rejected as too fragmentary for proper study, but are of interest for their similarity with the cephalopods from the Poindexter quarry lens. Further, their preservation was very similar to that of the Poindexter association and may have occurred under similar conditions.

CINCINNATIAN SERIES

COVINGTON SUBSERIES

Eden group.—The Eden in general contains the ubiquitous *Endoceras*, which is usually represented there by little more than the *spiess*, the mud filling of the last endocone, and which can be identified only by inference and comparison with better preserved material in the same beds, and *Treptoceras*. *Treptoceras* is often

[5] *Michelinoceras* (?) *ivorense* Flower, n. sp. This species, to be described more fully in Part II, is illustrated here on Plate 28, fig. 3, and therefore the following brief description is included: Shell circular, very slender, enlarging from 10 mm. to 10.5 mm. in 30 mm. Sutures straight, cameræ very shallow, 16 in a length of 17 mm. Maximum shell diameter of specimen, showing gerontic features, 10.5 mm. The bactritiform shell, small size, and very shallow cameræ distinguish it from all other cephalopods of the Middle and Upper Ordovician of America.

represented from the Economy up to the McMicken, and even in the overlying Mount Hope, by the preservation phase to which the name *Orthoceras hindei* was applied. *Treptoceras* is far from uniform in the Eden. The Fulton contains an association of several relatively large species, more similar to those of the Corryville than to any forms found higher in the Eden. Elsewhere, small externally banded forms appear which have been named *Orthoceras transversum*. It appears, however, that this form is either very variable or more than one species is involved.

1. Fulton beds

The *Treptoceras* of the Fulton, consisting of at least three species, have not as yet been thoroughly studied. The only additional form is that figured here as *"Spyroceras"*, sp.

2. Economy member
Treptoceras transversum
Trocholites, sp.
Endoceras, sp.

This formation is more calcareous than the Southgate, and it is possible that from it are derived some of the species which have been regarded as coming from the Southgate member, which is more shaly.

3. Southgate
Treptoceras transversum,
Trocholites, sp.,
Michelinoceras, sp., aff. *ludlowense*,
Diestoceras edenense Flower, n. sp.,
Westonoceras ventricosum (Miller)
Westonoceras, sp.
Westonoceras (?) *ortoni* (Meek)
Faberoceras magister (Miller)
Augustoceras (?), sp.

Most authors attribute *Trocholites minusculus* Miller and Dyer to this horizon. This little known species is not known to me from any stratigraphically determined collections.

4. McMicken

The McMicken beds have yielded no cephalopods other than the endoceroids and *Treptoceras*. The *"Orthoceras hindei"* preservation phase is particularly common in this bed, but occurs also in the Southgate. (See species of uncertain relationship.)

Maysville group.—A few species are described from the Maysville without indication of the subdivisions of this group from which they came. These forms are listed with notes on their probable origin.

Danoceras gracile Flower, n. sp. Fairview (?)
Vaupelia minutum Flower, n. sp. Fairview (?)
Augustoceras (?) *vallandighami* (Miller). Attributed to Fairmount by Nickles (1902) and Bassler (1915).
Augustoceras, 2 sp.

1. Fairview beds

The Fairview, the lower division of the Maysville, is divided into the Mount Hope beds and the overlying Fairmount member. The faunas are listed separately.

a. *Mount Hope*

Treptoceras transversum (Miller)
Treptoceras, sp.,
Troedssonoceras multiliratum Flower
(?) *Troedssonoceras turbidum* (Hall and Whitfield)
Vaupelia seiberti Flower, n. sp.

No cephalopods have been previously listed from the Mount Hope. Yet it is much richer in orthoceracones than is the overlying Fairmount.

b. *Fairmount*

Treptoceras, sp.
Troedssonoceras multiliratum Flower
Troedssonoceras turbidum (Hall and Whitfield)
Diestoceras bettinæ Flower, n. sp.,
Vaupelia russelli Flower, n. sp.

In addition, *Orthoceras cincinnatiense* and *O. meeki* were regarded as Fairmount by Nickles (1900), and Bassler (1915) cites as Fairmount *Orthoceras byrnesi,* in addition to the above. In view of the extreme rarity of orthoceracones in the Fairmount as at present delimited, the *Strophomena* zone marking its base, and the appearance of *Platystrophia ponderosa* marking the base of the overlying Bellevue, it seems more likely that the originals of these species came from either the underlying Mount Hope beds, which are similar in many faunal elements, or the overlying Bellevue beds.

c. *Leipers*

The cephalopod fauna of the Leipers is best developed in exposures along the Cumberland River in southern Kentucky. The cephalopods are best developed in the lower beds in association with two biostromes of *Tetradium.* Above these layers there is found a limestone layer, remarkable for the abundance of pelecypods, which has yielded some distinctive cephalopod species. Higher beds show a fauna dominantly composed of brachiopods and Bryozoa, with only occasional orthoceracones, and in the upper part of these beds *Platystrophia ponderosa* becomes a dominant element of the fauna. The cephalopods of the Leipers are listed with designations as to horizon.

Horizons.—1. Lower *Tetradium* reef. 2. Inter-reef beds. 3. Upper reef. 4. Pelecypod layers. 5. Higher beds.

Endoceras, sp. 1-4.
Anaspyroceras cumberlandense Flower, n. sp. 3-5.
Treptoceras, sp. 1-5.
Troedssonoceras rowenæ Flower, n. sp. 1-4.
Armenoceras, sp. 3 or 4.
Faberoceras percostatum Flower, n. sp., 1, 3-4.
Faberoceras transversum Flower, n. sp. 4.
F. multicinctum Flower, n. sp. 4.
F. shideleri Foerste and Flower, n. sp. 3-4.
Augustoceras shideleri Flower, n. sp. 1-4.
A. medium Flower, n. sp. 1-4.
A. commune Flower, n. sp. 1-3; rare in 4.
A. minor Flower, n. sp. 1-3.
Danoceras crater Flower, n. sp. 4.
Danoceras bulbosum Flower, n. sp. 1.
Oncoceras bassleri Flower, n. sp. 3-4.
Oncoceras arlandi Flower, n. sp. 4.

2. McMillan formation

This name is applied to the upper division of the Maysville, comprising the Bellevue, the Corryville, and Mount Auburn members.

a. Bellevue member

The only cephalopod other than *Treptoceras* and *Endoceras* thus far noted from the Bellevue is the form figured and described here as *Troedssonoceras* cf. *multiliratum.*

b. Corryville

The Corryville, which consists of thin-bedded limestones and alternating shales, is rich in cephalopods in contrast to the Fairmount or Bellevue. *Treptoceras* is abundant, though often poorly preserved. Shells commonly show a flattening of the upper side, which is indicative of wear or abrasion of the shell as it lay in its matrix. This is probably due to a lowering of wave base rather than to subaërial erosion, the explanation usually applied to such phenomena.

The Corryville is noteworthy also for the presence of feeding trains of cephalopods, linear impressions in the rock caused by the forward movement of these straight shells. In certain beds of the lower Corryville, notably at Stone Lick Creek, such markings have been found to exhibit an irregular radial arrangement, suggesting that the cephalopods clustered about some source of food. Also in the Corryville were found markings consisting of a horseshoe-shaped arrangement of a series of small vermicular markings. These are interpreted as impressions in the mud made by the tips of the tentacles of a straight cephalopod. The fuller description of these phenomena is intended to be included in Part II of the present work.

The writer has found few cephalopods other than the ubiquitous types in the Corryville. However, Nickles (1900) and Bassler (1912) have attributed to the Corryville *Oncoceras cincinnatiense* and *Oncoceras faberi*. The specimen here figured as *Oncoceras*, sp., was labeled as Corryville, but the stratigraphic designation was made long after the specimen was collected on the basis of Dr. Ulrich's recollection of the locality. *Faberoceras elegans* is attributed to the Corryville on a better basis, that of the Bryozoa which were found within the living chamber and which were studied by Miss Helen Duncan. Nickles (1900) lists *Orthoceras dyeri* and *O. harperi* as Corryville species. At the present time I am uncertain as to the limits of the species and have not been able to locate the types. Certainly more than two species of *Treptoceras* occur in these beds. The list of exotic forms is given below:

Oncoceras cincinnatiense (Miller)
Oncoceras faberi (Miller)
Oncoceras, sp.
Trocholites (?), sp.
Faberoceras elegans Flower, n. sp.

c. Mount Auburn

The Mount Auburn which overlies the Corryville contains fairly abundant remains of a large *Treptoceras*. Strangely, no species have been assigned to this formation by Nickles or by Bassler. *Endoceras* occurs sparingly. The only other cephalopod known from this formation is a single *Trocholites*, known only by a living chamber from the Ulrich collection of the U. S. National Museum.

RICHMOND SUBSERIES

The Richmond, the equivalent of the Covington, has generally been designated as a "group" but is more properly a subseries or a stage.

Arnheim formation.—The Arnheim has been regarded as a formation and divided into two members, the Sunset and the Oregonia. The present data on the small cephalopod fauna do not indicate the range of species in terms of these members. The only exotic types are from the Arnheim of Lebanon, Kentucky, not far below barren shales regarded as lower Waynesville. These consist of *Ecdyceras foerstei* and *Probillingsites lebanonensis*.

Elsewhere the only cephalopods known are *Treptoceras* and *Endoceras*.

Waynesville formation.—The Waynesville comprises a thickness of 97 feet of sediment and has been divided into three members, the Fort Ancient, the Clarkesville, and the Blanchester.

1. Fort Ancient member

Cephalopods are exceedingly rare and poorly preserved in the lower part of this member. The top, however, consists of a layer of soft clay shale, sometimes known as the trilobite bed, from the abundance of *Calymene*, and sometimes as the *duseri* zone, from the abundance of *Treptoceras duseri* (Hall and Whitefield). This zone has yielded the following fauna:

Treptoceras duseri (Hall and Whitfield)
Treptoceras, n .sp.
Endoceras, sp.
Gorbyoceras curvatum Flower, n. sp.
Oncoceras delicatulum Flower, n. sp.
Zitteloceras russelli Flower, n. sp.
Zitteloceras williamsæ Flower, n. sp.
Manitoulinoceras williamsæ Flower, n. sp.
Manitoulinoceras tenuiseptum (Faber)

It is also almost certainly the source of the unrecognizable

Manitoulinoceras (?) *irregulare* (Wetherby) and *Clarkesvillia halei,* tentatively assigned to the next member, might possibly have come from this zone.

The association is one noted for the beautiful preservation of the cephalopods, and specimens from this horizon can usually be recognized by their lithology. The cephalopod fauna is known entirely from streams in the vicinity of Clarkesville and Waynesville, and many of the rarer finds are due to the industry of Miss Carrie B. Williams of Clarkesville. *Treptoceras* is represented by well-preserved internal molds characterized by remarkably clear preservation of the features of the inner surface of the cameræ, in particular the septal furrow.

2. Clarkesville member

Cephalopods from this member are less well preserved, most of them being derived from the rubbly limestone layers filled with brachiopods and Bryozoa. The fauna is, however, an interesting one, being marked by such "typical" Richmond genera as *Schuchertoceras* and *Diestoceras.* The fauna, in addition to *Treptoceras* and *Endoceras,* is as follows:

Schuchertoceras obscurum Flower, n. sp.
Manitoulinoceras, sp. aff. *medium*
Diestoceras waynesvillense Flower, n. sp.
(?) *Clarkesvillia halei* Flower, n. sp.
Probillingsites, sp.

The *Probillingsites* is represented by several specimens, all of which are much flattened and show only the faintest traces of the sutures. The description of these forms is delayed pending the discovery of better material.

3. Blanchester member

Cephalopods are meagre in this bed. Only three forms are known in addition to the ubiquitous *Treptoceras* and *Endoceras*;

Michelinoceras clarkesvillense (Foerste)
M. clarkesvillense var. *distans* Flower
Probillingsites oxfordensis Flower, n. sp.

Liberty formation.—The Liberty in thickness is more comparable to one of the members of the Waynesville than to the Waynesville as a whole. The most characteristic cephalopod, an unnamed *Treptoceras,* is notable for the close spacing of the cameræ and the very gradual rate of expansion. *Endoceras* occurs here, not uncommonly preserving the tip of the siphuncle. It is possible that some of the Whitewater species which are reported as appearing in the Liberty may have been derived from loose fragments from the overlying lower Whitewater formation. From the nature of the localities, however, it seems unlikely that this can apply in all cases. The cephalopods are most abundant in the middle beds of the Liberty, just above the "*Asaphus* beds", the source of *Isotelus megistos* Foerste. The upper beds of the Liberty contain few well-preserved fossils, being either barren shales or limestones consisting of extensively reworked and fragmentary material.

Michelinoceras clarkesvillense (Foerste)
Michelinoceras clarkesvillense var. *distans* Flower, n. var.
Anaspyroceras williamsæ Flower, n. sp.
"*Spyroceras*", sp.
Lambeoceras richmondense (Foerste)
Probillingsites minutum Flower, n. sp.
Armenoceras richmondense Flower, n. sp.
Diestoceras, sp.

The *Diestoceras,* not figured or described, is a large form unlike either *D. waynesvillense* or any of the Whitewater species. The only specimen is a very badly weathered living chamber and two attached cameræ, from the middle Liberty of Flat Fork Creek collected by Miss Carrie Williams and the writer. Occasional *Characteroceras* have been found in the Liberty, but only at localities where they have come from the overlying Whitewater which in these cases is present in the overlying slopes.

Whitewater formation.—This formation is exceedinlyy variable in Ohio and Indiana. From eastern Ohio near Manchester northwest, it is of a noncommittal character and is not easily differentiated from the Liberty. From Elk Creek west to Flat Fork Creek, and Oxford, the lower Whitewater is characterized by a rich cephalopod fauna, which can be traced to near Versailles, Indiana. I have found remnants of the same fauna in the shales and limestones directly underlying the Saluda at Madison, Indiana, which are currently classed as Liberty, but are regarded by the writer as the remnant of the lower Whitewater.

The Saluda replaces most of the Whitewater, all except possibly the basal beds, at Madison, Indiana, where it is marked by the coral beds near its base and the Hitz fauna, a dwarfed fauna of upper Whitewater aspect, near its top. Farther north, near Canaan, the Hitz fauna persists through a greater thickness of the Saluda and is represented by larger forms. At Versailles, Indiana, the typical upper Whitewater is present above the Saluda, consisting of rubbly limestone and shale with abundant *Streptelasma,* and the Saluda consists of light yellow to gray dolomitic beds including the coral beds and shows some mud cracked layers.

Near Oxford, the Saluda lithology is restricted to the few feet surrounding the coral beds, and farther east it disappears. The relationship of the Saluda to the Whitewater is clearly faciological. The Saluda fauna is not so small as the present faunal lists would indicate. It is particularly rich in cephalopods, gastropods, and pelecypods in certain beds, often in association with or close to the coral beds. However, difficulty has been encountered placing the boundary between the Saluda and Whitewater precisely in some localities, while collections from others contained forms which could be assigned to the Saluda or Whitewater only on the basis of lithology, which may be sometimes deceptive. The difficulty is made greater by the origin of most of the specimens, which are weathered from slopes and sometimes found at the bottoms of cliffs containing lower Whitewater, Saluda, and upper Whitewater.

1. Lower Whitewater

A few feet above the beds, showing evidence of wave scour and the "turkey track layers" regarded as marking the base of the Whitewater, occurs the "*Charactoceras* bed". This bed rarely yields good specimens on weathered cliffs exposed to the air, as such weathering tends to break up the specimens rather than to expose them. However, in silicious limestones and more rarely in the associated shales, *Charactoceras* and other cephalopods are found in stream beds. The specimens are not abundant, and the present faunal list represents the product of years of careful collecting. The fauna is not uniformly distributed but appears to be concentrated in local pockets; further, species show some concentration. *Shideleroceras sinuatum* is known from a large suite of specimens from this zone at Little Four Mile Creek, while *Rizoceras bellulum* occurs only at Dodge's Creek, at Oxford, Ohio. Very large endoceroids characterize the bed and have been the means of recognizing it as far east as Manchester, Ohio. *Treptoceras* is represented by several species, not as yet fully studied. The arenaceous internal molds which come from this bed are quite distinctive in lithology. While they may present excellent surfaces, internal preservation is almost always very poor, and sections have only rarely revealed good siphuncles.

This horizon has long been neglected by Cincinnati collectors because the fauna is neither easy to see nor to obtain. The specimens rarely if ever weather out of the rock properly, as they do in most parts of the section. Indeed, the cephalopod-bearing layer tends to weather into small nodular pieces of silicious limestone which show scant regard for the outline of the fossils preserved there. At Dodge's Creek on the outskirts of Oxford, the layer shows abundant evidence of reworking by worms and also pelecypods have contributed, for small shells are found here in their life position preserved vertically in the rock. At Little Four Mile Creek a remarkable concentration of *Charactoceras* was found here, over a hundred specimens being obtained from a limestone layer containing fragments of Bryozoa, *Isotelus,* and brachiopods, in an area of not more than 12 square feet. With them were found a half dozen *Diestoceras,* a number of orthoceracones, and a *Shideleroceras.* Needless to say, the cephalopods are not so abundant as this in the layer at all places. I have found only a sparse association at Flat Fork Creek. The best results are always obtained by the systematic breaking up of the cephalopod layer. Unfortunately it is not always easy to find this layer, as other limestones resemble it quite closely, and the cephalopods are not always evident even upon the surfaces of the layers when exposed in streams. The fauna is such a varied one, however, that almost every trip to a locality showing the horizon has resulted in some cephalopod of special interest. Further collecting is to be urged, since with the fauna of 36 species described here are fragments indicating the presence of still other species thus far known only from fragments too poor to merit description.

Michelinoceras, sp.
Anaspyoceras williamsæ Flower, n. sp.
Bickmorites rarum Flower, n. sp.
Gorbyoceras, sp. aff. calvini (Foreste)
G. gorbyi (Miller)
G. duncanae Flower, n. sp.
G. simile Flower, n. sp.
Probillingsites oxfordensis Flower, n. sp.
P. faberi Flower, n. sp.
Schuchertoceras discretum (Foerste), n. sp.
S. discretum var. minor Flower, n. var.
S. prolongatum (Foerste) n. sp.
S. cf. rotundum Flower n. sp.
Gracinoceras extensum Flower, n. sp.
Rasmussenoceras variable Flower, n. sp.
Lambeoceras richmondense (Foerste)
Manitoulinoceras (?) trigonale Flower, n. sp.
M. moderatum Flower, n. sp.
Staufferoceras subtriangulare Flower, n. sp.
Beloitoceras cumingsi Flower, n. sp.
B. ohioense Flower, n. sp.
B., sp.
B. geniculatum Flower, n. sp.
B. protractum Flower, n. sp.
B. bucheri Flower, n. sp.
Neumatoceras subconicum Flower, n. sp.
N. chrysalis Flower, n. sp.
Oonoceras rectidomum Flower, n. sp.
Rizoceras bellulum Flower, n. sp.
Zitteloceras perexpansum Foreste, n. sp.
Shideleroceras sinuatum Foerste, n. sp.
S. simplex Flower, n. sp.
Diestoceras eos (Hall and Whitfield)
Diestoceras shideleri Foerste
Diestoceras indianense (Miller)
Diestoceras attenuatum Flower, n. sp.
Charactoceras baeri (Meek)

2. Saluda coral beds

The coral beds of the Saluda lie between the lower and upper Whitewater formations, though in southern Indiana they are capped by more beds of Saluda lithology, but beds containing a very different association of species. The precise origin of most specimens in the Saluda cannot be determined. In some regions the locality presents such evidence, notably where, as in the vicinity of Oxford, Ohio, the upper Saluda is replaced by the upper Whitewater. Other data are supplied by the collecting of Dr. W. H. Shideler and the writer.

Diestoceras shideleri (Foerste)

Diestoceras indianense (Miller)
Cyrtocerina carinifera Flower, n. sp.
Shideleroceras gracile Flower, n. sp.
Kindleoceras equilaterale Flower, n. sp.
Manitoulinoceras moderatum Flower, n. sp.
Manitoulinoceras gyroforme Flower, n. sp.
Beloitoceras amoenum (Miller)
Miamoceras shideleri Flower, n. sp.
Zitteloceras shideleri Flower, n. sp.
Lambeoceras richmondense (Foerste)
Probillingsites, sp.

3. Upper Whitewater

Charactoceras baeri (Meek)
Charactocerina faberi (Miller)
Schuchertoceras cf. prolongatum (Foerste)
Schuchertoceras (?), sp.
Lambeoceras richmondense (Foerste)
Schuchertoceras discretum var. minor Flower, n. var.
Schuchertoceras geniculatum Flower, n. sp.
Schuchertoceras rotundum Flower, n. sp.
Whitfieldoceras (?) casteri Flower, n. sp.
Rasmussenoceras variabile Flower, n. sp.
Oonoceras rejuvenatum Flower, n. sp.
O. shideleri Flower, n. sp.
O. fennemani Flower, n. sp.
Oncoceras anomalum Flower, n. sp.
Beloitoceras amoenum (Miller)
B. cumingsi Flower, n . sp.
B. ohioense Flower, n. sp.
B. chapparsi Flower, n. sp.
B. transiens Flower, n. sp.
Manitoulinoceras moderatum Flower, n. sp.
M. erraticum Flower, n. sp.
M. (?), sp.
Zitteloceras lentidilatatum Foerste, n. sp.

4. Upper Saluda of southern Indiana

The Hitz fauna receives its name from the Hitz quarry at Madison, Indiana. This association was regarded as an upper Whitewater fauna present in the upper beds of the Saluda. As typically developed, the fauna is confined to the extreme upper portion of the Saluda at Madison, and consists largely of small shells. Insofar as the cephalopods are concerned, the small size is due to the presence there of only early growth stages of the shells. It is not a true dwarf fauna, but the result of wave action in breaking down and sorting the shells. The same species, represented by larger individuals in a lesser concentration and spread over a greater thickness of the Saluda, occur in the hills at Canaan, Indiana. No Whitewater is known here overlying the Saluda. However, Whitewater beds occur above the Saluda at Versailles, but there also the highest beds of the Saluda contain a few representatives of this same association.

Treptoceras hitzi (Foerste)
Gorbyoceras crossi Flower, n. sp.
Gorbyoceras hammelli (Foerste)
Gorbyoceras gorbyi (Miller)
Fayettoceras thompsoni (Miller)
Kindleoceras rotundum Flower, n. sp.
K. cumingsi Flower, n. sp.
Manitoulinoceras moderatum Flower, n. sp.
Oncoceras anomalum Flower, n. sp.
Oncoceras duncanæ Flower, n. sp.
Oncoceras exile Flower, n. sp.
Oonoceras insuetum Flower, n. sp.
Diestoceras indianense (Miller)
Diestoceras cyrtocerinoides (Flower)
Diestoceras pupa Flower, n. sp.
Armenoceras madisonense Foerste and Teichert
Cyrtocerina madisonensis (Miller)
Cyrtocerina patella Flower
Cyrtocerina modesta Flower
Charactoceras baeri (Meek)
Zitteloceras hitzi (Foerste)

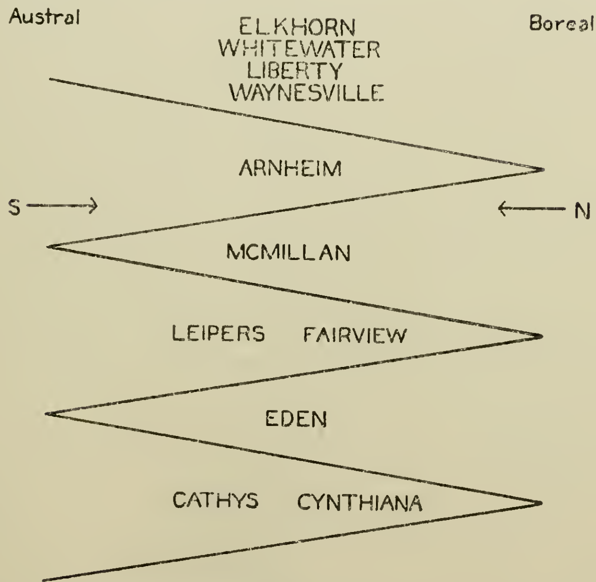

Figure 8. Diagrammatic representation of Ulrich's concept of the alternate incursion of southern (austral) and northern (boreal) faunal elements into the Cincinnati region. The zigzag line represents the boundary between the two geographic realms, as it changed throughout Upper Ordovician time at Cincinnati.

5. Saluda—division uncertain
Diestoceras eos (Hall and Whitfield)
(?) D. reversum Flower, n. sp.
D. (?) vasiforme Flower, n. sp.

Elkhorn formation.—Cephalopods are rare in the Elkhorn, and most specimens have been too fragmentary for certain identification.

Manitoulinoceras ultimum Flower, n. sp.
Manitoulinoceras cf. moderatum Flower, n. sp.
Schuchertoceras prolongatum Flower, n. sp.
Michelinoceras cf. clarkesvillense (Foerste)
Diestoceras cf. shideleri Foerste
(?) Diestoceras reversum Flower, n. sp.
Beloitoceras ulrichi Flower, n. sp.
Beloitoceras cf. amoenum (Miller)
Beloitoceras cf. cumingsi Flower, n. sp.

INTERPRETATION OF THE CEPHALOPOD FAUNAS OF THE CINCINNATI SECTION

While full analysis of the significance of the changing cephalopod faunas in the geological column at Cincinnati must be delayed until the completion of the second part of this study, the facts already ascertained have a considerable bearing upon the broader aspects of faunal and paleogeographic problems. Ulrich (see Foerste, 1932, p. 54) interpreted the recurrence of faunas at Cincinnati in terms of faunal invasions originating alternately from the north and from the south. He believed (fig. 8) that austral elements entered the Cincinnati area in Cynthiana and Cathys times, giving way to faunas from northern waters in Eden time, but reappearing in the Cincinnati region in Fairview time. Northern waters again brought in the McMillan fauna, but gave way to austral elements in the Arnheim, while the higher Richmond formations were marked by an increasing dominance of boreal invaders without further interference by southern faunas.

It has not been possible to recognize distinct austral and boreal elements in the cephalopod faunas. Perhaps this is partly because while supposedly boreal cephalopod faunas have been rather extensively studied, there was, at the outset of this investigation, no group of cephalopod genera or species which could be called austral with any degree of certainty. Perhaps this is because so little is known of the cephalopods of the southern Appalachians, and indeed also of the Nashville dome. On the other hand, many startling and characteristic types have come to be considered particularly diagnostic of the boreal faunas, the Apsidoceratidæ, the Diestoceratidæ, such actinoceroids as *Kochoceras* and *Selkirkoceras*, the Mixochoanites, *Westonoceras*, and *Ephippiorthoceras*, to cite only a few of the better known and more characteristic types.

The Cincinnati region seems to contain a few types of cephalopods which are indigenous, notably the genera *Treptoceras* and *Endoceras*. These are well developed in the Cincinnati area and appear in every formation. They are common to the Nashville dome, the Cincinnati arch, and the Cincinnatian of southern Ontario and northwestern New York. *Treptoceras* attains its maximum development in the Cincinnatian of Cincinnati. Although the species may change from one horizon to the other, the stock continues from the appearance of the Cynthiana and Cathys faunas to the close of the Richmond. *Endoceras*, *Treptoceras* (and *Trocholites*, which is rare and sporadic in the Cincinnati region but better developed in the Lorraine of New York) seem to be genera indigenous to the Cincinnati, Ontario, and New York formations of Cincinnatian age. They form essentially a background for the more rapidly changing pattern formed by the succession of the other cephalopod types.

The Cynthiana and Cathys faunas are marked by a large *Michelinoceras*, *Armenoceras*, *Probillingsites*, *Troedssonoceras*, *Kindleoceras*, *Deiroceras*, *Danoceras*, *Oncoceras*, *Oonoceras*, *Reedsoceras*, *Faberoceras*, and *Trocholites*. With the exception of the *Michelinoceras*, *Faberoceras*, *Trocholites*, and possibly *Oncoceras*, these are genera which, by their present known distribution, are regarded as characteristic of boreal faunas. *Probillingsites* occurs in the boreal invasion of the Cobourg faunas as noted by Kay (1935). The species of *Oonoceras* which occur here are strikingly similar to species from the Vaureal of Anticosti, the Bighorn formation, and the Fremont limestone, as previously noted (Flower, 1942). *Danoceras* appears in the Cape

Calhoun fauna, Anticosti, and in the Upper Ordovician of Oslo, and the Whitehead formation of Gaspé. *Armenoceras, Rizoceras, Kindleoceras,* and *Reedsoceras* are known largely from Black River faunas of supposedly boreal origin.[6]

This reduces the possible austral forms to *Troedssonoceras,*[7] possible oncoceroids, and the genus *Faberoceras.* Clearly, either something is wrong with previous concepts of the origin of some of these genera or the Cynthiana and Cathys must have received significant boreal contributions to their faunas.

The exotic members of the Eden fauna are confined to *Trocholites,* which may be indigenous, but suggests a connection with the Lorraine seas of New York, and the following cyrtoconic genera: *Faberoceras, Diestoceras, Westonoceras,* and, doubtfully, *Augustoceras.* The single *Diestoceras* is an anomalous species with no close relatives and is not a useful index to faunal relations. The *Faberoceras* is clearly inherited from the same realm which supplied this genus to the underlying Cynthiana formation. The *Augustoceras* is dubious, but the *Westonoceras* is not, and the genus is one well known from northern faunas, the Cape Calhoun formation, various equivalent horizons in the Arctic Archipelago, the Nelson limestone of Hudson Bay, the Red River series of Manitoba, the Bighorn formation, the Viola limestone, and the Stewartville dolomite. It has also been recognized in the Oslo region, (Strand, 1934) but the reference of these species to *Westonoceras* seems dubious in the absence

[6] Some of these faunas are now regarded by Kay as Rockland, basal Trenton. It seems, however, that they form a unit indicating a general boreal association with the Black River faunas as restricted, to which the middle Trenton faunas offer a sharp contrast. The Cobourg, which marks, at least in Ontario and New York, a second boreal invasion, contains cephalopods of markedly more advanced types. The matter of the Trenton-Black River boundary is not in itself such an important question, save that in its present position it leads to misleading generalizations in relation to Black River versus Trenton faunas. The writer would favor drawing this boundary at the top of the Hull, thus uniting the Rockland and Hull faunas with the Black River to which their cephalopods, at least, are very closely related.

[7] This is an actinoceroid, while species referred to the genus from the Cape Calhoun formation are not (Teichert, 1934; Flower 1939B).

of detailed information on the internal structure. As the only occurrence of *Westonoceras* in the Cincinnati section, not only is this genus a clear index of the occurrence of boreal faunas in the Eden, but it also suggests very strongly the pre-Richmond age of many of the boreal Ordovician cephalopod faunas.

Treptoceras and *Endoceras* held sway throughout the Fairview, being joined only by an occasional, and always rare *Troedssonoceras, Augustoceras,* and *Vaupelia*. *Vaupelia* is not known outside of the Cincinnati region and is confined to this horizon. *Troedssonoceras* and *Augustoceras,* although apparently specifically distinct at least in part from their relatives in the contemporaneous Leipers fauna, are clearly remnants of that fauna at the extreme northward extent of their range.

The cephalopod fauna of the Leipers, best developed in southern Kentucky, contains the most characteristic cephalopod assemblage to be found in the Covington subseries. *Faberoceras, Danoceras, Oncoceras, Troedssonoceras, Armenoceras, Anaspyroceras,* and *Augustoceras,* form this association. Except for *Augustoceras* and *Anaspyroceras,* these are genera found in the Cynthiana fauna, and their presence here supports the concept that the Leipers fauna is a recurrence, though in a modified form, of that of the Cynthiana. The species are different, however. The Leipers *Faberoceras* is more strongly ornamented than its Cynthiana forbears and is further specialized in the migration of the siphuncle toward the center of the shell and the appearance of endocones in some species. The *Danoceras* species are closely similar to forms known from the Upper Ordovician of the Oslo region, and to a lesser extent, to species from the Whitehead formation of Gaspé. The species of *Oncoceras* are in part closely related to their Cynthiana predecessors, but in part also to Black River species from Ontario. *Augustoceras* is not known outside of the Leipers and Fairmount with certainty. *Anaspyroceras,* is too little known and probably too broadly distributed to be a reliable guide to faunal relationships.

Persistence of the Leipers influence in the Bellevue formation at Cincinnati is shown by the presence of *Troedssonoceras*, the only exotic form thus far found in that horizon. The Corryville combines with its indigenous types a doubtful *Trocholites*, a *Faberoceras* which is clearly phylogerontic in relationship to the Leipers species, and *Oonoceras* of a rather generalized type. The only Mount Auburn cephalopod, aside from *Treptoceras* and *Endoceras*, is a single *Trocholites*.

Exotic types in the Arnheim, which is generally poor in cephalopods, are confined to a layer of silicious limestone replete with pelecypods and gastropods at Lebanon, Kentucky. Here *Ecdyceras* and *Probillingsites* occur. *Ecdyceras* was previously known only from the middle Chazyan of the Champlain Valley (Flower, 1941B). *Probillingsites* is known in earlier strata from the Cobourg of New York and Ontario and also from the Cathys limestone of Tennessee.

No exotic types are encountered again in the Cincinnati column up to the bed of shale marking the top of the Fort Ancient member of the Waynesville. This horizon, in the vicinity of Clarkesville and Waynesville, has long been noted for the abundance of *Calymene* and *Treptoceras duseri*. Here, for the first time, is an appreciable association of genera which will persist throughout the remainder of the Richmond. The indigenous types are joined by one species of *Oncoceras*, though this species is rather generalized, and might be interpreted as a recurrence of such forms as those of the Corryville. However, more significent are *Gorbyoceras*, *Manitoulinoceras*, and *Zitteloceras*, while the monotypic *Clarkesvillia* may have come from this horizon instead of the overlying Clarkesville member.

The Clarkesville member shows a continuation of *Manitoulinoceras* but is particularly marked by the appearance of a large *Diestoceras* and the mixochoanitic genera *Probillingsites* and *Schuchertoceras*. In the Blanchester *Probillingsites* continues. It is joined by the first *Armenoceras* encountered since the Leipers horizon and the characteristic *Michelinoceras clarkesvillense*.

The Liberty shows a continuation of the *Michelinoceras* in Ohio. In Indiana and Kentucky, notably in the Bardstown coral reef, *Armenoceras* reappears, and a tiny *Probillingsites* has been found in the Liberty in Ohio. The middle Liberty of Flat Fork Creek has yielded a single large *Diestoceras* of Richmondian aspect, but which is too poor to merit description. Specimens of *Charactoceras* and *Lambeoceras* have been reported from the Liberty, but practically all specimens are from outcrops also exposing the lower Whitewater, and may possibly have come from that horizon.

The lower Whitewater cephalopod association shows marked affinities with the fauna of Anticosti and with the boreal Ordovician faunas. *Charactoceras* and several large *Diestoceras* are the most conspicuous elements of a fauna containing also *Neumatoceras, Oncoceras, Beloitoceras,* including some phylogerontic forms and also the species group of *B. amoenum, Schuchertoceras, Probillingsites, Staufferoceras, Manitoulinoceras, Lambeoceras,* and *Rasmussenoceras,* all of boreal affinities. *Shideleroceras* makes its first appearance here, with *Whitfieldoceras, Graciloceras,* and *Zitteloceras* which are not typical boreal types.

Many of the same genera, sometimes the same species recur in the upper Whitewater, particularly in the vicinity of Oxford, Ohio. *Kindleoceras* and *Miamoceras* join the assemblage in the Saluda, as does the little known *Fayettoceras.* In the upper Saluda *Cyrtocerina* is the significant addition to the fauna.

Little is known of the Elkhorn cephalopods. No new generic types appear. Some specimens are too fragmentary for certain specific identification, while in a few cases better material has revealed new species which have a definite phylogerontic relationship with their predecessors in the Whitewater and Saluda.

From the above summary it is evident that, starting in the Waynesville, but reaching its maximum development in the Whitewater and Saluda, there is an incursion of faunal elements new to the Cincinnati area, most of which are better developed in the boreal Ordovician, including the Fremont limestone, Bighorn dolomite, the Red River series of Manitoba, the Nelson and Shamattawa limestones of Hudson Bay, the Ordovician of Atpatok Island, Frobisher Bay and Putnam Highland, various other localities in the Arctic Archipelago, and the Cape Calhoun series of Greenland. In comparing the Cincinnati forms with congeneric species from these regions a striking disparity in size is at once evident. The more northern forms are so very much larger as to suggest that these forms may well have lived under tropical conditions in contrast to which the seas of the Cincinnati-Nashville region, and probably also those of New York, Ontario, and even Anticosti were at the best temperate. This hypothesis becomes even more convincing when other faunal elements are compared in relation to size. The Red River corals are immense in contrast to those of Cincinnati, while the same is true of some of the brachiopods, as in the case of *Rhynchotrema capax*. Neither the Anticosti nor the Whitehead faunas share the gigantism which marks those of the Bighorn, Selkirk, or Arctic species. It would seem, therefore, that both the Anticosti and Whitehead faunas share in some measure the temperate aspects of the Cincinnati and New York faunas.

From the point of view of geography it is perhaps strange that the Anticosti fauna seems to contain much more in common with the fauna at Cincinnati than does the more southerly Whitehead fauna of Gaspé. The answer is perhaps partly ecological. Both the Cincinnati and Anticosti faunas lived in an environment of muds supplied by nearby continents. The contest between marine substance and detrital materials of continental origin is reflected in both sections by the rapid alternation of shale and limestone. The Whitehead formation, however, reflects as an environment a relatively shallow quiet sea far enough from any emergent land mass to be essentially free from the coarser products of subaerial erosion. Environmentally, faunally, and lithologically it is more closely allied to the Red River faunas, which developed in a widespread continental embayment, evidently from the Arctic, and was either relatively far from shore or was surrounded by land masses which had essentially attained peneplanation and were too low to contribute significantly to the composition of the sediments of the adjacent seas.

A possible solution may be offered to the problem of the distinction between the boreal and austral faunas encountered particularly in the lower two-thirds of the Cincinnati column. It may be that, lacking suitable criteria, we have failed to evaluate the austral elements properly. If they are present, however, it is clear that they have penetrated to some extent into faunas and regions previously regarded as boreal.

The association of Oncoceratidæ, *Danoceras, Armenoceras, Troedssonoceras,* and *Faberoceras* marks the Cathys-Cynthiana faunas, which with the loss of *Probillingsites* and the addition of *Augustoceras* and *Anaspyroceras,* recurs in Fairview time. The oncoceroids appear to be essentially an American stock; they are very poorly represented in the arctic faunas, except by notably specialized types, and are very poorly known in northern Europe. The closest relatives of *Faberoceras* occur possibly in the Bala of England, and certainly in the Lyckholm formation of Esthonia, while the *Danoceras* of the Cincinnati region find their closest counterparts in the Oslo faunas. It may be that except for the *Oonoceras,* this is the "austral" fauna so difficult to recognize in the cephalopods. If so, it may be possible to trace a faunal realm embracing these different regions. It would form essentially an arc, roughly concentric with and lying within the larger arc extending from Colorado to Greenland, and which we have ventured to interpret as a tropical realm. The austral realm would then have the approximate form of a part of the temperate belt such as we might expect if one of the poles lay somewhere in Africa. It is surprising, and reassuring, that this concept is not widely different from the pangaea for the Ordovician as postulated by Grabau on the basis of quite other evidence. The pattern is not perfect, but it is impossible to make proper allowance for modifications such as exist today due to the location of land masses and the consequent development of ocean currents.

SYSTEMATIC DESCRIPTIONS

As noted in the introduction, the arrangement of families and genera is somewhat arbitrary. First are placed those forms which are definitely included in the Stenosiphonata. Within this group, the arrangement is artificial. First are discussed the annulated orthoceracones which constitute two unrelated genera. These are followed by the suborthochoanitic cephalopods, for which no systematic name is used. Their derivatives, the Mixochoanites follow: and the secondarily cyrtochoanitic cephalopods with ventral siphuncles, constituting the Allumettoceratidæ, Oncoceratidæ, Valcouroceratidæ, and Diestoceratidæ. The Discosoroidea, of uncertain origin, are placed next, followed by brevicones of uncertain position. The nautiliconic types, the Apsidoceratidæ and Bickmoritidæ, follow, completing the stenosiphonate forms covered in the present volume. Next are placed as archaic cephalopod types *Shideleroceras* and *Cyrtocerina*, which apparently harken back to primitive and little understood Ozarkian and Canadian types. Following these groups, there is placed the suborder Eurysiphonata, of which only three genera of the Actinoceroidea are included here.

A key to the genera known to occur in the Cincinnati region is provided. This will be found to be of value only for relatively complete specimens. No key could probably be devised to accommodate the more fragmentary remains.

KEY TO ORDOVICIAN NAUTILOID GENERA OF THE CINCINNATI REGION

1. Siphuncle holochoanitic .... (Endoceroidea) Part II
   Siphuncle aneuchoanitic .... (Archaic genera) 2
   Siphuncle ellipochoanitic 3
2. Shell a slender cyrtocone. Siphuncle central, connecting rings very thin .... *Shideleroceras*
   Shell a rapidly expanding endogastric cyrtocone. Connecting rings distended into siphuncle .... *Cyrtocerina*
3. Shell gyroconic to nautiliconic 4
   Shell orthoconic, cyrtoconic or breviconic 7
4. Shell gyroconic, siphuncle central, exterior of shell with annuli .... *Bickmorites*
   Shell with an impressed zone 5
5. Siphuncle subcentral, cyrtochoanitic; shell rapidly expanding........ 6
   Siphuncle dorsal, tubular, expansion gradual ......*Trocholites* (Part II)
6. Shell with annuli throughout life .... *Charactocerina*

Shell with annuli only in early whorls .... *Charactoceras*
7. Shell orthoconic 8
Shell cyrtoconic or breviconic if essentially straight 17
8. Section prominently triangular, siphuncle in the ventral angle .... *Kindleoceras*
Section round, or depressed, never prominently triangular 9
9. Shell with prominent ornamentation 10
Shell essentially smooth or with only faint transverse markings 12
10. Shell fluted, with longitudinal ribs .... *Troedssonoceras*
Shell annulated; finer markings are always longitudinal, but transverse markings may also be present. 11
11. Siphuncle orthochoanitic .... *Anaspyroceras**
Siphuncle cyrtochoanitic .... *Gorbyoceras**
12. Cross section strongly flattened, a dorsal and ventral surface separated by sharp lateral angles 13
Cross section circular or slightly depressed 14
13. Siphuncle marginal, minute, often invisible, essentially suborthochoanitic or barely cyrtochoanitic .... *Rasmussenoceras*
Siphuncle large, prominent at the septum .... *Lambeoceras*
14. Septum deep, subconical; ventral flattened, suture with ventral lobe .... *Ecdyceras*
Septum normal; venter without prominent lobe or flattening 15
15. Siphuncle orthochoanitic, tubular .... *Michelinoceras* (Part II)
Siphuncle cyrtochoanitic 16
16. Siphuncle small, segments vary from slightly broader than long to suborthochoanitic in the later growth stages .... *Treptoceras* (Part II)
Siphuncle very large, at least one-fifth of the surface of septum; septal necks recumbent, segments broadly expanded throughout, rings broadly adnate adapically .... *Armenoceras*
17. Extant part of shell strongly gibbous, with sutures rising orad on dorsum. Siphuncle subcentral. Septum at base strongly rounded .... (Mixochoanites *pars*) 18
Extant part of shell without the combination of gibbosity and sutures with dorsal saddles 19
18. Dorsal saddles not set off sharply from rest of suture... *Probillingsites*
Dorsal saddles sharply set off from rest of suture by sharp lateral angles; sigmoid .... *Schuchertoceras*
19. Shell essentially straight 20
Shell markedly curved 23
20. Siphuncle subcentral; shell fusiform .... *Whitfieldoceras*
Siphuncle marginal, shell not fusiform 21
21. Shell breviconic, slightly compressed in section 22
Shell triangular in section........ *Kindleoceras*
22. Siphuncle slender, its outlines angular .... *Danoceras*
Siphuncle scalariform to rounded, more expanded and actinosiphonate .... *Diestoceras*
23. Siphuncle suborthochoanitic. Shell a slender compressed cyrtocone with short closely camerated phragmocone and a long living chamber .... *Graciloceras*
Siphuncle cyrtochoanitic. Shell without combination of a long living chamber, short phragmocone, and closely spaced septa 24

* Three species which are unknown internally are placed in "*Spyroceras*".

24. Siphuncle free from actinosiphonate or other deposits 25
Siphuncle with actinosiphonate or annulosiphonate deposits 36
25. Section compressed or round 26
Section strongly depressed 34
26. Shell gibbous adorally 27
Shell cyrtoconic, not gibbous 30
27. Ventral profile conspicuously humped before aperture...... *Neumatoceras*
Venter not prominently humped 28
28. Dorsal profile not convex over living chamber .... *Beloitoceras*
Dorsum convex over living chamber, adoral part of phragmocone or both 29
29. Gibbosity of shell located above base of mature living chamber .... *Beloitoceras*
Gibbosity located at or below base of living chamber .... *Oncoceras*
30. Shell rapidly expanding to aperture, adoral part essentially straight. Apex slightly curved .... *Rizoceras*
Shell a gradually expanding cyrtocone 31
31. Surface with prominent transverse annuli or projections which are more or less crenulated; siphuncle small .... *Zitteloceras*
Surface with only even transverse markings, or smooth 32
32. Adoral part of shell straight and slender .... *Miamoceras*
Shell uniformly curved 33
33. Shell very slender .... *Oonoceras*
Shell moderately expanding .... *Reedsoceras*
34. Shell a gibbous brevicone .... *Vaupelia*
Shell a slender cyrtocone 35
35. Siphuncle central .... *Shideleroceras*
Siphuncle close to convex side 38
36. Siphuncle actinosiphonate (Family Valcouroceratidæ) 37
Siphuncle annulosiphonate or with thickened walls 41
37. Shell a fusiform exogastric cyrtocone. Actinosiphonate structure prominent; section subtriangular .... *Augustoceras*
Shell a slender cyrtocone; apertural contraction absent or terminal and abrupt 38
38. Cross section strongly triangular .... *Kindleoceras*
Cross section rounded, depressed 39
39. Strongly curved, living chamber slightly inflated, then contracted; septa widely spaced .... *Staufferoceras*
Gently curved, living chamber simple, expanding to aperture 40
40. Septa closely spaced in adult, widely spaced in young. Living chamber long .... *Manitoulinoceras*
Septa widely spaced throughout; (living chamber unknown) .... *Fayettoceras*
41. Shell slightly curved in phragmocone, siphuncle segments subquadrate in section; shell gradually contracted to aperture *Westonoceras*
Shell definitely exogastric, segments of siphuncle rounded in section; aperture not contracted .... *Faberoceras*

Order **NAUTILOIDEA**
Suborder **STENOSIPHONATA**

In the Stenosiphonata (Teichert, 1933; Flower, 1942) are placed those cephalopods in which the connecting ring is thin and homogeneous in structure. The septal necks are ellipochoanitic, being both orthochoanitic and cyrtochoanitic in form. No aneuchoanitic genera are placed here. Apparently there is a group of aneuchoanitic cephalopods with thin structureless connecting rings, but the only genus definitely known to have such structure is *Shideleroceras*. Further investigations are necessary to determine whether more examples of this structural pattern may exist among pre-Chazyan cephalopods.

ANNULATED ORTHOCERACONES

INTRODUCTION

Because annulated orthoceracones are easily recognized as a homeomorphic unit and separation of the genetic groups involved is difficult, it has seemed that identification will be best facilitated by treating the Cincinnatian genera under a single heading. Thirty-one generic names have been proposed for such shells in the Paleozoic. These have been recently reviewed by the writer (Flower, 1942). Annulated shells of the Ordovician are of two general types those which have fine transverse markings and which have in the past been generally assigned to *Cycloceras*, although the type of that genus is so little known that it is even uncertain whether orthochoanitic or cyrtochoanitic shells should be placed here. The other type consists of those annulated shells which bear longitudinal markings, sometimes with secondary transverse markings. Such shells have been assigned by all recent workers to *Spyroceras*. This genus cannot, however, be properly applied to any known Ordovician species since it has been demonstrated that *Spyroceras* possessing the structure of a *Dolorthoceras*, is properly a member of the Pseudorthoceratidæ, and is, as far as is known, confined to Middle and Upper Devonian species. Nevertheless, even the most recent investigations of Ordovician nautiloids in America have failed to take these facts into account, and annulated shells have been assigned to these genera without even an adequate investigation of the internal structure of the shell. Ordovician species, which have the external features long considered diagnostic of both *Cycloceras* and *Spyroceras* are both orthochoanitic and cyrtochoanitic. Ordovician species of the general aspect of a *Cycloceras* constitute two and possibly three genera which are not closely related. Happily, this problem is of no immediate importance to the present investigation, as the type Cincinnatian has not yielded any annulated cephalopods with transversely striated surfaces. The several species known are of the general external aspect of *Spyroceras,* and some of them have been assigned to this genus by Foerste and by Miller. The Cincinnatian species, however, constitute one cyrtochoanitic genus, to which the name *Gorbyoceras* Shimizu and Obata can be applied, and one orthochoanitic group to which the name *Anaspyroceras* can be given. Shimizu and Obata (1935, 1936) applied a great many new generic names to annulated orthoceracones. A restudy of the Cincinnatian species shows that the criteria used for generic distinction, consisting of the sharpness and spacing of annuli and the character of finer surface markings, absolutely fail to serve to distinguish between the two generic types involved. Further, Shimizu and Obata proposed their generic names without any effort to study the species which they selected as genotypes. As a result some of their genera are based upon types so inadequately known that no other species than the genotypes can be assigned to them. Some of the genera which they regarded as orthochoanitic and assigned to their supposedly orthochoanitic family Spyroceratidæ, are actually cyrtochoanitic. This includes not only *Spyroceras* itself (Flower, 1939) but also *Gorbyoceras.* The taxonomic confusion has been unraveled as far as is possible by a restudy of the genotypes. However, a few of the genera are based upon species which either because of rarity, poor preservation or a combination of the two, are so little known that it is uncertain whether they are orthochoanitic or cyrtochoanitic; indeed, they are known only from the exteriors of internal molds to which adhere some fragments of the shell. From the genera of the external aspect of *Spyroceras* which were proposed by Shimizu and Obata, (1935) two names were rescued by a restudy of genotypes, which are employed in the present work. These were preceded in arrangement and pagination by some other genera which are inadequately known. It is greatly to be feared that the situation has not attained final stability. A change of name may eventually prove necessary when *Orthoceras teretiforme* Hall, the genotype of *Hypospyroceras* Shimizu and Obata, and *Spyroceras middlevillense* Foerste, the genotype of *Subspyroceras*, are made known, if that ever happens, because these genera precede *Anaspyroceras* and *Gorbyoceras*. Therefore it might eventually come to pass that one or even both of these genera might be found to be identical with those which precede them in page arrangement, and should therefore be reduced to synonymy in strict accordance with the rules of zoölogical nomenclature.

Because Ordovician annulated cephalopods have been previously assigned rather widely to *Spyroceras* without due regard to internal structural variations, it is impossible to assign them to their proper generic position on the basis of the published evidence. As a result, it has been necessary in comparing the exteriors of species of *Anaspyroceras* and *Gorbyoceras* of the Cincinnati region, to discuss their specific features in terms of species of "*Spyroceras*". Species from the Richmond of southern Ontario, from Anticosti, from the Maquoketa shale, and from the sediments of the arctic embayment, are very similar to Cincinnatian ones and are doubtless congeneric with them. However, the outline of the siphuncle is known for relatively few of the species. Thus far there has been so little accord between the general surface pattern and the condition of the siphuncle, that it seems unwise to attempt a transfer of these species to either *Anaspyroceras* or *Gorbyoceras*, at the present time, even on the basis of an external similarity to Cincinnati species of ascertained internal structure and generic position.

Three generic names are applied to the annulated orthoceracones of the Cincinnati region. I have assigned to "*Spyroceras*" two Trenton species and one fragment from the Fulton which are inadequately known. They are clearly not *Spyroceras,* for the Pseudorthoceratidæ did not appear until Devonian time and are traceable to Middle Silurian orthochoanitic ancestors. Nevertheless, until a better basis exists for placing these species, it seems unwise to attempt a revision of their nomenclature until a correct solution can be presented.

Two orthochoanitic annulated shells of the external aspect of *Spyroceras* are placed in *Anaspyroceras* Shimizu and Obata. One is from the Leipers formation of southern Kentucky, and the other is from the lower Whitewater of Richmond of Ohio and Indiana.

The remaining species are cyrtochoanitic and are assigned to *Gorbyoceras* Shimizu and Obata. Among these is *Gorbyoceras gorbyi* (Miller), the type of that genus.

RANGE OF ANNULATED ORTHOCERACONES IN THE CINCINNATI AREA

For completeness, two species described from the Trenton of Kentucky are included in this report. Neither are adequately known. *"S." bilineatum-frankfortense* Foerste is from the Curdsville horizon, while *"S." mcfarlani* Foerste is from the Perryville member of the Trenton, now considered as a formation beneath the Cynthiana limestone.

The Cynthiana has yielded no annulated shells. The Fulton has given up a single species known from a single living chamber. This is describel and figured as *"Spyroceras",* sp. and is too inadequately known to merit a specific name.

No annulated orthoceracones occur in the Covington of Cincinnati. The Leipers of southern Kentucky contains one small species, *Anaspyroceras cumberlandense* Flower, n. sp.

The Waynesville is known to contain only *Gorbyoceras curvatum* Flower, n. sp., clearly a very rare form as it is known only from the type which is from the shales of the *Orthoceras fosteri* beds, with *Oncoceras, Manitoulinoceras,* and *Zitteloceras* in the first significant Richmond cephalopod assemblage in Ohio.

The Liberty has yielded occasional impressions of annulated shells. The middle Liberty of Flat Fork Creek has yielded a single young *Anaspyroceras williamsæ*. All other specimens that have been gathered from the Liberty are badly weathered impressions of exteriors, which fail to show even the fine surface markings and are useless taxonomically. Probably more of these would be available, if it were not that they generally occur on the surface of heavy limestone slabs and are very difficult to collect.

The cephalopod beds of the lower Whitewater contain *Anaspyroceras williamsæ* Flower, n. sp., *Gorbyoceras duncanæ* Flower, n. sp., *G. gorbyi* (Miller), *G. crossi* Flower, and *Gorbyoceras simile* Flower, with *G.* sp. aff. *calvini* (Foerste) which is so similar to that Maquoketa species that I have hesitated to separate specifically the single specimen by which this form is known from the Ohio region.

The Saluda beds contain *G. gorbyi* and *G. crossi.* The latter is nowhere abundant, but seems to be present both in the lower Saluda and in the upper Saluda of southern Indiana which is the equivalent of the upper Whitewater farther north and west. The upper Whitewater equivalent in southern Indiana, a light-colored limestone generally classed with the Saluda, is particularly characterized by *Gorbyoceras hammelli,* which I have found fairly abundant in some regions there, in particular at Canaan, Indiana. At Madison, Indiana, early stages of this species have been found in numbers in the Hitz layer, a shaly bed in the Saluda long known to contain a fauna of upper Whitewater affinities. The species is not developed at all in the coral typical marine phase of the upper Whitewater in Ohio as developed above the Saluda north of Versailles, Indiana.

KEY TO CINCINNATIAN ANNULATED ORTHOCERACONES

Three inadequately known species placed tentatively in "*Spyroceras*" are not included.

1. Siphuncle orthochoanitic, perfectly tubular ....(*Anaspyroceras*) 2
   Siphuncle cyrtochoanitic, shell straight or curved ....(*Gorbyoceras*) 3
2. Shell small, (surface details unknown), gerontic cameræ at 7 mm. diameter. Siphuncle markedly eccentric ....*A. cumberlandense*
   Shell large, gerontic cameræ at diameter of 15 mm. or more. Siphuncle subcentral. Surface with distant equal coarse primary longitudinal liræ, and distant weaker transverse liræ.. *A. williamsæ*

3. Shell slightly curved, siphuncle relatively slender .... *G. curvatum*
   Shell straight, siphuncle broadly expanded 4
4. Annuli low and rounded 5
   Annuli sharply elevated 7
5. Shell with secondary and tertiary longitudinal liræ. Transverse liræ obscure or altogether absent .... *G. crossi*
   Shell without clear tertiary series of longitudinal liræ, transverse liræ present and well developed 6
6. Shell small, maximum diameter known 24 mm. Annuli only slightly oblique .... *G. hammelli*
   Shell large, annuli markedly oblique, vestigial on venter in adult .... *G. gorbyi*
7. Shell large, attaining diameter of 40 mm., surface with equal longitudinal liræ .... *G. simile*
   Shell smaller, longitudinal liræ of two series at least, differing in strength and prominence 8
8. Primary and secondary longitudinal liræ divided at crests; primary liræ divided throughout .... *G.* sp. aff. *calvini*
   Primary liræ only thickened over annuli but not divided. Secondary liræ simple .... *G. duncanæ*

Genus "SPYROCERAS" Hyatt

As noted in the introductory portion, the genotype of *Spyroceras, Orthoceras crotalum* Hall of the Devonian of New York, shows by its structure that it is an annulated shell, one of several ornamented derivatives of *Dolorthoceras.* The species which can properly be assigned to this genus are Middle and Upper Devonian. No Ordovician or Silurian species are known which combine the external appearance of this genus with slender cyrtochoanitic siphuncles bearing organic deposits formed by modified annuli which grow orad along the connecting ring in each segment of the siphuncle, finally fusing to form a lining which is continuous from segment to segment. (Flower, 1931, p. 169.)

Nevertheless I include three species of the Cincinnati region in *"Spyroceras"* since two of them have already been described under that generic name, and while the generic assignment is almost certainly highly incorrect, the internal structure of the species is still unknown. Eventually these species will probably be placed in either *Anaspyroceras* or *Gorbyoceras*, but this cannot be done until at least the form of the segments of the siphuncle can be made known. Of two of these species I have had no material. These are *"Spyroceras" bilineatum-frankfortense* Foerste and *"Spyroceras" mcfarlani* Foerste. The third form, briefly described and figured as *"Spyroceras"*, sp., is an inadequately known annulated shell from the Fulton. It is too poorly preserved to serve as a type of a species, and even the fine surface markings are unknown.

"Spyroceras" bilineatum-frankfortense (Foerste) Plate 2, figs. 2-3

Orthoceras (*Spyroceras*) *bilineatum-frankfortense* Foerste, Denison Univ. Bull., Sci. Lab., Jour., vol. 16, pp. 75-76.
Spyroceras bilineatum-frankfortense Foerste, *ibid.*, pl. 1, fig. 6A, B.

The type is a small fragment of an orthoceracone 40 mm. in length, apparently circular in section, and slender, increasing from 16 mm. to 17 mm. There are seven annuli in length of 22 mm., the annuli being low, rounded, and separated by shallowly concave interspaces. The surface is marked by prominent equal longitudinal liræ crossing the annuli, and spaced 10 or 11 in a width of 10 mm. According to Foerste's description, between these occur single very fine striæ which can be seen with a lens. His illustrations, which are reproduced here, show that in some instances more than one of the weaker striæ may occur between the prominent ones. In addition, Foerste notes the presence of fine but distinct transverse striæ (liræ) about 11 in the length of 1 mm.

Discussion.—From Foerste's description it appears that this species is known only from the type. The writer has had no material of this form. Foerste notes that *"Spyroceras" bilineatum* has more distant longitudinal striæ. He also notes that in *"Spyroceras clathratum* the intermediate (secondary) striæ are absent, but the prominent longitudinal striæ and transverse striæ are similar.

Type.—Holotype, location unknown.

Occurrence.—From a cherty limestone beneath the Logana bed, regarded as Curdsville in age. The type is from the Crow distillery, south of Glen Creek, 6 miles southeast of Frankfort, Kentucky.

"Spyroceras" mcfarlani Foerste Plate 5, fig. 5

Spyroceras mcfarlani Foerste, 1932, Denison Univ. Bull., Sci. Lab., Jour., vol. 27, p. 107, pl. 14, fig. 5.

Shell straight; circular in section; the type preserving 135 mm. of the shell, incomplete at both ends, but expanding from 34 mm. to 37 mm. in the middle 30 mm. The interior is unknown. The sutures are straight and transverse, slightly oblique, closely spaced, 10 in a length equal to a diameter of 36 mm. The annuli are low, rounded and numerous, seven or eight occurring in a length equal to the shell diameter. The annuli are oblique, sloping strongly apicad on the supposed venter. One annulation may cross four sutures, on the ventral side of the shell alone. On the surface 26 primary ribs occur, about half a millimeter in width. The interspaces are flat and marked by five to seven raised longitudinal lines, the central one slightly more prominent than the others. Transverse markings, visible only at the base of the type, occur in a length of 2 mm.

Discussion.—Foerste compared this species with typical *Metaspyroceras* which it approaches in the oblique annuli and in having the sutures slightly inclined in the opposite direction. However, on the same basis it can be compared with the cyrtochoanitic *Gorbyoceras*, and indeed, is rather closer to the genotype in the oblique annuli and sutures than other Cincinnatian species which are clearly closely related to *G. gorbyi.* Until the siphuncle of this species is known it is impossible to say whether it is a *Gorbyoceras* or whether it is orthochoanitic, in which case it might be placed in *Metaspyroceras*. The incomplete condition of the shell makes even the orientation of the conch uncertain.

The above description is based largely upon Foerste's original description and figure. His figure is reproduced in the accompanying plates. I have seen no additional material of this species.

Type.—Holotype, U. S. National Museum, No. 87115.

Occurrence.—Two miles south of the Crow distillery, seven miles south of Frankfort, Kentucky, from the Perryville member of the Trenton.

"Spyroceras", sp. Plate 2, fig. 6

A single fragment of an annulated cephalopod is known from the Fulton beds which does not correspond closely with any other Cincinnatian species. The specimen, only one side of which is preserved, represents a portion of a living chamber 42 mm. in length, with an approximately circular section and a mean diameter at the basal end of 22 mm., and 24 mm., at the adoral end. The septum is obscurely preserved at the base of the specimen, showing no trace of the siphuncle. The suture is weathered but was apparently nearly straight and transverse.

The annuli, of which six occur on the length of the specimen, a seventh at the base being lost by weathering, are very low and broadly rounded and separated by low slightly concave interspaces. No trace of the surface features of the shell is preserved.

Discussion.—This species is not well enough known to deserve a name at the present time, but is certainly unlike any of the other annulated cephalopods known from the Cincinnatian. Its generic position is uncertain in the absence of any data on the structure of the interior of the shell.

Figured specimen.—Univ. of Cincinnati, No. 23907.

Occurrence.—Fulton beds, Twelve Mile Creek, Cincinnati, Ohio.

Genus ANASPYROCERAS Shimizu and Obata, emend. Flower

Genotype.—*Orthoceras anellus* Conrad.

Anaspyroceras Shimizu and Obata, 1935, Shanghai Sci. Inst., Jour. Sec.2, vol. 2, p. 4; Flower, 1939, Palæont. Amer., vol. 2, No. 10, p. 109; Flower, 1943, Bull. Amer. Paleont., vol. 28, No. 109, p. 114.

This genus, as revised by the writer as the result of a restudy of the genotype (Flower, 1942) seems to be the only one of the various names already proposed which can legitimately be used for shells with the external aspect of *Spyroceras* but with an orthochoanitic siphuncle. It grades apparently into *Metaspyroceras* Foerste, of which I regard *Eospyroceras* Shimizu and Obata to be a synonym. It differs from *Metaspyroceras* in that the annuli and sutures are straight and transverse. However, it is to be feared that there is no hard and fast line between the two genera. Nevertheless they are so different in aspect in their typical developments, that it seems wisest at the present time to permit this distinction to stand as a generic criterion.

Only two species of *Anaspyroceras* are found in the Cincinnatian. *A. cumberlandense* is a small species from the Leipers of southern Kentucky. *A. williamsæ* is from the lower Whitewater of the Richmond, where it is associated with species of *Gorbyoceras* which it resembles very much externally. It is impossible to say how many of the American Ordovician species of "*Spyroceras*" may eventually fall within the limits of this genus. Consequently it is not possible to evaluate the genus or its species very closely for faunal evidence having any great value in rechecking present concepts of Paleozoic faunas and seaways.

Anaspyroceras cumberlandense Flower, n. sp. Plate 4, figs. 8-11

This is a small annulated shell, not known to attain a diameter of more than 12 mm. The holotype is subcircular in section and expands very slowly, increasing from 7 mm. to 12 mm. in the adoral 60 mm. The shell bears numerous narrowly rounded annuli, appearing subangular in section, separated by broad concave interspaces. Five occur in a length equal to the diameter of the shell, from 9 mm. to 11 mm. The annuli are straight and transverse. The surface of the shell appears to be irregularly nodose and fails to show more than very obscure traces of longitudinal markings. This effect is believed to be due to slight algal incrustation which has covered all of the very few representatives of this species so far known.

The features of the phragmocone are not well displayed in the ephebic part of the shell. The sutures are straight and transverse. The adoral cameræ, clearly gerontic, are very closely spaced, six occurring in the adoral 7 mm. of the phragmocone where the shell diameter is 11 mm. Here the siphuncle is located about 7 mm. from one side and 3 mm. from the other, is slightly less than 1 mm. at the septal foramen, and has orthochoanitic septal necks. The connecting rings have not been observed.

Discussion.—The known features of the conch of this species do not permit a very close comparison with Middle Ordovician cephalopods of superficially similar size and similar spacing of the annuli. This is because such species have been described largely from specimens showing the external features of the shell more clearly and very little is known about their siphuncles. No species of the Upper Ordovician thus far known, or of the Red River fauna, the Richmond age of which is still not demonstrated, are similar in proportions or aspect. The condition of the annuli is perhaps most nearly duplicated in *"Spyroceras" paquettense* Foerste of the Paquette Rapids of the Ottawa River beds which have long been regarded as Black River in age, but which Kay has placed in the Rockland member of the Trenton. *"Spyroceras" anellus* (Conrad) from the Black River of Wisconsin also shows similar closely spaced annuli. In both of these species the septa are much more widely spaced.

One fragment of *A. cumberlandense*, although badly overgrown by algæ and Bryozoa, shows traces of rather coarse longitudinal ridges, somewhat similar to those of *Anaspyroceras williamsæ* Flower of the Richmond. That species has the annuli much more widely spaced and the species are not all similar in general proportions.

Types.—Holotype and two paratypes, Univ. of Cincinnati, Nos. 24204-24206.

Occurrence.—From the *Tetradium* reef in the Leipers formation at Rowena, Kentucky, on the Cumberland River. The three types are from outcrops just downstream from the Rowena ferry.

Anaspyroceras williamsæ Flower, n. sp.

Plate 1, fig. 10; Plate 2, fig. 8; Plate 3, figs. 2-3

Shell straight, slender, probably originally circular in section. The early stages expand fairly rapidly, a slightly flattened paratype increasing from 20 mm. to 23 mm. in a length of 35 mm., measurements being taken at the interspaces of the annuli. The mature part of the shell is tubular, the holotype increasing from 22 mm. and 26 mm. in its length of 63 mm.

Sutures straight and transverse, located at the interspaces between annuli. Cameræ occur four in length equal to the adoral diameter of the shell. The siphuncle is central or nearly so, perfectly tubular, with very short septal necks. No deposits are known in either cameræ or siphuncle.

The annuli are well elevated, narrowly rounded, and separated by deeply concave interspaces. The diameter of the shell increases from 26 mm. to 29 mm. from an interspace to the crest of the annulation. Between four and four and a half interspaces occupy a length equal to the diameter of the shell adapically. Adorally three to three and a half interspaces occupy a similar length. The surface is marked by equal strong longitudinal liræ separated by broader interspaces. Adapically 12 liræ occupy a width of 10 mm.; adorally eight occur in the same interval. The interspaces are marked by prominent narrow transverse liræ which fail to cross the stronger longitudinal liræ, and which are separated by interspaces at least twice the width of the liræ. These liræ occur about five in a length of 2 mm.

Discussion.—The strong equal longitudinal liræ without weaker alternating longitudinal liræ, and finer transverse markings are found in no other Cincinnatian species. *"Spyroceras" clathratum* (Hall) (see Foerste, 1928, p. 182, pl. 40, fig. 6A, B) has similar surface markings, but is known only from much smaller specimens which have broad and low annuli. *"Spyroceras" olorus* (Hall) (see Foerste, 1928, pp. 179-80, pl. 40, fig. 9) of the Trenton limestone, also recognized in the Bighorn formation, is somewhat similar in ornament, but the transverse markings are much finer, and the annuli are lower. Nothing is known of the segments of the siphuncle of either of these species, and it is therefore uncertain whether they are orthochoanitic or cyrtochoanitic. Therefore the generic position of these species remains a matter of uncertainty. None of the Anticosti specimens which have been referred to *Spyroceras* appear to be very similar to this species. *S. anticosiense* Foerste (1928, p. 227, pl. 37, figs. 4-5) and *S. vaurealense* Foerste (1928, p. 277, pl. 37, fig. 6) show equal strong longitudinal markings, but whether finer transverse markings are present is not certain. Both species have lower annuli than *S. williamsæ*. *Spyroceras beauportense* Foerste (1932, p. 198, pl. 13, fig. 1A-B) from the Trenton near Quebec City, has lower annuli, more distant longitudinal liræ, and more numerous and more conspicuous transverse liræ, but may belong to the same species group. Also *Spyroceras whitcombi* Foerste (1932, p. 109, pl. 13, fig. 2A-B) from the Salona formation of Pennsylvania shows similar markings, but there the annuli are even lower than in *S. beauportense,* the longitudinal liræ more conspicuous and more widely spaced, but the transverse markings are spaced rather more as in *A. williamsæ.*

Possibly the most nearly comparable species which has yet been figured is *Spyroceras,* sp. (Foerste, 1935, p. 247, pl. 36, fig. 9) in which the annuli are a little less pronounced and slightly more closely spaced. Nothing is known of the surface, but the internal mold approaches that of *Anaspyroceras williamsæ* very closely in general aspect.

Aside from the holotype and paratype, I have encountered only two other representatives of the species. One I place here with some doubt. Although agreeing in general with the surface features of *A. williamsæ,* this shell, a somewhat flattened individual, has a nearly flat septum. This, however, may be the result of distortion. The other is a small individual from the middle Liberty beds of Flat Fork Creek, collected too late to be incorporated in the illustration or description.

Types.—Holotype, Univ. of Cincinnati, No. 24089. Paratype, Shideler Collection.

Occurrence.—From the lower Whitewater, Flat Fork of Caesar's Creek, (holotype), also from the same horizon at Little Four Mile Creek (paratype), and also a specimen referred to this species with doubt. A single representative of the species was collected by Miss Carrie B. Williams and the writer in the middle Liberty beds at Flat Fork Creek, north of Fort Ancient.

Genus **GORBYOCERAS** Shimizu and Obata, emend. Flower

Genotype.—*Orthoceras gorbyi* Miller, 1894. (See also Foerste, 1928, p. 283, pl. 41, fig. 4a-c.)

Gorbyoceras Shimizu and Obata, 1935, Shanghai Sci. Inst., Jour., sec. 2, vol. 2, p. 4; Flower, 1939, Paleontographica Americana, vol. 2, No.

10, p. 109; Flower, 1942, Bull. Amer. Paleont., vol. 28, No. 109, p. 116.

This genus, as revised upon the basis of a restudy of the genotype which is described and reillustrated in the present work, is here employed for annulated shells with longitudinal markings of the external aspect of *Spyroceras* which vary widely in details of the annulations and the surface features, but agree in having a subcentral siphuncle composed of cyrtochoanitic segments. These may vary among various species from faintly expanded segments to broadly expanded ones. There seems to be no good point of division between those species with relatively slender siphuncles, such as *G. curvatum*, or *G.* sp. aff. *calvini*, and those with broader segments as are exhibited by *G. gorbyi* and *G. crossi*. I consider this genus one which existed throughout the Ordovician, being represented in the Chazyan by several closely related species formerly included in *Spyroceras clintoni* (Miller). There are probably many Middle and Upper Ordovician species yet to be placed in this genus when they are known internally as well as externally. *Spyroceras microlineatum* Foerste (1928) of the Richmond of Anticosti clearly belongs here as shown by its known internal structure. *Spyroceras porteri* of the Ordovician of Baffin Land is placed here, and the generic name *Porteroceras* which Shimizu and Obata based on this species is one for which I can discover no good use. Likewise the genus includes *S. hammelli* Foerste, the genotype of *Hammelloceras* Shimizu and Obata. As previously noted (Flower, 1942) and as is brought out in the specific descriptions below, this species is quite closely related to *G. gorbyi* with which it is associated.

The outline of the siphuncle is quite plastic in *Gorbyoceras*, as shown by the species from which it is best known, *Gorbyoceras clintoni* of the Chazyan and *G. hammelli* of the Richmond. The siphuncle in *G. hammelli* clearly becomes more expanded adorally than adapically. The gerontic portion of the phragmocone is not known in section for this species. In *G. clintoni* the segments assume a broadly nummuloidal outline early in life, but are more slender in the very first stages found. Later segments of the siphuncle of this and associated and apparently closely related species show some variation, but in general the outline of the segments becomes simplified gerontically approaching an orthochoanitic condition as in many Sactoceratidæ.

The cameræ contain mural deposits. The siphuncle is known to bear small annuli at the septal foramina, but these are greatly delayed in their development, appearing only well apicad of the first traces of cameral deposits. No specimens are known in which the annuli develop very far. As a consequence the genetic relationship of this genus is doubtful. In some respects, notably the late stages of the siphuncle, it resembles *Treptoceras* and shows actinoceroid characters. However, the siphuncle is slender in the extreme adapical portion which is not an actinoceroid feature, and the annuli have not been known to develop so as to fill the cavity of the siphuncle except for the radial canal system as in true actinoceroids. These two features indicate that *Gorbyoceras* is not an actinoceroid, but leave no definite solution as to where it should be placed in the present scheme of cephalopod classification. In this it is not without company.

Gorbyoceras gorbyi (Miller) Plate 2, figs. 1, 9-10; Plate 4, figs. 3, 6-7

Orthoceras gorbyi Miller, 1894, Indiana Dep. Geol. Nat. Res., 18th Ann. Rep., p. 322, pl. 10, fig. 2. (Adv. sheets, 1892); Cumings, 1908, Indiana Dep. Geol. Nat. Res., 32nd Ann. Rep., p. 1037, pl. 52, fig. 3.

Spyroceras gorbyi Foerste, 1928, Denison Univ. Bull., Sci. Lab., Jour., vol. 23, p. 283, pl. 61, fig. 4.

Gorbyoceras gorbyi Shimizu and Obata, 1935, Shanghai Sci. Inst., Jour., sec. 2, vol. 2, p. 4-5.

Conch orthoceraconic, originally circular in section, expanding very slowly over the mature part of the shell, from a diameter of 20 mm. onward, but more rapidly in the early portion. The smallest specimen observed expands from 8 mm. and 10 mm. to 11 mm. and 13 mm. in a length of 30 mm., while later portions show an increase of 1 mm. in the length of 60 mm.

The sutures are straight and transverse at a diameter of 8 mm. but soon become oblique, sloping orad on the supposed ventral (antisiphonal) side of the conch, in a direction opposite to that taken by the oblique annuli. The cameræ are uniformly shallow, but become more closely spaced adorally in relation to the diameter of the shell. Six and a half occur in a length equal to a diameter of 24 mm. Farther orad this increases to nine in a length equal to the adoral diameter. There is some variation, however, as one specimen shows nine in a length equal to a diameter of 28 mm., while another shows twelve in a length equal to the same diameter. Cameræ have been observed in portions of the shell up to a diameter of 34 mm. and fail to show the adoral contraction which is usual in full-grown individuals of orthoceracones.

The septum is very flat and oblique. Normal to the suture, the depth of the septum is about two-thirds the depth of the camera, and 2 mm. at a diameter of 24 mm. The plane of the suture is inclined about 30 degrees from the normal transverse condition.

The siphuncle is not often seen in this species, owing to poor preservation. It is located slightly eccentrically, closest to the side upon which the sutures slope apicad and the annuli slope orad, which in one of our specimens (Pl. 2, figs. 9-10) is slightly convex. Where the shell height is 32 mm., the center of the siphuncle is 9 mm. from the convex side, and 13 mm. from the concave side. This specimen when sectioned revealed the outline of the segments, though only faintly. The segments are essentially similar in form to those of *G. crossi*, in which the siphuncle is better known. A segment 4 mm. long expands from 3 mm. at the septal foramen to 4 mm. in the camera. The necks are short, cyrtochoanitic, and the form of the segment is like that of the ephebic portion of a *Treptoceras*, dorsum and venter convex, the segment slightly more slender than in typical *Ormoceras*. No organic deposits have been observed in the siphuncle of this species, but mural deposits have been observed in the cameræ. However, the absence of deposits has not been demonstrated, as no specimens have been available for sectioning which were located far enough apicad of the living chamber that siphonal deposits may reasonably be expected. On the contrary, the closely allied *G. crossi* suggests that *G. gorbyi* may also have annulosiphonate deposits.

The annuli are low, rounded, and strongly oblique from the earliest stage of the shell observed. They are spaced normally with four (occasionally four and a half) interspaces in a length equal to the diameter of the shell. Up to a diameter of 25 mm. the annuli can be traced across the supposed ventral side where they slope strongly apicad. At a diameter of 30 mm., however, the ventral part of the annulation is lost, and the ribs cannot be traced across the venter. The annuli are so oblique that a line normal to the axis of the shell will touch three adapically, and adorally where the obliquity is slightly greater will easily cross three. The septa, being oblique in a direction opposite to that taken by the annuli, will easily cross three annuli adapically. Adorally they should cross four annuli, except that the annuli are not visible on the ventral surface.

The surface markings of the species are variable and irregular. The strong longitudinal liræ occur about eight in a width of 10 mm.; secondary liræ, weaker, are interspaced. Tertiary longitudinal markings occur, but are irregular in spacing, number, and erratic in distribution. Transverse markings are always present but irregular in spacing and strength. They are usually best seen at the crests of the annuli.

The living chamber is long and slender in proportion to the diameter of the shell. A living chamber, 105 mm. long, increases from 26 mm. to 28 mm. in greater diameter, but is very slightly flattened. Even this living chamber may not be complete adorally.

When complete this very slender species must have attained a length of at least 30 inches and probably attained a diameter of 40 mm., as the phragmocone is known to continue up to a diameter of 34 mm.

Discussion.—This species is well developed in the Saluda and upper Whitewater in Indiana and in the vicinity of Oxford, Ohio, but is not known farther east in the Clarkesville region, or farther east and south from there. The strongly oblique annuli serve as the most diagnostic character, together with the suppression of annuli on the ventral side of the mature shell. No other species have the annuli quite as strongly oblique. However, it often happens that shells are so preserved that the ventral side is missing. Such specimens sometimes fail to show the obliquity of the annuli and may be confused with *G. crossi* on the basis of this feature alone. *G. crossi* can be readily distinguished on the basis of septate specimens, as the cameræ are much deeper. Aseptate specimens may be distinguished only if they retain the surface markings clearly, for *G. gorbyi* has transverse markings which *G. crossi* lacks, while *G. crossi* has more numerous and more regularly spaced tertiary longitudinal markings. The species is larger than *G. hammelli* and has more oblique annuli which persist to a much later stage of growth. On *G. hammelli*, the annuli become very faint at a diameter of 30 mm. The species is not readily confused with other associated forms.

Species from other regions fail to resemble *G. gorbyi* closely in the strongly oblique annuli which become obsolescent on the venter in later stages of growth. "*Spyroceras*" *geronticum* Foerste and Savage (1927, p. 38, pls. 5-6) has oblique annuli but straight sutures. The adapical portion of the annuli remain strong throughout, and the shell contracts toward the aperture. The form of the siphuncle segments and consequently the generic position are uncertain for this species from the Shamattawa limestone of Hudson Bay. Similar in aspect are "*Metaspyroceras*" *gaspense* Foerste (1936, p. 377, pl. 56, fig. 6) of the Whitehead formation of Gaspé and *Metaspyroceras clavatum* Miller and Carrier (1942, p. 536, pl. 75, fig. 5) of the Bighorn formation. In having annuli which slope forward on one side of the shell and sutures which slope forward on the opposite side, all species included in *Metaspyroceras* in the sense in which it was used by Foerste, are comparable on the basis of gross features. Typical *Metaspyroceras* is orthochoanitic. It is not known, however, whether some of the other species including the two noted above, are orthochoanitic or cyrtochoanitic.

Types.—Holotype, U. S. National Museum, No. 64337. Hypotypes, Univ. of Cincinnati, No. 24207, Shideler Collection, 3 specimens.

Occurrence.—From the cephalopod zone of the basal Whitewater beds, Little Four Mile Creek, near Oxford, Ohio. The species is best developed in the Saluda, where it has been found at various localities largely in Indiana. The holotype is from Franklin County, Indiana. Other specimens are from Batesville, Indiana, Laurel, Indiana, and McDill's Mills, Oxford quadrangle, Ohio. The species is not developed in the upper beds of the Saluda in southern Indiana, but appears to be confined very largely perhaps completely to the lower beds near or at the level of the *Tetradium* reef.

Gorbyoceras crossi Flower, n. sp.

Plate 1, fig. 7; Plate 2, figs. 4, 7; Plate 3, figs. 5-8; Plate 4, fig. 4

Shell straight, circular in section, with low slightly oblique annuli, very simiar to *G. gorbyi* in aspect. The rate of expansion is gradual, the type increasing from 21 mm. and 23 mm. to 22 mm. and 24 mm. in a length of 60 mm. The sutures are slightly oblique, uncurved, and slope orad on the siphonal side of the shell. The cameræ are deeper than in *G. gorbyi*, occurring five in a length equal to the diameter of the shell and have been observed in portions of the shell ranging from 18 mm. to 27 mm. in diameter. The septum is oblique and relatively flat, being 2 mm. in depth at a diameter of 18 mm., and 2.5 mm. at a diameter of 20 mm. The siphuncle, well exposed in the holotype and a paratype, is eccentric, its center 6 mm. from one side of the shell and 11 mm. from the other at the apical end of the holotype. Here a segment 4 mm. in length increases in diameter from 2 mm. to 3.5 mm. The segments are similar to those of ephebic *Treptoceras* in form. Near the adapical end of the holotype faint traces of annulosiphonate deposits can be seen, suggesting that *Gorbyoceras* in having such deposits may be traced back to the Chazyan "*Spyroceras*" *clintoni* (Miller). Mural cameral deposits are developed which extend farther orad in the cameræ than do the siphonal deposits.

The annuli are low, rounded, perhaps slightly less elevated than those of *G. gorbyi*, and differ from those of that species mainly in being much less oblique. They slope apicad over the antisiphonal side of the conch, but are nearly transverse on the antisiphonal side particularly in the younger stages of the shell.

Adorally the annuli appear to become more uniformily oblique, and fragments of the later stages of growth are easily confused with *G. gorbyi* if aseptate, particularly when the ventral side of the shell is missing. The annuli here lack the tendency to disappear on the venter, evident in the later stages of *G. gorbyi,* and fail to weaken adorally as rapidly as in *G. hammelli.*

The fine surface markings of the species consist of three series of longitudinal markings. The strongest longitudinal liræ, spaced about 2 mm. apart, have between them a weaker series, and in addition fine longitudinal lines which vary in number. From one to three may occur in an interspace between a primary and a secondary longitudinal ridge. Transverse markings are vestigial, and when they can be seen are very fine and closely spaced, yet occasionally one will be thickened and made prominent, though this event seems to occur only occasionally and irregularly.

One large fragment assigned to this species is an aseptate shell 190 mm. in length, increasing from 34 mm. to 38 mm. Near the adoral end the shell is contracted over a region about 18 mm. in length. The annuli of this form are slightly more closely spaced, approaching a condition where five and even five and a quarter interspaces occur in a length equal to the diameter of the shell. However, the annuli are less oblique than in *G. gorbyi,* and the surface markings lack the transverse elements of that species.

Discussion.—*G. crossi* may be confused with *G. gorbyi,* and with only poorly preserved material, the two are sometimes difficult to distinguish. However, *G. gorbyi* has the annuli more strongly inclined, and when the surface markings are preserved it can be distinguished by the development of transverse raised lines, while *G. crossi* fails to show prominent transverse markings, and has more secondary longitudinal markings than *G. gorbyi.*

Among shells from other regions of somewhat similar aspect are *"Spyroceras" parksi* Foerste (1924, p. 223, pl. 29, fig. 2; pl. 30, fig. 4) which has more numerous and more closely spaced secondary longitudinal markings and the siphuncle is described as subcentral. Judging from the known specimens, this species does not attain a size comparable with *G. crossi.* It is nevertheless the only form which appears to be very closely similar to the Cincinnati species. "*S*". *parksi* is older than *G. crossi,* being from the Clay Cliffs (Meaford) which is regarded as the equivalent of the Waynesville. No specimens of *G. crossi* are known below the base of the Saluda coral bed, and many are from the upper Saluda of Indiana which is properly the equivalent of the upper Whitewater. "*Spyroceras*" *chambliense* Foerste (1924, p. 222, pl. 39, fig. 3; pl. 40, fig. 1) from the Lorraine of Ontario is readily distinguished by the fewer and more prominent secondary longitudinal markings. No known Anticosti forms are strictly comparable to this species.

Types.—Holotype, Univ. of Cincinnati, No. 24083. Two paratypes, W. H. Shideler Collection.

Occurrence.—The holotype is from the Saluda of Versailles, Indiana. Other specimens, also from the Saluda of Indiana, are from the Hitz layer of Madison, Indiana, and Canaan, Indiana.

Gorbyoceras hammelli (Foerste)

Plate 1, figs. 2, 3, 9; Plate 2, fig. 5; Plate 3, figs. 1, 4; Plate 4, figs. 1, 2, 5; Plate 5, figs. 4, 9

Orthoceras (*Dawsonoceras*) *hammelli* Foerste, 1910. Denison Univ. Bull., Sci. Lab., Jour., vol. 16, p. 74, pl. 1, fig. 4. (Expl. of plates read *Dawsonoceras hammelli.*)

Dawsonoceras hammelli Bassler, 1915. U. S. Nat. Mus., Bull. 92, vol. 1, p. 388.

Spyroceras hammelli Foerste 1924, Geol. Surv. Canada, Mem. 138, p. 222, pl. 39, fig. 1; pl. 40, fig. 3.

Hammelloceras hammelli Shimizu and Obata, 1935, Shanghai Sci. Inst., Jour., sec. 2, vol. 2, p. 6.

Conch orthoceraconic, circular in section, slender, marked by broad rounded annuli which are developed in the earliest stage observed, at a diameter of 2.2 mm., and which tend to become lower and more obscure over the adoral part of the shell. The rate of expansion as measured on a considerable series of specimens appears somewhat variable. A slightly flattened shell, the most complete individual retaining early stages, increases from 4 mm. and 5 mm. to 6 mm. and 8 mm. in a length of 40 mm. Another increases from 5 mm. to 13 mm. in 80 mm., and to 15 mm. in the succeeding 35 mm. The later stages are more uniformly slender, one hypotype increasing from 18 mm. to 21 mm. in 40 mm., and another, from 20 mm. to 24 mm. in 60 mm.

The annuli are only slightly oblique, sloping apicad on the antisiphonal side of the shell. The sutures are slightly oblique in the opposite direction, so that a suture will touch two annuli. The cameræ are spaced at intervals corresponding to the annuli in the early stages, but gradually become slightly more closely spaced farther orad. Three annuli and cameræ occur in a length equal to an adoral diameter of 4 mm. The annuli occur three and a half to four in a similar diameter at 6 mm., ranging between three and a half to four up to 16 mm., then becoming more closely spaced so that up to a shell diameter of 24 mm., the latest stage of the shell observed four and a half to five annuli occur in a length equal to an adoral shell diameter. The cameræ are spaced about equally with the annuli adapically, though they are obscure there in most specimens. The septa seem to occur generally at the interspaces, which appears to be the generalized condition in annulated orthoceracones. Adorally the septa are more closely spaced than the annuli, four cameræ occurring in a length equal to a diameter of 9 mm., where three and a half annuli occupy the same length, and five occur in a similar length at 16 mm. where there are four and a quarter annuli.

The septum is very shallow, 1 mm. in depth at a diameter of 12 mm., and slightly less than 2 mm. at 18 mm. The siphuncle is eccentric but has not been observed in a stage where the diameter is less than 5 mm. It becomes more eccentric adorally, so that in an early stage its center is 4 mm. from one side and 8 mm., from the other, but where it is 6 mm. from one side it is 11 mm. from the other. The segments of the siphuncle are cyrtochoanitic. At a diameter of 5 mm. in transverse section they are elongate oval, resembling in form very closely the segments in the Pennsylvanian *Pseudorthoceras*. Adorally, in vertical section, the siphuncle becomes biconvex, the side closest to the wall of the shell has a strongly recurved neck, but the connecting ring has not been observed. The opposite side is broadly expanded, with a recurved neck and uniformly convex connecting ring, more expanded than in a similar stage of *Gorbyoceras duncanæ* and closer to the condition of *G. crossi*.

The surface markings vary with the growth stage. In the early stages only a single series of longitudinal liræ are present. Farther orad secondary weaker liræ alternate with the original primary ones. A tertiary weaker series is then developed, which is rather irregular in spacing, there being sometimes two liræ in an interspace, normally one, and occasionally none. In addition, very fine faint longitudinal markings form a fainter background appearing in the interspaces between the stronger ones. These have not been observed except in the best preserved surfaces. Transverse markings appear at a diameter of about 10 mm. These are strongest and most conspicuous near the crests of the annuli, and may be faint or altogether absent in the interspaces. They may become irregular adorally. The primary liræ are 2 mm. apart at a diameter of 14 mm., but adorally may be 3 mm. or even 4 mm. apart, the spacing varying erratically around the circumference of a single individual.

The living chamber was probably long and slender in this species. I have seen no examples in which it can be said to be complete.

Discussion.—This species is marked by the adoral decrease in the strength of the annuli and is particularly characteristic of the upper Whitewater horizon and its southern extension at Madison, the Hitz layer. The low rounded annuli distinguished the species from *Anaspyroceras williamsæ, Gorbyoceras duncanæ,* and *G. simile.* They are much less oblique than in *G. gorbyi. G. crossi* is the most similar species. However, in that species the annuli remain strong to a later stage of growth, tertiary longitudinal markings are much stronger and more numerous, the species attains a considerably larger size, and the siphuncle is not as eccentric in portions of the shells of equal diameters.

The ornament of this form sometimes approaches closely to that of *G. duncanæ*, but the annuli are lower and more rounded, and the liræ are not strengthened as they cross the annuli. *G.* sp. aff. *calvini* may be separated on the same basis and also by the presence of grooves dividing the liræ Except for this feature, however, the two may sometimes be rather difficult to distinguish, as in early stages comparable in diameter to the known portion of *G.* sp. aff. *clermontense* the annuli are still rather strong. However, in this stage other differences appear which in well-preserved specimens should serve to separate the two readily, in particular the depth of the cameræ which are relatively very shallow in *G. hammelli,* and the siphuncle which is more eccentric and also more expanded in *G. hammelli.*

"Spyroceras" ferum (Billings) of the Ellis Bay formation at Anticosti is superficially rather similar to *G. hammelli,* so much so that it is suspected that the two are very closely related. However, in that species the annuli are broader, though low and rounded, and persist to a later growth stage. The annuli are more widely spaced. Surface markings of the two species are quite similar.

Foerste described this species from the upper Richmond of Indiana. His type specimen is figured in an inverted position, that is, with the adapical end uppermost on the plate, thus giving the impression of a shell which contracts toward the aperture. That this is not the case is perfectly clear, however, from his description. He subsequently recognized this species from the Meaford formation of Ontario, which is currently correlated with the Waynesville, and is therefore, slightly earlier than the occurrence of the species in Ohio or Indiana. I have had none of the Ontario material for comparison; however, from Foerste's description and figures there are slight differences, which, if constant, may eventually serve to set the Ontario form apart as a separate species or variety. The annuli are slightly lower than in corresponding stages of typical *G. hammelli,* and longitudinal markings of the tertiary series are slightly more numerous and more conspicuous. Foerste described the siphuncle as nearly central in location, but did not give exact measurements. The writer would not apply such a description to the siphuncle of typical *G. hammelli,* and it is possible that this feature may supply a more significant difference than that shown by the surface markings.

G. hammelli was made the type of this new genus *Hamelloceras* by Shimizu and Obata, which they placed in a new family

Hammelloceratidæ, erected for annulated shells with longitudinal markings and with a cyrtochoanitic siphuncle. This family was set apart from the Spyroceratidæ, which they erected for annulated shells with longitudinal markings and an orthochoanitic siphuncle. However, their indiscriminate proposal of new generic names was obviously not accompanied by any first hand study of the species which they used as genotypes. As shown elsewhere by the writer *Spyroceras* is not orthochoanitic, but a member of the Dolorthoceratinæ of the family Pseudorthoceratidæ. This cyrtochoanitic family, dominately composed of orthoceracones, did not make its appearance until Devonian time and is characterized by highly modified annulosiphonate deposits. Here it is shown that *Gorbyoceras gorbyi*, which they believed to be orthochoanitic, therefore placing their new genus *Gorbyoceras* in the supposedly orthochoanitic Spyroceratidæ, is cyrtochoanitic. As such it is the first generic name proposed for annulated cyrtochoanitic shells with longitudinal markings and generalized annulosiphonate deposits. It has page priority over *Hammelloceras* and *Porteroceras*, genera proposed for such shells. *Gorbyoceras hammelli, G. crossi,* and *G. gorbyi* are very closely related species, so much so that I am not certain whether their earlier stages can be separated with certainty. It is obviously absurd to attempt to place such closely related forms in two distinct genera, therefore *Hammelloceras* is regarded as a synonym of *Gorbyoceras*. *Porteroceras* Shimizu and Obata incidentally shares the same fate.

Types.—Location of holotype, unknown. Hypotypes, Univ. of Cincinnati, Nos. 24164-24166, Shideler Collection, Miami University, two figured specimens and a large suite of supplementary specimens.

Occurrence.—This species is best developed in the upper part of the Saluda of southeastern Indiana. Many of the specimens, including the holotype, are from the upper Saluda in the vicinity of Madison, Indiana. There the Hitz layer has yielded a considerable number of small shells referable to this species. The species may be traced northward to Canaan, Indiana, where it is fairly abundant and well preserved, and to Versailles where it is rare. It is not known to appear farther north where the upper beds of the Saluda grade into the upper Whitewater facies.

Gorbyoceras duncanæ Flower, n. sp. Plate 1, figs. 1,6; Plate 4, fig. 12

Conch orthoconic, slender, circular in section. The shell expands slowly. The holotype, the most complete specimen known, is slightly flattened, but increases from 15 mm. and 14.5 mm. to 22 mm. and 18 mm. in the 50 mm. of the phragmocone, and in the succeeding 90 mm. of the shell, apparently complete, attains an estimated width, slightly flattened, of 30 mm. and a height of 18 mm. The shell is marked by conspicuous transverse annuli. A suture is found in each interspace. The sutures are straight and transverse. The cameræ are spaced three and a half in a length equal to the adoral diameter of 14 mm., but four in a length equal to a diameter of 20 mm. The septum is more strongly curved than in any other species of the genus. It is between 4 mm. and 5 mm. deep where the diameter of the shell is 15 mm., and becomes shallower farther orad, being 3 mm. deep at a diameter of 20 mm. The siphuncle is eccentric, its center 5 mm. from one side of the shell and 9 mm. from the other. The segments are expanded. In transverse section the segments are rounded but longer than high, as in ephebic *Treptoceras* when just past the condition of typical *Ormoceras*. In vertical section the siphuncle is much more strongly expanded on the side closest to the wall of the shell. On both sides the septal necks are short and cyrtochoanitic, but on the supposed ventral side the connecting ring is much more expanded.

The annuli are straight, transverse, and prominent. Four interspaces occur in a length equal to the diameter of the shell throughout, except in the earliest stage noted where, as in the case of the cameræ, three and a half occupy such an interval. The annuli are narrowly rounded and separated by broad deep concave interspaces. The surface of the shell is marked by a series of longitudinal liræ, alternating in strength. The strongest of these, of which 12 occur in half the circumference of the holotype, are conspicuous because they are thickened over the annuli, a feature which may even be retained on the internal mold in the form of low vestigial nodes on the annuli. These liræ are spaced from

2 mm. to 3 mm. apart, the distance varying about the circumference of the holotype at a single region. Between the primary liræ are slightly fainter secondary liræ which fail to enlarge as they cross the annuli. Tertiary liræ appear, at least one between each primary and secondary set of liræ. The types fail to show any finer transverse markings, but the surfaces are not clearly enough preserved that such markings can be said to be definitely absent.

Discussion.—The thickening of the primary liræ over the annuli is a feature which will set this species apart from all of its associates. Indeed, few other species show such features. One is *"Spyroceras" perroti* (Clarke) (see Foerste, 1935, p. 244, pl. 37, fig. 7) of the Elgin member of the Maquoketa shale, but the annuli of that form are much closer, and secondary as well as primary ribs are strengthened. Further, both primary and secondary ribs are much coarser than in our species. Probably *"Spyroceras" calvini* Foerste (1935, p. 245, pl. 32, fig. 2) is closely allied. Here only the primary ribs are strengthened. Again the annuli are more closely spaced, and this time are much lower and less conspicuous than in *G. duncanæ*. *S. calvini* is one of the few species in which the primary ribs are known to be divided, so that they would be concave at their crests in section. *G. duncanæ* does not show this feature, but one specimen, that is similar to *G. duncanæ* but with deeper cameræ and a more slender siphuncle, described as *Gorbyoceras* sp. aff. *calvini*, does.

Types.—Holotype. Univ. of Cincinnati Museum, No. 24086. Paratypes, Univ. of Cincinnati, No. 24087, Shideler Collection, 2 sp.

Occurrence.—Lower Whitewater, Saluda and upper Whitewater, western Ohio and Indiana. Holotype—Saluda (?) by lithology, found loose near top of lower Whitewater at McDill's Mills, College Corners quadrangle, near Oxford, Ohio. Lower Whitewater, Little Four Mile Creek, near Oxford, Ohio, (paratype, Shideler Collection). Liberty or lower Whitewater, from the upper cuts of the railroad at Weisberg, Ind. (U. C., No. 24087). One additional specimen is from the upper Whitewater from railroad cuts west of Oxford, Ohio.

Gorbyoceras, sp. aff. calvini Plate 1, figs, 4-5

Cf. *Spyroceras calvini* Foerste, 1935, Denison Univ. Bull., Sci. Lab., Jour., vol. 35, p. 245, pl. 32, fig. 2.

A single specimen has been found which resembles "*Spyroceras*" *calvini* in the essential features of the ornamentation of the shell. This specimen, 40 mm. in length, is circular in section, and expands from 11 mm. to 13 mm. in that length. The shell is strongly annulated, three interspaces occurring in a length equal to the adoral diameter of the shell. The annuli are narrowly rounded, prominent, and separated by broad concave interspaces. The aspect of the shell is similar to that of *Gorbyoceras duncanæ*. Three series of longitudinal markings are present. The primary liræ spaced about 1.8 mm. apart, are thickened as they pass over the annuli. The crest of each of these liræ is divided by a shallow median longitudinal groove, discernible throughout the length of the specimen, but slightly broader on the crests of the annulations than elsewhere. The secondary liræ are slightly weaker, spaced between each pair of primary liræ. They are also marked by median grooves so that their crests are bifid, but these grooves are narrow, sometimes vestigial in the interspaces, and clear only on the crests of the annuli. The tertiary longitudinal markings are simple and fine. Transverse liræ separated by broader interspaces occur about 16 in a length of 5 mm. These cross the tertiary longitudinal liræ, but are interrupted by both the primary and secondary longitudinal liræ.

The conch has yielded four and a half segments of the siphuncle upon being sectioned. These are subcentral, straight on one side, very slightly expanded on the other, not so much as in *Gorbyoceras curvatum*, and are empty. Three and a half occur in a length equal to the diameter of the shell.

Discussion.—The specimen here described resembles *G. duncanæ* very strongly. The differences in ornament were at first assumed to be due to different conditions of preservation and weathering. However, subsequently enough specimens of *G. duncanæ* were examined to lead to the belief that the differences shown by this specimen were real. Further, the annulations and cameræ are slightly deeper than in *G. duncanæ* and the siphuncle is more slender than in any known representative of that species. Fortunately specimens of *G. duncanæ* equal in diameter to this form have been available for comparison.

Comparison with *"Spyroceras" calvini* is more difficult inasmuch as that species is based upon a single flattened specimen which does not show the features of the cameræ or siphuncle. Aside from the considerably larger size, which might mean only that our form represents an earlier stage of growth, differences are supplied by the somewhat closer annuli, which are also considerably lower than in the Cincinnati form. The two are probably not identical, but better material of both the Maquoketa and the Whitewater form is needed for a fuller comparison.

Figured specimen.—Univ. of Cincinnati Museum, No. 24090.

Occurrence.—From the lower Whitewater at McDill's Mills, on Four Mile Creek, near Oxford, Ohio.

Gorbyoceras curvatum Flower, n. sp. Plate 5, figs. 2, 3

This species is represented in our material by a single specimen, a portion of a phragmocone 40 mm. in length, somewhat flattened, increasing from a height of 11 mm. and a width of 9.5 mm. to a height of 17 mm. and a width of 13 mm. Three and a half cameræ occur in a length equal to the greater diameter of the shell. The sutures are straight and transverse, the septa so spaced that the sutures fall in interspaces between the annuli. Both annuli and sutures slope faintly orad on the convex side of the very slightly curved shell. The septum is shallow, equal in curvature to half the depth of a camera. The siphuncle is planoconvex in vertical section. At a shell height of 12 mm. the center of a segment is 5 mm. from the convex side of the shell, 7 mm. from the concave side. A segment is 3 mm. in length, expanding from 1 mm. in diameter at the septal foramen to 1.8 mm. within the cameræ. The side closest to the shell wall is faintly expanded, the neck slightly recurved, and the profile of the connecting ring slightly but uniformly convex. On the opposite side the siphuncle wall is straight and the neck is not recurved.

The surface of the type is obscured by Bryozoa. However, it is evident that the annuli were low and relatively broad, and that this species agrees with *G. duncanæ* in that primary liræ are thickened as they pass over the annuli. Secondary liræ show evidence of a slight thickening there also. Tertiary liræ were probably present but are obscured by Bryozoa as are any transverse markings which may have been present.

Discussion.—This species resembles *G. duncanæ* but differs from it in the simpler condition of the siphuncle. Happily the siphuncle in *G. duncanæ* is known for a comparable growth stage in vertical section, and in that species the siphuncle is definitely broader and more expanded. Further differences are found in the slightly curved condition of this species, the lower and broader annuli, and the thickening of secondary as well as primary liræ over the surface of the shell. *"Spyroceras" calvini* Foerste of the Maquoketa lacks the curvature of this species, does not have the secondary liræ strengthened over the annuli, and has the annuli more closely spaced. *"Spyroceras" perroti* (Clarke) of the Maquoketa is straight, so far as is known, is more closely annulated, and has the liræ much more strongly developed.

Type.—Holotype, Univ. of Cincinnati Museum, No. 24088.

Occurrence.—From the Richmond, near Clarkesville, Ohio. By lithology, in particular the aspect of the preservation of the septa, this specimen is believed to be derived from the *Orthoceras fosteri* zone near the top of th Fort Ancient member, the basal member of the Waynesville. The type is the gift of Miss Carrie Williams of Clarkesville, Ohio.

Gorbyoceras simile Flower, n. sp. Plate 1, fig. 8

Only adoral portions of this shell are known, ranging in diameter from 27 mm. to 40 mm. The shell is straight, slender, probably originally circular in section, though most specimens are slightly flattened. The rate of expansion was apparently slightly greater adapically than adorally. The holotype with a maximum length of 120 mm., expands from 38 mm. to 40 mm. in a length of 90 mm., increasing to 39 mm. in the first 40 mm. The largest specimen observed is an aseptate fragment increasing from 39 mm. to 43 mm. in 100 mm. and incomplete adorally.

The sutures are spaced equally with the annuli of the shell, and like the annuli, are slightly oblique, sloping apicad on the supposed ventral side. Five cameræ occur in a length equal to the diameter of the shell. The septum is well curved, 8 mm. in depth at a shell diameter of 34 mm. The siphuncle has not been observed. Evidently it was not marginal and must have been very nearly central in position, as shown by preserved parts of the septal surface. The form of the segments of the siphuncle is not known. The species is assumed to be cyrtochoanitic on the basis of its strong similarity with *Gorbyoceras microlineatum* Foerste, as noted in the discussion below.

The annuli are spaced five in a length equal to the diameter of the shell, or rather, five interspaces occur in such an interval. The annuli are rounded, well elevated, narrow, with broad concave interspaces. The holotype preserves traces of fine equal longitudinal markings, but they are too obscure to be measured. Probably they were spaced about eight in a width of 5 mm. One specimen shows in addition irregular transverse rugose markings, clearly a feature of the interior of the shell and not of the exterior. Almost identical markings have been figured by Foerste (1936, pl. 57, fig. 4) in *"Metaspyroceras" gaspense* and have been noted in other annulated species of spyroceroid aspect.

Discussion.—This species may be recognized by the large size of the shell, the strong annuli, and the very fine surface markings. *Anaspyroceras williamsæ* which has somewhat similar strong annuli and deep septa is known to be orthochoanitic, but can be differentiated best by the condition of the annuli which are perfectly transverse, and the coarse longitudinal markings and finer transverse markings. It is not known to approach this species in size. *Gorbyoceras duncanæ* also has strong annuli and deeply curved septa, but has transverse annuli which do not slope apicad on the venter, and has prominent longitudinal markings which alternate in strength. Such markings would be preserved if they were present on *Gorbyoceras simile.*

The species is more closely similar to *Gorbyoceras microlineatum* (Foerste, 1928, p. 274, pl. 36, figs. 1-2; pl. 37, fig. 1) of the English Head and Vaureal formations of Anticosti than to any other described species. Superficially specimens of these two species are very similar in aspect, both having the annuli and sutures similarly spaced and slightly oblique. The annuli of the two species are similar in strength and appearance. However, *S. microlineatum* can be differentiated because four annuli occur in a length equal to the diameter of the shell, while five occur in a similar interval on the Cincinnati species. The same applies to the spacing of the cameræ. Quite probably a further difference is supplied in the spacing of the longitudinal markings. Foerste records the liræ of *G. microlineatum* as occurring 11 in a width of 1 mm. while the markings are very faint on even the best preserved of the specimens of *G. simile,* they are obviously not that closely spaced. *G. microlineatum* was described by Foerste as a species of *Spyroceras.* While true *Spyroceras* is cyrtochoanitic, the segments are barrel shaped, expanding more at the ends than in the middle, and contain deposits similar to those of *Dolorthoceras. G. microlineatum* has a cyrtochoanitic siphuncle, but the segments are only very superficially similar to those of *Spyroceras.* The curvature of the siphuncle wall is more uniform and the necks are shorter and more recurved. Deposits are not known in the species. However, what is known of the interior indicates that this species must be placed in *Gorbyoceras,* as defined in the present work. The Cincinnatian species is so similar that it is placed in *Gorbyoceras* on the basis of its strong resemblance to *G. microlineatum.*

Types.—Holotype and two paratypes, collection of Prof. W. H. Shideler. A third paratype is in the collection of the University of Cincinnati Museum, No. 24198.

Occurrence.—The types are all from the cephalopod zone at the base of the lower Whitewater formation. These specimens are from the vicinity of Oxford, occurring at Little Four Mile Creek (College Corners quadrangle) and Dodge's Creek. One flattened specimen is from the same horizon on Flat Fork of Caesar's Creek. One flattened shell placed in this species with doubt is from the basal Liberty of Dodge's Creek, College Corners quadrangle, near Oxford, Ohio.

SUBORTHOCHOANITIC CEPHALOPODS

This term was proposed by the writer (Flower, 1941, p. 524) as a receptacle for a group of early Paleozoic nautiloids, which are properly neither orthochoanitic nor cyrtochoanitic, but lie on the indefinite boundary between these two dichotomous categories. It contains a small but significant group of genera, believed to represent a stage in the evolution of the stenosiphonate line prior to the development of cyrtochoanitic siphuncles. Although it is known largely from its Chazyan and Mohawkian representatives at the present time, these show deviation in form and structure indicative of a considerable period of pre-Chazyan development of the stock. Further, it is to this stock that the next major division can be traced, the secondary cyrtochoanitic cephalopods. Probably also it is the point of origin of the little known Stereoplasmoceratidæ and is certainly the origin of two anomalous groups, the Mixochoanites and the family Clinoceratidæ.

The writer (Flower, 1941A) in tracing the development of those cephalopods primitively characterized by a thick-walled siphuncle, for which Teichert's term Eurysiphonata was appropriated, implied that stemming from the primitive Plectronoceratidæ there was another genetic line characterized by the retention of thin fragile connecting rings in which there was none of the remarkable regional differentiation of layers and regions found in the Eurysiphonata. Very little is known of the development of the Stenosiphonata in the Ozarkian and Canadian.

Orthoceracones first appear in the Gasconade horizon. The siphuncle is invariably close to the margin of the shell, and the cross section is generally compressed rather than circular. Some of these forms, like *Ellesmeroceras* have large thick-walled siphuncles, and evidently had nothing to do with the beginning of the suborthochoanitic cephalopods. Others, however, have small siphuncles. While the structure of the siphuncle wall is not adequately known, it is possible that they may belong to the stenosiphonate line. Genera as *Ectenoceras* and *Walcottoceras* may have such a relationship. While the Middle and Upper Canadian contain more orthoconic types, genera with thin-walled siphuncles have not been adequately demonstrated here among the orthoceracones, and while depressed or circular sections appear, the siphuncle remains usually close to the ventral side. Further, such of these genera as have been studied adequately, including *Protocycloceras*, *Rudolfoceras* (=*Orygoceras* Ruedemann), and *Baltoceras* exhibit thick rings suggestive of eurysiphonate instead of stenosiphonate affinities.

On the other hand, *Bassleroceras* and possibly the entire Bassleroceratidæ, for *Bassleroceras* appears to intergrade with some of the other genera placed in this family, have thin and undifferentiated connecting rings indicative of the stenosiphonate line. This suggests that the origin of the suborthochoanitic cephalopods may eventually be found in Canadian cyrtoceracones with the siphuncle on the convex side. The relationship, if any, existing between such exogastric Canadian genera, and supposedly endogastric genera which dominated the Wanwanian (=Gasconade) is still highly uncertain.

The recently completed study of the Ozarkian and Canadian cephalopods (Ulrich, Foerste, Miller, and Furnish, 1942; Ulrich, Foerste, and Miller, 1943; Ulrich, Foerste, Miller, and Unklesbay, 1944) presents so little information concerning the structure of the siphuncle wall of the pre-Chazyan cephalopod genera, that it is impossible to distinguish eurysiphonate and stenosiphonate forms or even to inquire critically into the value of such a division. It is clear, however, that gradation between the groups is to be expected among just these cephalopods, for the two lines of descent had not only become well separated but also highly diversified by Chazyan time.

Because of this lack of information it is not possible to determine which of the Ozarkian and Canadian genera mark the beginning of the suborthochoanitic cephalopods. However, stratigraphic evidence found in this work coupled with certain general morphological concepts, indicate that the group probably had its origin in cyrtoconic shells.

It was previously believed by the writer (Flower, 1941B) that the primitive radicle of the suborthochoanitic cephalopods was a generalized orthoceracone, circular in section, with a subcentral siphuncle, such a form as was included in the genus *Sactorthoceras*. Morphological considerations alone indicate that this may not be true. The cephalopod is a bilaterally symmetrical organism. A straight shell, circular in cross section, with a central siphuncle is not a primitive condition for such animals, though it would be for radially symmetrical forms. That it is a successful type as indicated by its persistence from the Chazyan well into the Triassic, is beside the point.

By Chazyan time two groups of suborthochoanitic cephalopods can be differentiated, one an essentially orthoconic type with the central siphuncle, the other an exogastric cyrtoceracone with a ventral siphuncle. The orthoconic types have generally been regarded as primitive. However, on the basis of stratigraphic evidence it now seems necessary to reverse this concept. Orthoceracones with central siphuncles are practically unknown prior to the Chazyan, the older types having marginal siphuncles. Consequently it seems necessary to admit that these forms which have long been regarded as the simple generalized types of cephalopods, and have come to be regarded as primitive, are in fact derived from forms which not only have marginal siphuncles, but are dominantly cyrtoconic.

The secondarily cyrtochoanitic cephalopods (Flower, 1941B) were previously regarded as springing from *Sactorthoceras*. In the light of this new information it appears necessary to revise this concept recognizing the more ancient condition of the suborthochoanitic cyrtoceracones with marginal siphuncles. In the diagrammatic representation of the phylogeny (fig. 9) I have used no family name for these forms because genera known to have such structure, while they embrace *Graciloceras* and *Eorizoceras* of the Chazyan, also may include at least the compressed genera of the Bassleroceratidæ, which would include *Bassleroceras* itself.

From this stock (fig. 9) there must have developed such a form as *Centroonoceras* by migration of the siphuncle toward the center of the shell. Concurrently the cross section becomes more

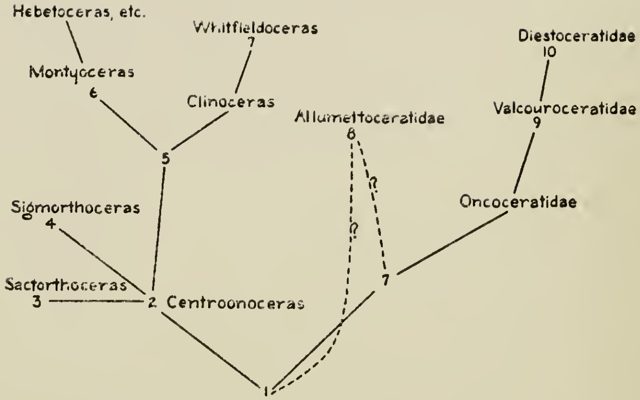

Figure 9. Phylogeny of the suborthochoanitic cephalopods. The ancestral type (1) is a compressed exogastric cyrtocone with a marginal siphuncle. Subsequent figures indicate changes in this morphological pattern. 2. Siphuncle becomes central. 3. Orthoconic form develops. 4. Irregular orthoceracones. 5. Siphuncle becomes planoconvex. 6. Natural truncation of the shell. 7. Cyrtochoanitic segments develop. 8. Cross section becomes depressed. 9. Actinosphonate structure appears. 10. Shells become straight to endogastric brevicones.

rounded. Perfection of the circular section and development of the orthoconic form is noted in *Sactorthoceras,* while doubtless the erratically bent *Sigmorthoceras* belongs to the same general stock. Also from *Centroonoceras* there developed a shell, probably slightly cyrtoconic, in which the segments of the siphuncle are essentially straight dorsally but slightly inflated ventrally. Such shells as yet unknown, are the common ancestor of the Mixochoanites and the Clinoceratidæ. In *Clinoceras* the only deviation from this hypothetical type of shell is the development of a constriction near the aperture of the shell, producing a fusiform living chamber. *Whitfieldoceras* is more specialized in that the segments of the siphuncle have become biconvex, and the fusiform condition of the adoral part of the shell has become more pronounced.

The primitive Mixochoanites are distinguished from the line leading to the Clinoceratidæ first by the appearance of natural truncation of the shell. This produced *Montyoceras* Flower (1941B) which had not yet attained biconvex segments. Biconvex segments appear only in the gerontic cameræ of *Hebetoceras*. The remainder of the development of the Mixochoanites is not represented in the present figure, since it has already been treated adequately by the writer (Flower, 1941B, p. 526).

A second line originating in the compressed suborthocoanitic cyrtoceracones led to the secondarily cyrtochoanitic cephalopods as previously recognized on the basis of Chazyan forms. The development of cyrtochoanitic segments in the ephebic part of the siphuncle must apparently be supplemented by the development of a breviconic living chamber to produce the oldest of the Oncoceratidæ, compressed exogastric cyrtoceracones with empty siphuncles.

Whether the depressed Allumettoceratidæ were differentiated from secondarily cyrtochoanitic cephalopods by the development of a depressed section, or whether the depressed section was developed in suborthochoanitic ancestral types, prior to the appearance of cyrtochoanitic segments, is uncertain. Tentatively the Allumettoceratidæ are treated with the other secondarily cyrtochoanitic cyrtoceracones.

The relationship of the remainder of this general stock is quite well established. The writer (Flower, 1942) has dealt with the development of the form genera of the Oncoceratidæ, a matter treated more extensively in the present work, under the discussion of that family. In Chazyan time actinosiphonate structure appeared in descendants of this stock and produced the family Valcouroceratidæ, the development of which is treated in the systematic part of the present paper. The strong similarity of the early stages of *Diestoceras* with *Valcouroceras* seems to warrant the hypothesis of the close relationship of these two families. The Valcouroceratidæ are more similar to the simpler Oncoceratidæ in the exogastric form of the shell. The Diestoceratidæ are more specialized in the straight to endogastric breviconic form of the shell, and have developed aberrant types of actinosiphonate deposits.

Family **SACTORTHOCERATIDÆ** Flower, n. fam.

This family is proposed for suborthochoanitic cephalopods with subcentral siphuncles. The shell is orthoconic or cyrtoconic, but the siphuncle is located at or close to the center, and expands slightly within the cameræ. The segments are not typically plano-convex in vertical section. The cameræ and siphuncle are usually free from any known organic deposits. Kobayashi originally defined the genus in much broader terms and referred to it species from the Ordovician of Manchuria. Under his definition, however, the genus could be recognized in the Silurian and Devonian and even Mississippian. However, as noted above, the distinction made on the basis of the outline of the siphuncle appears to be useful for Mohawkian cephalopods, but is clearly inadequate in itself when applied to cephalopods from later horizons. This difficulty is eliminated by restricting the genus to species which lack organic deposits in the phragmocone.

Kobayashi regarded *Sactorthoceras* as intermediate between *Orthoceras* on one hand and *Stereoplasmoceras* and *Sactoceras* on the other. He regarded it as representing a stage in the development of the actinoceroid from orthochoanitic cephalopods. The writer has rejected this view since the evidence supplied by the early stages of *Actinoceras* cannot be demonstrated to have the genetic significance which Kobayashi saw in it; instead several other conclusions are possible from the extant morphological evidence (Flower, 1940). Further, a connection between the actinoceroids and *Ellesmeroceras* has subsequently been traced (Flower 1941) leading to the conclusion that Teichert (1933) was correct in the main in proposing a connection between the Actinoceroidea and the Endoceroidea.[8] The genus has not been previously recognized or used by other authors. However, in

[8] *Ellesmeroceras* was formerly considered an endoceroid. Kobayashi regarded the family as holochoanitic and as characterized by diaphragms. Flower (1941) redefined the family as characterized by aneuchoanitic siphuncles with thick rings and no organic diaphragms, regarding it as the common ancestor of the Endoceroidea and Actinoceroidea, probably also the Baltoceratidæ and Tarphyceratidæ.

dealing with Chazyan and Black River cephalopods, I have found that there is a clear distinction between species with tubular and those with faintly expanding and suborthochoanitic siphuncles. The genus *Sactorthoceras* is known in the Chazyan of the Champlain Valley. The writer would also place in it species from the Black River limestones, as well as others from the *Orthoceras* limestones of Sweden.

Sigmorthoceras Kobayashi, typified by *Orthoceras vagum* Ruedemann of the Champlain Valley, differs from *Sactorthoceras* only in its development of erratic curvature, frequently producing a sigmoid shell. Chazyan of America, Toufangian of Manchuria.

Centroonoceras Kobayashi, of the Toufangian of Manchuria and the Chazyan of the Champlain Valley, is similar to the above genera in internal structure but is a slender cyrtoceracone.

I have regarded these three genera as closely united. *Sigmorthoceras* is an erratic form derivation, perhaps not really worthy of a new generic name. *Centroonoceras* is the point of contact of this family with two other distinct lines. In one line, leading to the Clinoceratidæ and the Mixochoanites, the siphuncle remains subcentral, but becomes planoconvex in vertical section. The suture likewise tends to become asymmetrical in vertical section. A slightly curved shell with such a phragmocone would be the common ancestor of *Clinoceras* and of *Montyoceras*. Other specializations appear to characterize these two genera. *Montyoceras* retains the simple outline of the shell, but develops natural truncation, the end of the siphuncle being closed by a lens-shaped plate. *Clinoceras* does not develop natural truncation and is distinguished from the ancestral stock of the Hebetoceratidæ mainly by the form of the living chamber, which is constricted adorally and then expanded at the aperture. However, the simpler but still hypothetical ancestor of *Clinoceras* and *Montyoceras* would probably be better placed in the Clinoceratidæ than in the Hebetoceratidæ, being excluded from the Mixochoanites arbitrarily by the revised definition (Flower, 1941) by which the beginning of the family was placed at the initiation of natural truncation of the shells.[9]

It should be noted that true cyrtochoanitic segments appear in both the Clinoceratidæ and in the Mixochoanites. In the Mixochoanites they are first seen in *Hebetoceras* and become progressively more expanded in higher and younger genera. However, they are always confined to the adoral part of the shell, and the early segments, wherever known, remain planoconvex. In the older and simpler genera there is gradation between the planoconvex and the biconvex and more broadly expanded segments. In more specialized genera the intermediate stages have been lost, and the change has become a more abrupt one. In *Clinoceras* only planoconvex segments are known. In the younger and more specialized *Whitfieldoceras* the ephebic segments have become biconvex. Segments of the siphuncle have not been observed in the early stages of this genus, so it is impossible to say whether they exhibit a recapitulatory planoconvex or an earlier suborthochoanitic stage. As the Oncoceratidæ show some tachygenetic reduction of the suborthochoanitic stages, which are certainly pushed farther back toward the apex of the shell in Trenton than in Chazyan species, it is possible that a similar process may have

[9] Schindewolf (1942) derives the ''Ascoceracea'' from the ''Orthoceracea'' without defining or delimiting either group. At the same time he rejects the connection between the simpler orthoceracones and the Mixochoanites traced by the writer (Flower, 1941) through the slender Hebetoceratinæ as primitive ascoceroids because they ''seem to be closer to the typical representatives of the Orthoceracea''. Apparently he means by this that the Hebetoceratinæ look too much like orthoceracones to be Mixochoanites, or ''Ascoceracea''. This seems a peculiar objection. If, the Mixochoanites were derived from orthoceracones as Schindewolf believes, I am sure that I do not know what else he expects primitive members of the group to resemble. He rejects, without explaining why, natural truncation reported by Barrande in *Orthoceras truncatum*. Whether Schindewolf is correct in this or not, it does not follow that natural truncation in the Hebetoceratidæ is to be accepted or rejected by this criterion. He seems to have overlooked the lens-shaped plate closing the apex of the siphuncle in the Hebetoceratinæ, the vertical asymmetry of the sutures and the progression of the siphuncle. His reasoning seems involved and a little confused. Possibly it is actuated by the fact that the development of the Mixochoanites presents a remarkably lucid example of the biogenetic law, beginning with a simple tachygenetic series, later complicated by the omission of growth stages. The stratigraphic support of the sequence is such that it cannot possibly be inverted to form a proterogenetic series. Schindewolf has previously written a book purporting to show that the biogenetic law is completely false.

been at work in *Whitfieldoceras,* but whether it has progressed to completion is unknown.

The line from which *Centroonoceras* itself develops is one to which I hesitate to apply a family name at this time but is certainly not identical with any previously described family group. These shells are characterized by a compressed section, a cyrtoconic form, simple though probably variable sutures, a siphuncle which is suborthochoanitic as in the Sactorthoceratidæ, but which lies close to the ventral wall of the shell. In this family are placed the Ordovician genera, *Graciloceras,* known from the Chazyan and Richmond, and *Eorizoceras,* known thus far only from the Chazyan genotype. I tentatively include the Canadian genus *Bassleroceras* and regard it as highly probable that many more pre-Chazyan cyrtoceracones of this stock await recognition. This stock is characterized by the type of phragmocone throughout life found in the youngest stages of many cyrtochoanitic genera of the Chazyan. The known genera are compressed shells. As such, barring minor specializations of form, ornament, and suture, they duplicate the features found in the early stages of Chazyan Oncoceratidæ and Valcouroceratidæ. As these families are differentiated only by the absence of siphonal deposits in the Oncoceratidæ and the development of first a siphonal lining from the connecting ring and then true actinosiphonate deposits in the Valcouroceratidæ, it is highly likely that the Valcouroceratidæ developed from the Oncoceratidæ after the cyrtochoanitic pattern was established. Two other radicles are traceable to these same suborthochoanitic cyrtoceracones, though with less certainty. One consists of the Allumettoceratidæ, which, like the Oncoceratidæ, is suborthochoanitic in the early growth stages. Yet this family, although fundamentally exogastric, with the siphuncle on the convex side, differs from the Oncoceratidæ in its depressed section, a feature retained in the earliest known growth stage. It seems probable, although the conclusion is not absolutely necessary, that the Allumettoceratidæ arose from another part of the suborthochoanitic cyrtoceracones. Even here we meet a problem; for as yet no suborthochoanitic cyrtoceracone is known to combine a marginal thin-walled siphuncle with a slightly depressed section.

The family Diestoceratidæ is regarded as belonging to the same general stock, but evidence of its early ontogenetic stages is lacking, although it is clear that even in Cincinnatian species the segments of the siphuncle are quite slender in the early stages, and this condition may be retained by small species though lost by larger ones, and there appears to be a correlation here between size of the individual and the degree of specialization attained in the siphuncle just as was found in the Chazyan *Valcouroceras*. The similarity between immature *Diestoceras* and *Valcouroceras* suggests a close relationship between the genera.

On the basis of the present known distribution, it is clear that the suborthochoanitic cephalopods were a highly diversified group in the Chazyan. The Toufangian of Manchuria I regard as embracing at least the upper Chazyan equivalent, as is shown by the development in both regions of *Sactorthoceras, Sigmorthoceras,* the Stereoplasmoceratidæ, and several other groups. A few of these genera continue into the Black River in North America, though I have not yet had opportunity to prepare adequate figures of these forms, some of which have been in manuscript for six years. *Gracilocerás* alone is known to extend into the Richmond, though, as noted, the modifications of the Sactorthoceratidæ in Trenton and younger strata are uncertain, but are a possibility that must be investigated before the complicated history of the straight orthoceracones can be unraveled.

From the diversity of this group in the Chazyan and its decline in later divisions of the Ordovician, the existence and in fact the abundance of the group in the Canadian, can be inferred.

Figure 9 illustrates the phyletic relations proposed here. It deals with the two major groups of cephalopods stemming from a primitive cyrtocone. The cyrtochoanitic siphuncle is attained independently at least three times, once in the Mixochoanites, once in the transition from *Clinoceras* to *Whitfieldoceras* in the Clinoceratidæ, and at least once, and probably twice, in the development of these families grouped in the following division, the secondarily cyrtochoanitic cephalopods.

FAMILY UNDESIGNATED

Suborthochoanitic exogastric cyrtocones with marginal siphuncle; typical forms are smooth, externally, and compressed in section. As noted above no name is proposed for this family because it is not yet certain that emendation of the limits of some family already proposed may not prove necessary.

Genus **GRACILOCERAS** Flower

Genotype.—*Graciloceras longidomum* Flower.

Graciloceras Flower, 1943, Bull. Amer. Paleont., vol. 28, No. 109, p. 72.

Conch cyrtoconic, gently curved, slender. The greater part of the length of the shell consists of a living chamber, which is at least twice the length of the phragmocone. The sutures are straight and transverse or sloping faintly orad from dorsum to venter. The septa are usually quite closely spaced. The siphuncle is minute, suborthochoanitic, and located close to the venter. The surface features are not known.

Discussion.—This is an extremely generalized form pattern, but cephalopods which fit it are exceedingly few. Aside from the Chazyan genotype, and a few fragments in association with it that might represent another species, the Richmond species described below is the only species known. Doubtless others await description in intervening parts of the column. The shells are generally small and inconspicuous and may easily have been overlooked as slightly distorted orthoceracones.

Graciloceras extensum Flower, n. sp. Plate 40, figs. 4-5

This species is known only from a single specimen, one lateral side of which is lost by weathering. The shell is 84 mm. in length, very gently curved, with a radius for the venter of about 200 mm. In the basal 20 mm., which constitute the phragmocone, the height increases from 7 mm. to 8 mm., and in the 65 mm of the living chamber the height increases to 27 mm.

The exterior is somewhat roughly preserved. but the sutures are clearly straight and transverse. Three adoral cameræ occupy 6 mm. and do not appear to be contracted adorally. The septum is moderate in curvature, and in vertical section the suture slopes very faintly orad from dorsum to venter. The siphuncle is not preserved. The exterior of the specimen indicates that the greatest width of the shell lies ventrad of the center. In the adoral part of the shell the section is a smooth oval; adapically the venter seems flattened and the section appears triangular. This may, however, be an effect of flattening.

Discussion.—Even in the absence of the essential morphological features of the siphuncle, there is little reason to doubt the generic position of this species. *Gracileceras,* formerly known only from the Chazyan, is characterized by the extremely long living chamber and the extremely short phragmocone. No other Ordovician genus is known which shows these characters in conjunction with an extremely slender and gently curved shell.

Whether the apparent subtriangular section in the early stages is natural or not this form may be distinguished from its Chazyan congeners by the much larger size and the somewhat relatively deeper cameræ. Whether the original section was compressed is uncertain, as the present specimen has evidently undergone some distortion. I have not attempted to restore the width of the shell since the present specimen does not supply a basis for any conclusions on the subject which will have to await better material.

At the base of the type, on the side exhibiting a natural section, are to be seen fragments, including the aboral side of one arm of a minute starfish.

Type.—Holotype, Shideler Collection.

Occurrence.—From the lower Whitewater beds, Flat Fork of Caesar's Creek, near Oregonia, Ohio.

Family **CLINOCERATIDÆ** Flower, n. fam.

This family is erected for a group of faintly curved longiconic cephalopods characterized primarily by a siphuncle which is subcentral throughout life, and in which the segments are planoconvex to cyrtochoanitic. The known genera are further characterized by a gradual adoral contraction of the living chamber, followed by a rapid expansion at the extreme aperture. The aperture is inclined slightly orad from dorsum to venter but lacks a clear hyponomic sinus.

Three genera are assigned here, *Clinoceras, Whiteavesites,* and *Whitfieldoceras.*

Discussion.—This family is distinguished from most other cyrtochoanitic families by the subcentral position of the siphuncle. It is distinguished from the primitive Mixochoanites by the absence of natural truncation, and, in the known genera, by the peculiar form of the living chamber. It is differentiated from the ancestral genus *Centroonoceras* by the form of the living chamber, which is prominent but superficial, but primarily by the development of planoconvex or else cyrtochoanitic segments instead of the suborthochoanitic segments.

Theoretically, there should be a cephalopod which is a simple cyrtoceracone with an unmodified living chamber, which retained its phragmocone entire throughout life, and which differs from *Centroonoceras* in the planoconvex segments of the siphuncle and in septa which are more strongly curved on the ventral than on the dorsal side. Such a type, which is considered here as a primitive *Clinoceras,* would combine the more generalized features of the known Clinoceratidæ and Hebetoceratinæ. Such a form would probably be best included in the Clinoceratidæ. By only the development of natural truncation of the shell *Montyoceras* may be produced from this theoretical type. By modifications of the living chamber, the Clinoceratidæ as at present known may be developed. Were such a form known, it would probably require a new generic name. As a theoretical genus it is in itself unimportant, but it is significant inasmuch as such a form must necessarily have preceded *Clinoceras.* As the boundary separating the Mixochoanites from their ancestors has been arbitrarily drawn by the writer (Flower, 1941) on the basis of the appearance of natural truncation of the shell, this type would, by definition, belong to the Clinoceratidæ, although such a shell, if known from fragmentary specimens failing to show the development of an apical plate closing the siphuncle, would probably not be distinguished for all practical purposes from *Montyoceras* itself.

Each of the three genera of the Clinoceratidæ has some specializations of its own. *Clinoceras,* known at present only from the genotype, *C. dens,* from Ordovician erratics of Prussia, resembles *Montyoceras* in vertical section, in the course of the septa, and the form of the segments of the siphuncle. Its siphuncle, however, lies dorsad of the center of the shell, and the conch is faintly curved exogastrically. Foerste (1926, p. 348) considered *Clinoceras* among the endogastric genera since its siphuncle was closer to the concave than to the convex side of the shell. Reversal of this orientation suggested by the writer (Flower, 1941) on the basis of the similarity of the planoconvex segments with those of the Hebetoceratinæ, serves further to show at once the strong similarity of this shell with the exogastric genera *Whitfieldoceras* and *Whiteavesites.* The dorsal siphuncle is the most peculiar feature of the genus, and one which might appear less constant were more than the single species known. I regard it as a specialized feature, since the siphuncles of all related genera are slightly ventrad of the center when they are all eccentric.

Whiteavesites Foerste (1929, p. 167) is known only from the genotype, *W. winnipegensis* (Whiteaves), of the Dog Head formation of Lake Winnipeg. The siphuncle here is ventrad of the center adapically, dorsad of the center adorally, and the segments are slender but convex on both the dorsum and venter. The shell is depressed but has developed lateral lobes in the sutures.

Whitfieldoceras, discussed in detail below, has simpler sutures, a siphuncle which is central or ventrad of the center, but which appears to be more advanced than that of *Clinoceras* or *Whiteavesites* in having broadly biconvex cyrtochoanitic segments. The form of the living chamber agrees with that of *Clinoceras,* but the contraction and subsequent flaring may be even more pronounced. In the monotypic *Whiteavesites* the living chamber is faintly contracted adorally so that it is slightly fusiform, and only a faint expansion occurs at the aperture.

No other genera are known at present which can be placed with these three in the Clinoceratidæ.

Genus **WHITFIELDOCERAS** Foerste

Genotype.—*Oncoceras mumiæforme* Whitfield.

Whitfieldoceras Foerste, 1933, Denison Univ. Bull., Sci. Lab., Jour., vol. 28, p. 60; Foerste, 1935, *ibid.*, vol. 30, p. 45.

Cross section circular or slightly depressed, shell slightly curved exogastrically in the early portion, straight or nearly so in the mature portion. The shell expands gradually to a point located close to the base of the mature living chamber, and then contracts slowly to the aperture, producing a slender fusiform shell. Curvature is highly variable. Some species, the adapical portion of which is unknown, may appear to be straight. Others are straight except for a slight geniculation at the base of the mature living chamber. The sutures are essentially straight and transverse. The septa are shallow, the siphuncle is located at or slightly ventrad of the center. Dolomitic internal molds show that the segments of the siphuncle expand within the cameræ, but no member of the genus has been examined in section to determine the details of internal structure, so the affinities of the genus are somewhat uncertain. It is not clear from the descriptions whether the aperture preserves a hyponomic sinus. Clearly most species show a main aperture which is slightly inclined orad from dorsum to venter, but neither descriptions nor material show the ventral portion of the aperture clearly.

Discussion.—This genus is very distinctive in its form, on the basis of which one slightly atypical species from the Richmond of Ohio is placed here with doubt, as some of its morphological features are inadequately known, and the shell is somewhat larger than that of previously described species. The previously known species which have been placed in the genus by Foerste are listed below:

W. baffinense Foerste. "Arctic Ordovician" (Trenton-Richmond), Frobisher Bay, Baffin Land

W. clarkei Foerste. Decorah shale, Minnesota

(?) *W. contractum* (Miller), Foerste, 1935, pl. 47). Lander sandstone, Big Horns

W. exiguum (Billings). Trenton limestone (probably Sherman Fall), Ottawa

W. cf. *exiguum* (Billings). Prosser limestone, Minnesota

W. minimum Foerste. Prosser limestone, Iowa

W. mumiæforme (Whitfield). Platteville limestone, Wisconsin

W trentonense Foerste. Trenton limestone (Sherman Fall), New York and Ontario

This genus, in spite of its Trenton-Black River range, does not appear to be confined, as are most such genera, to the Black River and lower Trenton. Mr. G. Winston Sinclair has shown me excellent material which is clearly from the Sherman Fall member at Ottawa, and which is apparently identical with *W. exiguum* (Billings). The range of the genus in the New York Trenton is uncertain, but the writer has seen representatives of the genus in collections consisting otherwise only of material from the cephalopod bearing beds, apparently the Denmark member of the Sherman Fall. The generic position of the single reported Bighorn species is still uncertain in the opinion of the writer, although it would appear that it is at least atypical of *Whitfieldoceras* if, as Miller believed, the siphuncle lies close to the ventral margin of the shell. However, better material is necessary before the position of this species can be determined with any degree of certainty.

Whitfieldoceras is distinctive among cyrtochoanitic cyrtoceracones of the Ordovician not only in its tapering form, but also in its subcentral siphuncle. Marginal siphuncles are found in the Diestoceratidæ, Oncoceratidæ, Valcouroceratidæ, and Allumettoceratidæ. The only genus agreeing closely with *Whitfieldoceras* in the position of the siphuncle is *Clinoceras* Mascke (see Foerste, 1926, p. 348, pl. 37, fig. 2). Flower (1941, p. 528, also fig. 1, p. 526) regarded this genus as faintly exogastric rather than endogastric, a conclusion reached apparently on the basis of the aperture which slopes slightly apicad on the side accepted as ventral by Foerste. If the shell is oriented on the basis of the planoconvex siphuncular segments and the demonstrated orientation of similar segments in *Montyoceras* and *Hebetoceras,* it becomes an exogastric shell with a siphuncle slightly dorsad of the center. Further, if the shell were oriented on the basis of the similarity of the features of the aperture with those of *Whitfieldoceras,* the same interpretation would result. Therefore *Clinoceras* is regarded as a close relative of the most primitive of the mixochoanitic cephalopods, one actually more primitive than *Montyoceras* in that it did not attain natural truncation, though perhaps slightly specialized in the contraction of the entire shell just before the mature aperture is attained. *Whitfieldoceras* is regarded as a specialized descendant of *Clinoceras,* differing in the somewhat greater contraction of the living chamber, and in the development of apparently biconvex instead of planoconvex segments of a siphuncle which still remain relatively close to the center of the shell. Unfortunately this view lacks possible stratigraphic confirmation based upon the age of the genera concerned. *Whitfieldoceras* is not known prior to Black River time. The age of *Clinoceras* is unknown, as the genotype, and insofar as I have been able to discover, the only typical species, is from Ordovician erratics of Germany. While most such erratics are from the "*Orthoceras* limestone" that term covers a multitude of horizons, and while it is certain that relatively low Ordovician is contained in the interval embraced by the term, including some Canadian, the exact position of *Clinoceras* remains uncertain. There is a possibility that it may be pre-Black River. However, the morphological similarity between *Clinoceras* and *Hebetoceras* on one hand, and *Clinoceras* and *Whitfieldoceras* on the other seems sufficiently strong to warrant the relationships quite apart from any stratigraphic evidence, particularly in view of the dissimilarity of other Ordovician cyrtoconic genera.

Whitfieldoceras (?) casteri Flower, n. sp. Plate 41, figs. 1, 2

Conch straight, slender, slightly fusiform. The supposed venter is slightly convex over the greater part of the shell, but is slightly concave near the aperture where the shell is gently constricted before flaring to the margin. The dorsum is essentially straight except in the constricted region. The sides are faintly convex over the base of the living chamber, apparently straight elsewhere, but modified by flattening. The shell is 18 mm. high by 14 mm. wide at the base, enlarging gradually in the 32 mm. of the phragmocone to 24 mm. and 19 mm. at the base of the living chamber. The living chamber is 35 mm. long, and contracts gradually in the basal 28 mm. to 20 mm. and 14 mm., then flaring slightly to 21 mm. and 15 mm. at the aperture.

The sutures are oblique, a condition due probably to distortion, as they form broad lobes on one lateral surface and broad saddles on the other. They were probably originally straight and transverse. Three normal cameræ near the living chamber are subequal and 4 mm. deep. The last two cameræ are shortened gerontically and together embrace an interval of 2.5 mm. Nothing is known of the siphuncle or internal structure. The shell surface is not known. Such traces as remain of the aperture show no evidence of a hyponomic sinus.

Discussion.—The unique specimen upon which this species is based, is given a name here in spite of the somewhat distorted condition of the type and lack of information as to internal structure which is essential for certain generic diagnosis. *Whitfieldoceras* has a subcentral nummuloidal siphuncle. This species is typical in form of *Whitfieldoceras* but is a giant among the other species, all of which are very minute, and it is twice the size of the largest form previously known, judging only by the length of the living chamber. *Dowlingoceras* Foerste (1928A) is slightly similar in form, but lacks the flaring aperture and is a naturally strongly compressed shell. Some of the slender species of *Oonoceras* showing only slight curvature may resemble this form superficially, but those shells are not gibbous at the base of the living chamber; they are naturally compressed with lateral lobes well developed in the sutures, and the cameræ are always quite closely spaced. The condition of the sutures in the holotype suggests extensive flattening, such as would be possible only on the assumption that the holotype was a shell of nearly circular section. In the above description the shell is oriented on the basis of the hypothesis widely applied in such cases that the more convex side is the venter. There is, however, no actual morphological justification for such an assumption on the basis of the single known specimen.

Type.—Holotype, collection of Dr. W. H. Shideler.

Occurrence.—From the upper Whitewater beds of McDill's Mills, near Oxford, Ohio.

MIXOCHOANITES

INTRODUCTION

The Mixochoanites, proposed by Hyatt (1900) as a suborder of the Nautiloidea, as revised by Miller (1932) and later by Flower (1941), now constitute a small aberrant group of cephalopods comprising 14 genera, ranging from Chazyan to Middle Silurian. The forms originally included here are largely the ascoceroids, curious inflated shells in which the sutures are produced into broad saddles which swing orad along the greater part of the length of the living chamber. (Fig. 10.) These, the most specialized members of the group, were the first ones to be known. Subsequently similar inflated shells in which the sutures were less markedly produced on the dorsum and lacked the strong sigmoidal curvature of more specialized types were discovered in the American Ordovician. These constitute the genera *Probillingsites* and *Shamattawaceras*. Of these genera *Probillingsites* was found to range as far down as the Trenton. Flower (1941) subsequently found Chazyan Mixochoanites, constituting the new genera *Montyoceras, Hebetoceras,* and *Ecdyceras* which were not only more primitive in the form of the segments of the siphuncle, but also showed that the slender form of the early stages of the shell in the specialized ascoceroids was recapitulatory in its significance and is not a cœnogenetic feature as was implied by Miller (1932) who proposed that the Mixochoanites were related to some *Oncoceras*-like form.

The developmental stages of the Mixochoanites have been treated elsewhere by the writer. They arose from slender cephalopods with thin-walled (stenosiphonate) connecting rings and short essentially straight septal necks. The initiation of the group is marked by the development of septa which are asymmetrical in vertical section, being deepest well ventrad of the center, and with the septum more steeply inclined on the venter than on the dorsum. Apparently contemporaneous with this feature or nearly so, is the development of an entirely new habit, the ability of the animal to moult adapical cameræ during life and to close the open siphuncle which is left by such a process by a small lens-shaped plate. Subsequently the adoral siphuncular segments tend to broaden from a suborthochoanitic segment which is plano-convex in vertical section, to a broader biconvex segment. This development occurred in the Lower Ordovician, in or before Chazyan time. In Middle Ordovician time the mature part of the shell, all that is commonly found of these organisms, has become inflated, and the sutures show a tendency to slope orad on the dorsal side of the shell. This is carried farther in Upper Ordovician genera, and in the Upper Ordovician the sigmoidal ascoceroid septum is developed, in which the dorsal saddle is sharply set off from the remainder of the suture, and in which it becomes broader adorally than it is at its base. This type of suture is characteristic of the Ascoceratidæ as revised by Flower (1941).

It is not necessary to review the development of the group here further, as no new morphological information has been obtained since this was previously done by the writer. The special modifications of the shell have necessitated the use of some special morphological terms which require explanation.

The mature part of the shell, all that is known of the Cincinnatian forms, consists of a living chamber and a few attached cameræ, normally not more than four. The septum at the base of the specimen has been termed the septum of truncation (T, in fig. 10A) (Miller, 1932). If this is followed by septa which are relatively simple, such septa are termed nautiloid septa. Properly speaking, the septa remain nautiloid throughout life in the Hebetoceratidæ, including the gibbous Upper Ordovician genera *Probillingsites* and *Shamattawaceras*. However, in some representatives of these genera the adoral sutures slope so strongly forward as to suggest the ascoceroid septa of more specialized forms.

The ascoceroid septum (A in fig. 10A) properly confined to one which not only has a dorsal lobe, but in which the dorsal lobe is sharply set off from the remainder of the suture by well-defined lateral angles (L, in fig. 10A). From two to four, rarely more, sutures may be ascoceroid. In such cases the sutures are free where they cross the dorsal surface of the shell, but are either very close together, or more often, fused laterally; while still dorsad of the lateral angles. Normally these septa are either very close together or fused ventrad of the lateral angles, though they often become discrete for a short distance on the mid-ventral region of the shell.

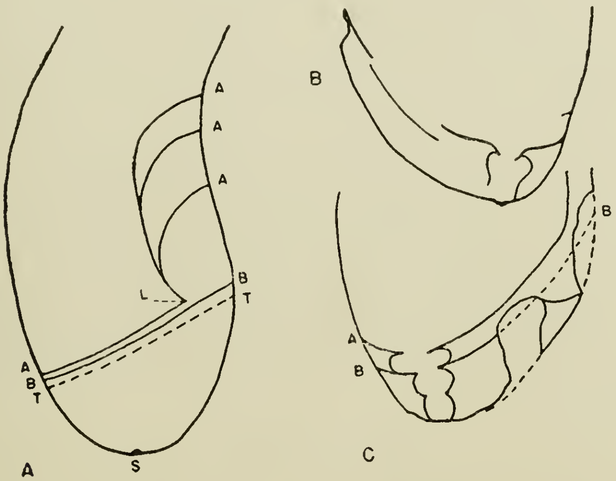

Figure 10. Structure of Cincinnatian Mixochoanites.—A. Lateral aspect of a *Schuchertoceras* internal mold, showing nomenclature of structure. B. Vertical section through base of *Schuchertoceras obscurum* showing suggestion of two areas of inflation in the first segment of siphuncle. C. Vertical section through apex of *Schuchertoceras* cf. *prolongatum* (Foerste), partially restored. A. Ascoceroid septa. B. Basal septum. T. Septum of truncation. L. Lateral angle. S. Siphuncle.

Difficulty was encountered in the study of the Cincinnatian Ascoceratidæ owing to the close similarity of two genera, *Schuchertoceras* and *Billingsites*. These genera can be distinguished by the presence of a single nautiloid septum in *Schuchertoceras* between the septum of truncation and the first ascoceroid septum. *Billingsites* lacks this structure. For brevity, Miller (1932) proposed the term *basal septum* for this septum in *Schuchertoceras*, a term which has been used in the following descriptions. Occasionally a *Schuchertoceras* may show clearly both the suture of the septum of truncation and the basal septum. More often, only a single nautiloid septum is seen at the base of a shell. It has been necessary to resort to sections to demonstrate whether this represented the suture of the septum of truncation or whether the suture of the septum of truncation was not evident, and this represented a true basal septum. In both *Schuchertoceras* and *Billingsites,* the septum of truncation may blend so perfectly with the outline of the rest of the shell that no suture as such is visible.

A peculiar feature of *Schuchertoceras* is the form of the siphuncle between the septum of truncation and the basal septum. It may show two successive bulges, suggestive of two segments of a siphuncle. One species, *S. thomasi* Miller, shows traces of three such segments. Both Miller and Flower have interpreted these bulges as relics of segments formed in the ancestry of *Schuchertoceras* in two distinct cameræ, the septa of which were since lost. Whether in the ontogeny of *Schuchertoceras* itself such septa are first formed and then resorbed. is still a very uncertain point, since no specimens are known which have not attained full maturity.

SEXUAL DIMORPHISM

It is always a different matter to put forward a convincing case for sexual dimorphism in a group of extinct organisms, particularly when no close living relatives are known. However, the possibility is one which was suggested first by Ruedemann (1921) and evidence favoring the recognition of two size groups within a species has since been found by Flower (1938) and Teichert (1940, p. 60) while Kobayashi (1937) has invoked a similar hypothesis to explain differences between the apical portions of actinoceroids.

The problem is a particularly difficult one when the organisms which are suspected of exhibiting sexual dimorphism are so rare that in some instances only a single pair of individuals is known. This is unfortunately true of the Cincinnatian mixochoanitic species concerned. Because sexual dimorphism could not be demonstrated, but only suggested, the two types are treated under different names in two of the three cases. In the third, one member of the pair was too incomplete to merit description. This was the case with *Probillingsites lebanonensis* Flower, n. sp., of the Arnheim of Kentucky. This species is known from a complete holotype representing a small individual and a very incomplete specimen representing a considerably larger individual. As inflation of the shell, present in both specimens, is a phenomenon developed only in the late stages of growth, there are obviously here two mature individuals differing mainly in size. A similar difference was found between two pairs of species in the lower Whitewater horizon. One is represented by the small *Probillingsites oxfordensis* Flower, n. sp., known from only two individuals and the larger form which is given the name of *Probillingsites faberi,* known from a single specimen. In the same horizon were found the relatively large *Schuchertoceras discretum* (Foerste) and the smaller form described as *S. discretum* var. *minor* Flower, n. var. These two forms differ in more than size, exhibiting minor differences in shell proportion and in the course of the sutures. Somewhat greater differences distinguish a third possible but less probable pair of species which might together represent sexual dimorphism in a single true species, *S. geniculatum* and *S. rotundum.* The small *S. geniculatum* differs from most other species of *Schuchertoceras* in that the greatest shell diameters occur well orad on the mature part of the shell. They are nearer the apex of the specimen in *S. rotundatum* which is a larger form. Each of these species is represented by a single well-preserved specimen, though a number of badly flattened shells are referred with doubt to *S. rotundum.* Because of the great difficulty involved in presenting sexual dimorphism as more than a possibility worthy of further consideration, these forms are not treated here taxonomically as conspecific. They are sufficiently different to receive specific or varietal rank on the basis of morphology alone, and therefore have been treated in this way.

STRATIGRAPHIC RANGE OF MIXOCHOANITES IN THE CINCINNATI REGION

In the Cincinnati region the Mixochoanites are rare and usually not very well preserved. None are known here below the base of the Richmond. The Cathys limestone of the Nashville area has yielded a single species, *Probillingsites williamsportensis*

(Foerste, 1924, pp. 217-218, pl. 35, fig. 2A-C). This species or a closely related one may eventually be found in the equivalent Cynthiana limestone of Kentucky, as the two formations are presumably continuous under younger strata separating their areas of outcrop and have many faunal elements in common.

The first of the Cincinnatian Mixochoanites constitute two specimens both from a single layer in the Arnheim at Lebanon, Kentucky. This layer is a thin silicious bed, replete with pelecypods and *Bucania*, which has yielded only three specimens of recognizable mixochoanitic cephalopods. One is the straight slender *Ecdyceras foerstei* Flower, n. sp., the only representative of that genus thus far recognized aside from the Chazyan genotype. The other, *Probillingsites lebanonensis* Flower, n. sp., is based upon a single complete small individual and a fragment of a considerably larger shell too incomplete for description which is tentatively placed under the same specific name.

Two specimens and two species appear in the Blanchester member of the Waynesville. *Schuchertoceras obscurum* Flower, n. sp., is from the basal Blanchester near Jacksonburg, Ohio, while a single living chamber of *Probillingsites oxfordensis* Flower, n. sp. is from the Blanchester of Stony Hollow near Clarkesville.

Probillingsites (?) minutum Flower, n. sp., the only Liberty mixochoanite so far discovered, is from the middle part of the formation, at Dodge's Creek, Oxford, Ohio.

The cephalopod zone just above the base of the lower Whitewater has yielded *Probillingsites oxfordensis* Flower, n. sp., *Probillingsites faberi* Flower, n. sp., *Schuchertoceras prolongatum* (Foerste), *Schuchertoceras discretum* (Foerste), and *S. discretum* var. *minor* Flower, n. var. In addition, this horizon has yielded some badly flattened specimens which cannot be identified with certainty, but probably include *S. rotundum* better known on the basis of material from the upper Whitewater above the Saluda.

The Saluda beds have yielded *Schuchertoceras distinctum* Flower, n. sp., and *S.* cf. *prolongatum* (Foerste). In addition there are in our collections two specimens too poorly preserved to merit figures or description, one possibly a small *Probillingsites* from the Saluda of Versailles, Indiana, and the other probably a *Schuchertoceras* larger than *S. prolongatum* which, however, fails to show either the sutures or the septum of truncation clearly.

The upper Whitewater above the Saluda has yielded *S. discretum* var. *minor, S. rotundum,* and *S. geniculatum.* The Elkhorn has produced a single specimen and species *S. prolongatum* (Foerste).

Mixochoanitic cephalopods are exceedingly rare fossils in the Cincinnatian and are usually not very well preserved. The species listed above are based upon a series of only 15 specimens, with perhaps eight others so incomplete or poorly preserved that identification is uncertain in most instances. These constitute all of the mixochoanitic cephalopods thus far known from the Cincinnati region. With such scant material, little is known of variation within the species and there is little basis for determining the precise vertical range of the species. *S. prolongatum* seems to range from the Saluda to the Elkhorn. Most species present in the lower Whitewater appear in the upper Whitewater also. One form, *Probillingsites oxfordensis,* is represented by a single poor living chamber far out of its normal occurrence. This species is typically developed in the lower Whitewater, but one living chamber is included there which on morphological grounds alone cannot be distinguished specifically. This is from the Blanchester member of the Waynesville. Only *Probillingsites* (?) *minutum* is known from the Liberty, which has yielded few cephalopods other than orthoceracones, and none at all are known from the Covington subseries.

KEY TO CINCINNATI MIXOCHOANITES

1. Shell straight and tubular, orthoconic, readily distinguished from other orthoconic genera by the small number of septa (4) found with a living chamber, and the very deep subconical form of the septa........ *Ecdyceras foerstei*
   Shell gibbous, usually strongly exogastric 2
2. Adoral septa may be more strongly inclined orad than the earlier septa, but are not sigmoidal, that is, do not have dorsal lobes which extend orad without approaching each other .... (*Probillingsites*) 3

Adoral septa are sigmoidal, the dorsal saddle well set off and extending abruptly orad, either its sides parallel or sloping ventrad for a greater part of its length .... (*Schuchertoceras*) 6
3. Shell constricted laterally before the aperture, basal portion gibbous, adoral region tubular 4
Shell evenly curved in outline, without a constriction dividing it into two regions 5
4. Shell minute .... *P.* (?) *minutum*
Shell of moderate size .... *P. lebanonensis*
5. Shell small, living chamber with a maximum length of 25 mm. .... *P. oxfordensis*
Shell larger, living chamber 40 mm. in length .... *P. faberi*
6. Septum of truncation with a clear suture, distinct from basal suture. Lateral angles rounded .... *S. distinctum*
Septum of truncation without a clear suture; lateral angles well developed 7
7. First dorsal saddle low, scarcely produced adorally, not advanced beyond the suture of *Probillingsites*. (Shell small, ovoid, with two widely separated ascoceroid septa, only the last slightly expanded ventrad beyond its base) .... *S. obscurum*
First dorsal saddle with the sides diverging or parallel but truly ascoceroid 8
8. Dorsal saddles narrow, convex adorally over the mid-dorsal region. Sutures dorsad of the lateral angles do not slope distinctly ventrad 9
Dorsal saddles broad, transverse or faintly concave adorally at center. Sutures dorsad of the lateral angles diverge and slope definitely ventrad 10
9. Size large, length 60 mm., greatest diameters at mid-height of shell .... *S. discretum*
Size smaller, length 40 mm., greatest diameters attained apicad of center of shell .... *S. discretum* var. *minor*
10. Shell large, length at least 60 mm., usually more, only two ascoceroid septa which are high and close together .... *S. prolongatum*
Shell smaller, at least three ascoceroid septa, more evenly spaced . 11
11. Greater diameters well orad of center; ventral profile abruptly bent at region of greatest diameters .... *S. geniculatum*
Greatest diameters at center, all profiles well rounded .... *S. rotundum*

STRATIGRAPHIC AND PALEOGEOGRAPHICAL SIGNIFICANCE

The first Mixochoanites known are those of the middle and upper Chazyan, a fauna generally conceded to have boreal affinities. There is undoubtedly a close connection between the faunas and faunal succession in the Chazyan of the Champlain Valley with those of the Mingan Islands. However, the Mixochoanites are not known from the Mingan region as yet, and the cephalopod fauna of the Champlain Chazyan is showing much in common with the southern Appalachian and Murfreesboro (Tennessee basin) Chazyan, as well as with the northward Mingan Island region. Whatever the origin of the Chazyan faunas, subsequently many of the faunal elements did come to be associated with embayments which clearly came from the arctic region. No further Mixochoanites are found, however, until late Trenton time, when *Probillingsites* is found in the Cobourg of Ontario, unnamed upper Trenton of Montreal, the Prosser of Iowa, the Galena of Illinois, and the Cathys of Tennessee. Of these, only the Cathys has not been formerly regarded as carrying a boreal fauna. Recent investigations of the closely allied Cynthiana (Flower, 1942) have shown the presence of not only boreal cephalopod genera, but of species showing closest affinities to supposedly much younger ones of the Fremont limestone, Bighorn and Whitehead formations, the Vaureal of Anticosti,

The Arnheim like the Cathys has been regarded as containing a fauna of south Atlantic origin. This is based upon the known geographic occurrence of some of the species the appearance of which characterize the Arnheim in the south but not in its northern extremities. Such species are those which are new to the region, and their southward range has been taken as an indication of their southern origin. Difficulties are encountered in trying to explain the presence here of *Probillingsites* and *Ecdyceras*. The best hypothesis involves a connection with an arctic embayment from the north, probably extending west of the Cincinnati embayment, although no beds have been identified in the Mississippi region or farther west as being Arnheim in age. However, granting the presence of such an arm of the sea which may have left no permanent record, its existence and a temporary connection with it considerably south of Cincinnati would supply the best explanation of the peculiarly arctic elements in the Arnheim, and probably a similar explanation must be invoked for the Cathys.

The presence of *Schuchertoceras* from the Waynesville to the Elkhorn might seem to indicate that the genus is "diagnostic" of the Richmond, and moreover, of not very early Richmond. However, if as is generally believed, the incursion of new faunal elements from the north into the Cincinnati area is the essential faunal criterion of Richmond time, it must automatically follow that these types must have existed elsewhere in pre-Richmond time. Consequently their presence in strata deposited within the arctic embayment cannot be taken as proof of Richmond age of the beds concerned.

Genus ECDYCERAS Flower

Genotype.—*Ecdyceras sinuiferum* Flower.

Ecdyceras Flower, 1941, Jour. Paleont., vol. 15, pp. 246-7.

The shell is straight, strongly depressed in section, the venter more flattened than the dorsum. The septa in the mature part of the shell, the only part known, are deep and subconical, the greatest depth occurring ventrad of the center, with the siphuncle at the deepest portion. The sutures of the genotype bear lobes on both the dorsum and the venter. The species described below has no clear lobes on the dorsum, but this difference does not seem adequate for the erection of a separate genus. The siphuncle is not adequately known. The early ephebic segments are slender and biconvex in vertical section, like the segments of *Montyoceras* and the basal segments of the mature *Hebetoceras*. Adoral segments may very probably become more broadly expanded where the adoral cameræ are shortened.

The living chamber characteristically has attached to it not more than four cameræ, others having been lost by natural truncation. There is evidence in the genotype of plugging of the apex of the siphuncle in truncated shells.

The surface bears only transverse markings, which slope apicad on the venter to form a broad shallow hyponomic sinus.

The genus is known from the genotype of the middle Chazy limestone of the Champlain Valley and the species described below from the Arnheim of Kentucky. No other species are known.

Ecdyceras foerstei Flower, n. sp. Plate 5, figs. 6-8

This species is represented in our material by a single specimen, 84 mm. in length, consisting of a complete living chamber and four attached cameræ. The shell is strongly depressed in section, both dorsum and venter being strongly flattened, though the venter is more strongly flattened than the dorsum. The shell expands from the blunt apex made by the initial septum to 16 mm. and 21 mm. at the first suture. In the 12 mm. of the phragmocone the shell increases to 19 mm. and 25 mm., and in the 56 mm. of the living chamber a height of 22 mm. and a width of 30 mm. are attained at the aperture.

The sutures are straight and transverse dorsally and laterally but form shallow lobes on the venter. The four cameræ in the 12 mm. of the phragmocone are subequal in length. The conical septum at the base of the specimen is not clearly preserved, but the greatest depth was attained well ventrad of the center of the shell. The siphuncle cannot be seen at the apical end of the type, nor could it be located in a vertical section, as the only trace of internal structure remaining consisted of the extreme ventral portion of the septa.

The aperture of the living chamber is clearly marked and is straight and transverse.

Discussion.—This species, in spite of the absence of data on the structure of the siphuncle, is placed in *Ecdyceras,* of which it is perfectly typical in the strongly flattened section, the very deep subconical septum, and the ventral lobes of the sutures. It differs from the much older *Ecdyceras sinuiferum* Flower of the Chazyan in that the sutures are simpler, there being no good development of dorsal lobes in this species. The type may not represent a mature individual. There is no contraction of the adoral cameræ, and the shell is expanding to the aperture, though the rate of expansion is slightly less on the adoral part of the shell than on the adapical part. These features suggest that the shell represented an immature individual. The type is preserved in a silicious matrix, unfavorable for the retention of internal structure. Unfortunately this is a type of sediment in which many of the Cincinnatian Mixochoanites are found.

Type.—Holotype, W. H. Shideler Collection.

Occurrence.—Arnheim formation of the Richmond, Lebanon, Kentucky.

Genus **PROBILLINGSITES** Foerste

Genotype.—*Probillingsites welleri* Foerste.

Probillingsites Foerste, 1928, Denison Univ. Bull., Sci. Lab., Jour., vol. 23, p. 317; Miller, 1932, Univ. of Iowa Studies, Studies in Nat. Hist., vol. 14, No. 4, pp. 20-22; Foerste, 1933, Denison Univ. Bull., Sci. Lab., Jour., vol. 28, p. 137; Foerste, 1935, *ibid.*, vol. 30, p. 18; Flower, 1941, Jour. Paleont., vol. 15, pp. 529, 538-9.

The mature part of the shell, all that is known for any representative of this genus, is a gibbous shell of slightly depressed section consisting of a living chamber and usually not more than four cameræ. The septum at the base of the specimen is deeply curved especially vertically, and the deepest part lies ventrad of the center, where the siphuncle is located. All sutures slope forward from venter to dorsum. In some species, particularly those of the Middle Ordovician, the sutures are essentially parallel. In other species the adoral sutures are more oblique than the earlier ones. Such shells approach more closely to the plan of the ascoceroid, but the sutures are not bent sigmoidally and the dorsal lobes are never inflated adorally. Unfortunately nothing is known as yet as to the structure of the siphuncle in this genus.

Form varies considerably among the various species. In general the ventral profile is convex and fairly uniformly so, while the dorsum is less convex, sometimes being concave adorally.

The Trenton species of *Probillingsites* consist of only three described species. These are *P. williamsportensis* Foerste (mentioned above) from the Cathys of Tennessee, *P. welleri* Foerste (1928, p. 318, pl. 71, fig. 2A-B) of the Galena of Illinois or Wisconsin, and *P. milleri* Foerste (1935, p. 18, pl. 1, fig. 3) of the Prosser of Iowa. In addition there are undescribed species from the Cobourg of Ontario and the uppermost Trenton of Montreal which agree with the three described species in having the sutures oblique but parallel, the adoral sutures not being more oblique than the others.

Another group of species is characterized by adoral sutures which are markedly more inclined than the adapical ones. This condition is found in but one Trenton species, *P. primus* Fritz (in Parks, 1928, pp. 85-86, see also Miller, 1932, pl. 3, fig. 13) of the upper Cobourg of Ontario. The same condition is found in *P. manitoulinensis* Foerste (1924, p. 221, pl. 42, fig. 1a-d) of the Meaford of Ontario as well as in the Richmond species described here, *P. lebanonensis* and *P. oxfordensis*. The same is probably true also of *P. faberi* but is not demonstrated by the present material. Miller (1932) pointed out these groups and noted that they might eventually be set apart into distinct genera. However, such a refinement did not seem necessary at that time. Since then our knowledge of the species has not advanced very materially. Even yet no *Probillingsites* has been found which has yielded the siphuncle in section, and consequently the ontogenetic modifications of the segments of the siphuncle in this genus are still unknown.

Probillingsites lebanonensis, Flower, n. sp.
Plate 6, fig. 6; Plate 7, figs. 12-14

The holotype is a small complete mature shell 43 mm. long, somewhat flattened, the lower portion gibbous, the adoral part produced. The shell expands from a blunt apex to 26 mm. and 17 mm. in the basal 20 mm., and contracts to 25 mm. and 16 mm., 30 mm. from the apex. The remainder of the shell is tubular, so that in 15 mm. on the venter the aperture of 25 mm. and 16 mm. is attained. The shell is curved, the venter convex. The curvature is variable and has been modified slightly by pressure, but the shell evidently becomes less strongly curved adorally, and the greatest curvature is near the base of the mature shell. The dorsum is nearly straight, slightly convex adapically and slightly concave adorally. The sides are convex over the lower portion of the shell and are straighter near the aperture.

The septum of truncation is not completely blended with the remainder of the shell in outline and its suture is clearly visible dorsally though obscure ventrally. The septum has the usual subconical form and its oblique suture is straight 6 mm. above the apex on the venter and 14 mm. from it on the dorsum. The next suture is only slightly more oblique, being 4 mm. farther orad on the dorsum and 3 mm. on the venter. The next two sutures are very close together laterally, but separate slightly on the venter (where the first is 3 mm. beyond the previous suture, and the second is 1 mm. farther orad) and are more widely separated on the dorsum. The first of these is 4 mm. beyond the previous septum, the second is only 2 mm. farther orad than the first.

The aperture, which is not inclined apicad on the venter as in many other species of this genus, shows no trace of a hyponomic sinus.

A second specimen, from the same locality and horizon, is referred to this species with doubt, as it is considerably larger. The shell is incomplete adorally and the venter is lost by weathering. The shell is 47 mm. long in its present state and attains a width of 32 mm. and a height estimated at 25 mm., 25 mm. beyond the apex. The suture of the septum of truncation is obscure. The first clear septum is 11 mm. beyond the apex on the venter and 22 mm. beyond the apex on the dorsum. The next camera is 1.5 mm. deep on the venter and 5 mm. deep dorsally. The last is .8 mm. deep ventro-laterally, being lost by weathering on the venter, and 4 mm. deep dorsally. Except for its considerably larger size this specimen agrees in proportions very closely with the holotype, and in the absence of any striking distinguishing characters other than the dubious criterion furnished by its greater size, is tentatively assigned to this same series. (Pl. 6, fig. 6.)

Discussion.—This species includes and is based upon the only two specimens of *Probillingsites* known from the Arnheim formation. Both came from the same few inches of rock near Lebanon, Kentucky. With only these two specimens it is of course impossible to say what significance should be placed upon the very considerable difference in size between the two conchs. Sexual dimorphism is suggested, but as is the case in even more abundant forms, cannot be proved or disproved on the scant evidence at hand. Unfortunately nothing is known of the internal structure of this species or indeed of any species of *Probillingsites* so far studied.

This species is more advanced in the greater distance between the sutures on the dorsum than those species known from strata of definite Trenton age. It can be recognized by the broadly gibbous lower portion and the produced adoral portion. *P. oxfordensis* is not only considerably smaller but is much more slender, the gibbosity of the lower portion being less marked. The same difference serves to distinguish *P. faberi,* which is more comparable in size but has a considerably longer living chamber in proportion to its diameters. Other Upper Ordovician or supposedly Upper Ordovician species are not closely comparable.

Types.—Holotype and paratype, Shideler Collection, Miami University.

Occurrence.—Caney Creek, directly east of Lebanon, Kentucky, from a single silicious bed in the Arnheim formation, the remainder of the fauna of which consists of pelecypods and *Bucania.*

Probillingsites (?) minutum Flower, n. sp. Plate 38, figs. 4-5

This form is known only from a living chamber which is gibbous basally but produced near the aperture. The basal septum is preserved only on the dorsum, being lost by weathering on the venter. The suture is strongly inclined orad from venter to dorsum. At its base the living chamber is 17 mm. high and 19 mm. wide. The dorsum is concave in profile. The venter is convex in the lower part, approaching the dorsum strongly, then becomes concave and is straighter to the aperture. The sides are convex over the basal part, then constricted and produced, converging slightly to the aperture. The constriction is attained 11 mm. above the base of the specimen where the shell becomes 16 mm. wide and 12 mm. high. The aperture lies 3 mm. beyond and is 11 mm. high and 15 mm. wide. No hyponomic sinus is evident.

Discussion.—This small anomalous species is represented only by the type. The slope of the sutures orad from venter to dorsum is a feature which is developed only in the mixochoanitic cephalopods. This shell agrees with *Probillingsites* in the depressed section of the shell, but is unique in the shortness of the living chamber and in the development of a prominent constriction near the aperture. Nothing is known of the siphuncle. The basal septum is incomplete, being lost by weathering, and only the dorsal third of it is retained. Likewise, a small part of the base of the living chamber on the ventral side is lost by weathering.

Holotype.—Shideler Collection.

Occurrence.—Middle Liberty, Dodge's Creek, Oxford, Ohio.

Probillingsites oxfordensis Flower, n. sp.

Plate 6, figs. 7-8; Plate 7, figs. 5-7

This is a small *Probillingsites* represented in our material by two specimens. The holotype, somewhat crushed dorso-ventrally, has a maximum length of 36 mm. and attains a maximum height of 18 mm. and a width of 20 mm. at a distance of 12 mm. above the base of the specimen. The ventral profile is strongly curved at the center of the specimen but less curved at both extremities. The dorsum is convex in the basal two-thirds and becomes slightly concave adorally. The first septum is 12 mm. beyond the base on the dorsum and 5 mm. on the venter. It is strongly inclined and straight. The next septum is nearly parallel to the first, being 2 mm. distant from it on the venter and 4 mm. on the dorsum. The third is less than 1 mm. from the second on the venter, but departs from it more widely on the dorsum, so that there that camera is 4 mm. in depth. Two more sutures are visible only laterally. They rise orad from contact with the others laterally and are joined for some distance, but become separated half the distance to the adoral end of the shell. On the dorsum the first of these must lie 10 mm. orad of the last septum. The two are probably close together on the dorsum, though they are not clearly preserved on our specimen. No internal structure is preserved in the holotype. The aperture is not clearly shown.

A hypotype consists of a mold of the true living chamber—all cameræ being lost. This specimen, strongly flattened dorso-ventrally, corresponds closely in proportion to the holotype, including the living chamber and the last two strongly oblique septa. Possibly it represents a young individual, or one in which these last septa, always thin, were destroyed prior to burial. The septum at the base of the specimen corresponds in position and inclination to the third of the septa shown on the holotype. This specimen is 25 mm. in length, with a width of 17 mm. and a height of 13 mm. near the base, and a view a width of 16 mm. and a height of 7 mm. at the aperture. The latter is strongly inclined to the axis of the conch, sloping apicad toward the venter, though without any definite hyponomic sinus. The specimen gives the impression of shell-boring sponges, for fossil representatives of which Clarke proposed the generic name *Clionolithes*.

Discussion.—This is a relatively advanced *Probillingsites*, as shown by the steeply inclined adoral sutures of the holotype. It fails, however, to approach the Ascoceratidæ in the complexity of the adoral sutures any more closely than previously known species. *P. primus* Fritz is a smaller species in which the sutures are uniformly more oblique than the more transverse ones of *P. oxfordensis.* It is also a more gibbous species. Other species fail to approach this one in proportions.

Types.—Holotype and paratype, collection of W. H. Shideler, Miami University, Oxford, Ohio.

Occurrence.—Holotype from the lower Whitewater horizon, Little Four Mile Creek, Oxford quadrangle, Ohio. Paratype, Blanchester division of the Waynesville, Stony Hollow, Clarkesville, Ohio.

Probillingsites faberi Flower, n. sp. Plate 7, figs. 8-9

This species is erected for the reception of a form represented in our material by a single living chamber. The type has a maximum length of 40 mm. The suture of the basal septum is not clear, but the septum itself is only slightly curved laterally, though considerably curved vertically. The suture is 2 mm. from the apex on the venter and 12 mm. from the apex on the dorsum. The ventral profile is convex, the curvature strongest near the middle. The dorsum is faintly convex adapically, but concave over the greater part of its length. The shell has a basal width of 25 mm., which increases to 26 mm. and contracts to 21 mm. at the aperture. The height of the shell attains 21 mm. at the position of the dorsal saddle of the basal suture bounding the type. It contracts gradually orad to 16 mm. at the aperture. The aperture is inclined apicad on the venter, but no clear sinus is developed.

Discussion.—Clearly only the living chamber is known of this species, and its holotype is comparable to the paratype of *Probillingsites oxfordensis.* It agrees with that species in the almost parallel lateral outlines, but is much larger, being about twice the size of that species, and is considerably more strongly curved.

Type.—Holotype, University of Cincinnati Museum, No. 24208.

Occurrence.—Lower Whitewater beds, Little Four Mile Creek, Oxford quadrangle, Ohio. Charles L. Faber Collection.

Genus SCHUCHERTOCERAS Miller

Genotype.—*Ascoceras anticostiense* Billings.

Schuchertoceras Miller, A. K., 1932, Univ. of Iowa Studies, Studies in Nat. Hist., vol. 14, No. 4, pp. 28-32.

This is known only from mature shells which retain with the living chamber rarely more than four cameræ. The shell is gibbous, generally slightly wider than high. The septum of truncation is deep, rounded, often blending with the outline of the remainder of the shell so that its suture is not evident. It is followed by a basal septum, with an oblique but straight suture, and then by a variable number of ascoceroid sigmoidal septa which are oblique, sloping orad from venter to dorsum, but laterally the sutures bend abruptly orad and a little ventrad, and then turn gradually dorsad, forming dorsal saddles which are broader adorally than basally. Generally the ascoceroid sutures are fused laterally and may or may not become discrete on the mid-ventral region. A peculiar feature of the genus is the form of the siphuncle in the first camera. The outline simulates that of two and sometimes three segments, leading to the conclusion that more basal septa were present in the ancestry of this genus, the septa being lost while the segments of the siphuncle still retain traces of the vanished cameræ.

Schuchertoceras is sometimes difficult to distinguish from *Billingsites,* which it resembles closely except for the presence of the basal septum. However, sometimes the septum of truncation may blend perfectly with the outline of the rest of the shell, leaving no visible suture. In such cases, the suture of the basal septum may appear to belong to the septum of truncation, and such shells may resemble *Billingsites,* although in that genus the septum of truncation normally does not show a clear suture. However, in order to determine the generic position of some of the Ohio species it has been necessary to resort to sections in order to determine whether a basal septum was present or not. Happily it was shown in several of the species, notably in *S. obscurum* of the Waynesville and *S. discretum* var. *minor* of the Whitewater. Two of the species described here are from the manuscript of the late Dr. Foerste. Both were referred to *Billingsites.* I am uncertain whether Dr. Foerste found the genera as difficult to distinguish as I have, or whether these descriptions were written prior to the description of the genus *Schuchertoceras.*

The described species of *Schuchertoceras* outside of the Cincinnati area are few. The genotype, *S. anticostiense* (Billings), is from the English Head and Vaureal formations of Anticosti. *S. newberryi* (Billings) is from the English Head formation of the same region. *Schuchertoceras logani* (Cooper) is from the Whitehead formation of Gaspé. *S. troedssoni* Foerste of the Kallholn limestone of Norway and *S. norwegicum* (Barrande) has also been referred to this genus. Miller has listed these species under *Schuchertoceras* and has also noted the probable occurrence of the genus in other areas, including the Cincinnati region. Miller (1933) subsequently described *S. thomasi* from the Maquoketa shale of Iowa.

All of the ascoceroid conchs, with one possible exception, of the Cincinnati region, are referred to *Schuchertoceras.* These are *S. obscurum* Flower, n. sp., of the Waynesville, *S. discretum* (Foerste) of the lower Whitewater, *S. discretum* var. *minor* Flower of the lower Whitewater. *S. geniculatum* Flower of the lower Whitewater, *S. distinctum* Flower of the Saluda. *S. rotun-*

dum Flower of the upper Whitewater, and *S. prolongatum* Foerste of the Elkhorn. There are in addition fragments suggesting that possibly other species may still await discovery. At least one such form is represented by material too fragmentary to deserve description.

Of these species *S. distinctum* is the only one known showing clearly both the suture of the basal septum and that of the septum of truncation. This species is primitive in the very slight inflation of the dorsal lobes of the ascoceroid septa, and probably approaches closer to *Probillingsites* than any other member of the Ascoceratidæ. Unfortunately the structure of the interior of this interesting form is still unknown. The older *S. obscurum* is more specialized, both in the loss of the suture of the septum of truncation and the perfection of the ascoceroid septa. Curiously, two of the species of *Schuchertoceras* show a strong superficial resemblance to species of *Billingsites*. *S. discretum* is very similar in aspect to *Billingsites landerensis* Foerste (1935, p. 20, pl. 1, figs. 4-5) while *S. prolongatum* is very similar in shape and sutures to *Billingsites acutus* Foerste (1928, pl. 28) of the English Head of Anticosti, but neither is closely allied to any species of *Schuchertoceras* thus far described. *S. rotundum* is perhaps closer to *Billingsites canadensis* (Billings) than to any other species in general proportions and aspect. Yet the position of these species in *Schuchertoceras* is established beyond doubt, and there is no reason to suspect that the comparable described species do not belong in *Billingsites*.

Schuchertoceras distinctum Flower, n. sp. Plate 5, fig. 1

Conch small, the mature shell being 41 mm. long. expanding to a height of 21 mm. and a width of 23 mm., 20 mm. above the base, and contracting to 16 mm. and 20 mm. at the aperture. The ventral profile is almost uniformly convex, the dorsum very faintly convex, nearly straight. The lateral profiles are evenly rounded. This species differs from all others encountered in the Cincinnatian in that the septum of truncation does not blend with the remainder of the shell in outline and its suture and the suture of the basal septum are distinct. The suture of the septum of truncation is strongly oblique, straight laterally and dorsally, but forming a distinct lobe on the ventral side. The suture is 3 mm. from the apex ventrally and 12 mm. from the apex dorsally. The septum of truncation is deepest close to the venter where the siphuncle is located. The suture of the basal septum is oblique, essentially parallel to that of the septum of truncation except that it lacks a distinct lobe on the venter and is straight there though oblique. The first two sutures are 2½ mm. apart on the venter and 4 mm. apart on the dorsum. The third septum forms a clearer saddle on the dorsum and resembles some of the sutures of *Probillingsites*, not being sigmoidal. It is 1 mm. from the preceding suture on the venter, and 7 mm. on the dorsum. This suture is joined laterally by that of the next two septa. These two sutures together depart from their junction with the third on the venter, but are less than 1 mm. from it. On the dorsum they rise in a gently undulate sigmoidal curve and form the usual saddles which are convex adorally and rather narrow. The first of these is 9 mm. from the preceding suture on the dorsum and the last is 4 mm. father orad.

Discussion.—This species is larger and less evenly rounded in form than the Waynesville *S. obscurum*. It is smaller than either *S. discretum* or *S. discretum* var. *minor*, and the adoral part of the shell is less slender. The remaining species of *Schuchertoceras* in the Cincinnatian and elsewhere are broader, have broader and flatter sigmoidal septa on the dorsum, and sutures which are more angular laterally at the inception of the dorsal saddles. The distinctness of the four visible sutures on the venter, which do not separate farther on the mid-ventral region, and the lobe of the suture of the septum of truncation are distinctive features, as is the failure of the septum of truncation to blend so perfectly with the outline of the shell that its suture is not evident. The Whitehead and Anticosti species are clearly distinct from this one in these features. The species which is most similar to this is the somewhat larger *S. discretum* and its variety, but there are important sutural differences as well as differences in shell proportions.

This species appears to be a relatively primitive one for *Schuchertoceras,* in the distinctness of the septa on the venter, the failure of the sutures to become discrete over a narrow midventral region, and the imperfection of the ovoid surface at the base of the specimen. A section of the type has failed to reveal the structure of the siphuncle.

Type.—Holotype, Shideler Collection, Miami University.

Occurrence.—From the Saluda formation, near head of a west of Oxford, Ohio.
small stream, 150 yards north of the Mixerville Pike, five miles

Schuchertoceras obscurum Flower, n. sp. Plate 6, figs. 4-5; Text fig. 1B

The holotype, and only known representative of this species, represents a nearly complete mature shell, the apical portion missing due apparently to natural truncation. The shell is 38 mm. long, attaining a maximum width of 23 mm. and a height of 19 mm. near the center, and contracting to a width of 17 mm. at the aperture, where the height is unknown, since the dorsum is lost adorally by weathering. In vertical profile the venter is clearly more convex than the dorsum, more curved apicad than orad, and blends in outline with the deeply rounded septum of truncation.

The exterior of the specimen shows a strongly oblique suture separating the septum of truncation from the rest of the shell. Apparently this is identical or nearly so with the suture of the basal septum on the venter, which can scarcely be distinguished. On the dorsum the suture of the basal septum is not clearly seen externally due to weathering, but lies 3 mm. orad of the septum of truncation. Two other sutures are shown on the exterior of the specimen, both ascoceroid. The first, barely sigmoidal, crosses the dorsum 4 mm. from the basal septum. The second is not so strongly modified as in other species of this genus. It is sigmoidal, and gently sinuate throughout its free portion, not transverse for any distance on the dorsum, and narrowly rounded at its point of departure from a course parallel to that of the basal septum on the sides.

A vertical section of the type (text fig. 1B) revealed the course of the basal septum and the siphuncle between the basal septum and the septum of truncation. The septal necks are sharply recurved. The connecting ring is thick and forms a segment consisting of two expanded portions, an adapical portion which is faintly biconvex, and an adoral portion which is broadly expanded. The constriction between these two regions is gentle and does not suggest two siphuncular segments in outline as in the case of those species which have been illustrated in section by Foerste (1928) and Miller (1932, 1934).

Discussion.—From the exterior it is not always obvious whether a mixochoanitic cephalopod should be assigned to *Billingsites* or *Schuchertoceras,* because specimens of the latter genus may be preserved with the suture of the septum of truncation practically in contact with that of the basal septum, or one or the other may be so obscure that only a single normal suture is evident on the shell. This species may be distinguished from all Ascoceratidæ of the Cincinnati area by its small size and its oval form.

In comparing this with the four other described species of *Schuchertoceras*, *S. anticostiense* (Billings), *S. newberryi* (Billings), *S. logani* (Cooper), and *S. troedssoni* (Foerste), some difficulty is encountered owing to the variation shown by the few figured specimens assigned to certain of these species. Unfortunately specimens are so rare, usually rather distorted, while nothing is known of the possibilities of variation within any of these species in regard to size, as well as position and form of the sutures, simply because enough good specimens have not been brought together to serve as a basis for any such study. All of these species have the ascoceroid sutures either forming a lobe over the center of the dorsum, or straight and transverse over the dorsum for a considerable distance. In the species described here the sutures from saddles over the entire dorsal surface. Another peculiar feature of the species is the remarkable proximity of the sutures on the ventral side of the shell. The suture of the septum of truncation is here apparently identical with that of the basal septum, and is separated by less than 1 mm. from what appears externally to be the ventral part of one of the ascoceroid septa.

Type.—Holotype, collection of W. H. Shideler, Miami University.

Occurrence.—From near the base of the Blanchester division of the Waynesville, Dry fork of Elk Creek, ¼ mile east of road south from Jacksonburg, Ohio.

Schuchertoceras discretum (Foerste), n. sp. Plate 7, figs. 10-11

Billingsites discretus, new species, Foerste, ms.

Original description.—The holotype is 61 mm. long, its basal end originally being about 1 mm. longer. Its maximum lateral diameter, 34.5 mm., is above its base, and here the dorso-ventral diameter is 31 mm. The suture of the septum forming the base of this specimen is almost straight on lateral view, and rises from an elevation of 3 mm. on its ventral side to 20 mm. dorsally. Above this basal suture the ventral outline of the conch has a radius of convex curvature of 50 mm., the corresponding dorsal outline being only faintly convex except near its top where it becomes slightly concave. Above this basal suture there are three additional sutures, which are closely approximate ventrally, but which rise abruptly near the middle of the lateral side so as to form tall dorsal saddles conspicuously remote from each other. The lowest of these three saddles has an elevation of 20 mm. above the base of the specimen, the next one has an elevation of 43 mm., and the top one has an elevation of 50 mm. The characteristic feature of this specimen is the presence of a distinct interval between the suture of the septum at the base of the specimen and the lowest one of the three overlying sutures on the ventral side of their course. This interval equals 1.5 to 2 mm. along the middle part of the lateral side of the conch. Another feature, found in several specimens, is the considerable interval between the lower and middle one of the three conspicuous dorsal saddles, compared with the intervals immediately above and below.

Occurrence.—Little Four Mile Creek, 7 miles north of Oxford, Ohio; in the basal part of the Whitewater formation.

Discussion.—The above description. quoted from Foerste's manuscript in full, is based completely upon the holotype. This specimen was sectioned, after being photographed complete, to determine whether a basal septum was present as was suspected from the slight elevation of the first suture. Unhappily the holotype failed to reveal structure other than that of a gastropod which was found within it, and some *Homotrypa*, probably *H. wortheni*, the septa being completely destroyed except for their sutures. However, on the basis of the probable conspecific nature of another specimen, described below as *Schuchertoceras discretum* var. *minor*, the structure of the interior is made known.

The presence of a basal septum is established on the basis of this specimen which externally is almost identical with "*Billingsites*" *discretus* except for the smaller size and the slightly different spacing of the septa.

This species is a relatively slender *Schuchertoceras*, with the greatest height of the shell attained at the level of the dorsal saddle of the first ascoceroid septum. The dorsal lobes are rounded and convex orad throughout. Other species have broader and more nearly flat or more concave dorsal lobes, and are generally more gibbous.

Type.—Holotype, collection of Dr. W. H. Shideler, Miami University.

Occurrence.—Lower Whitewater formation, Little Four Mile Creek, Oxford quadrangle, Ohio. Distorted specimens, doubtfully identical, are, one other from the same locality and another from the same horizon at Dodge's Creek, near Oxford, Ohio.

Schuchertoceras discretum var. minor Flower, n. var.

Plate 6, figs. 1-3; Text fig. 1C

This form resembles *S. discretum* in general conformation and the course of the sutures, but differs in being considerably smaller and in having the greatest diameters attained at an earlier point on the shell. The variety shows some additional features which cannot be compared with *S. discretum* as they are not known from the typical representatives of that species.

The shell is 50 mm. in length, in contrast to the 61 mm. of typical *S. discretum.* The greatest height is 28 mm., the width 26 mm., which are attained 15 mm. above the base of the specimen, at a region halfway between the first two sutures, at about the point where a slight ridge on the dorsum simulates a suture, and would have been mistaken for one had not the preservation of the interior shown otherwise. The venter is nearly uniform in curvature in profile, the dorsum is convex adapically and straight adorally. The type has apparently been compressed by pressure, though only very slightly, and preservation of internal features is excellent.

The first suture is strongly oblique but sinuate upon approaching the mid-ventral area. On the venter two sutures are visible, 1 mm. apart. On the dorsum only two ascoceroid septa are developed. The first of these is much farther from the nautiloid suture than in typical *S. discretum*, being 17 mm. from it and only 5 mm. from the next suture. The dorsal lobes of these two septa are slightly narrower than in the type of *S. discretum.*

A vertical section showed two segments of the siphuncle at the base of the specimen. These are broadly expanded biconvex segments, such as are found in conjunction with the ascoceroid septum, but not normally in conjunction with the basal septum. The first of these lies between the basal septum and the septum of truncation, the substance of which is not preserved, the specimen being an internal mold. Even the mold is imperfect, the surface being poor especially on the venter where the camera was filled with calcite. A third segment of the siphuncle is not preserved. This is shorter than the other two, and lies between the two ascoceroid septa.

Discussion.—This species is very similar in aspect to *S. discretum,* but is considerably smaller, and shows differences in the narrower dorsal lobes of the sutures, the earlier attainment of the greatest width and height, and the more evenly arched dorsal lobes of the sutures. Although a considerable array of minor differences can be found, it is not certain whether they may fall within the normal range of variation within a mixochoanitic species, or whether they represent sexual dimorphism. Data do not exist for comparison of these forms, since the known comparable specimens, in addition to these two types, consist of only three other specimens. Two are badly flattened, while a third, though rather weathered and slightly flattened, agrees almost precisely in proportions and in the position and course of the sutures with *S. discretum* var. *minor.*

Type.—Holotype, W. H. Shideler Collection, Miami University.

Occurrence.—The type is from the lower Whitewater horizon from Little Four Mile Creek, 7 miles north of Oxford, Ohio. The only other identical specimen is from the *Rhynchotrema* *dentata* zone, upper Whitewater, from Dodge's Creek, near Oxford, Ohio.

Schuchertoceras prolongatum (Foerste), n. sp. Plate 6, figs. 10-11

Billingsites prolongatum, new species, Foerste, ms.

Original description.—The holotype is approximately 76 mm. long. Its maximum lateral diameter, 42 mm., is located 45 mm. above its base. The lateral outline has a radius of curvature of 90 mm., shortening to 12 mm. at the base. Its dorso-ventral diameter, in the present condition of the specimen, is 34 mm. but originally was evidently greater. The uppermost dorsal saddle reaches an elevation of 65 mm. (from the base of the specimen). The one next beneath reaches an elevation of 55 mm. There is room for a lower saddle, but none is distinctly outlined, at least along its crest. The suture of the septum forming the base of the specimen rises to a height of 20 mm. dorsally and is assumed to sink to an elevation between 11 mm. and 13 mm. ventrally.

Remarks.—This specimen is characterized by its large size and elongate form.

Supplementary notes.—The clarity of the septum at the base of the specimen and its suture suggest that this species is probably a *Schuchertoceras* rather than a *Billingsites,* the same phenomenon being demonstrated by the internal structure to have a similar significance in *S. discretum* var. *minor.*

This species may be distinguished by the very deep conical septum of truncation, the large size and slender form, and the very high arched saddles of the two sigmoidal septa known.

The species which is most similar to this one in general aspect belongs not to *Schuchertoceras* but to *Billingsites. Billingsites acutus* Foerste (1928, p. 261, pl. 38, figs. 1-3) of the English Head of Anticosti is of somewhat similar proportions, but the septum of truncation is more strongly conical, the sigmoid sutures are more abruptly bent laterally, the saddles are broader and are concave adorally in the center.

Type.—Holotype, W. H. Shideler Collection, Miami University.

Occurrence.—Two and one-tenth miles west of Hamburg, Indiana, road metal quarry ¼ mile north of road bridge, upper Elkhorn beds.

Schuchertoceras cf. prolongatum (Foerste) Plate 6, figs. 9; Text fig. 1C

Under this name a single specimen is described and illustrated which is of special interest for the internal structure preserved. The type is an internal mold, much weathered externally and incomplete adorally, and with the base of the specimen poorly preserved owing to filling with friable calcite. The shell is 63 mm. in length, expanding from a blunt apex to a height of 37 mm. and a width of 39 mm., in the basal 40 mm., and contracting at the adoral end to a width of 34 mm. and a height of 27 mm. The ventral profile is almost uniformly convex with a radius of curvature of 70 mm. The dorsal profile is faintly convex adapically and still convex but less curved adorally. The lateral outlines are convex.

The sutures are poorly shown at the base of the specimen, and the septum of truncation is not clearly preserved. Externally it can be seen that the sutures are strongly oblique, sloping apicad on the venter, but the exterior does not clearly show the suture of the basal septum on the dorsum. Ventrally the basal septum can be made out, and orad of it two sutures of ascoceroid septa form shallow saddles as in many species of both *Billingsites* and *Schuchertoceras*. These are very obscure and fail to show in section. The saddles of the two ascoceroid septa depart from the general course of the sutures near the dorsum, being only 30 mm. apart at their base, but the larger saddle attains a width, measured across the curved dorsal surface, of 70 mm. The two sutures are rounded and convex adorally. The first crosses the dorsum 46 mm. above the base of the specimen, the second 57 mm. above the base.

In section, the type shows only two septa crossing the shell from venter to dorsum. Apicad of the first, which is not clear ventrally, being obscured by calcite, are two prebasal segments of the siphuncle in the usual position. These are biconvex but not broader than high. Between the basal septum and the next is a faintly preserved segment shorter and broader and strongly expanded. The last septum when traced dorsally splits to both of the ascoceroid dorsal saddles. Ventrally it fails to swing forward as far as the two faint adoral sutures, which may be adventitious structures.

Discussion.—The type, if slightly flattened vertically by crushing and also slightly elongated by the same process, will approach very closely in proportion to the holotype of *S. prolongatum* of the Elkhorn. The spacing of the two ascoceroid septa of the two specimens agrees very closely, but the dorsal saddles are broadened in the holotype, which thus presents a rather different aspect. Nevertheless this Saluda specimen does not seem to be distinct enough to be placed in a separate species. The basal septum does not appear to be as deep but is imperfectly preserved.

Type.—Figured specimen, University of Cincinnati, No. 24209.

Occurrence.—From the Saluda beds, Shera farm, near Oxford, Ohio. Collected by M. S. Chappars.

Schuchertoceras geniculatum Flower, n. sp. Plate 7, figs. 3. 4

The mature part of this species is broad and gibbous. The basal part of the shell is detached in outline from the remainder, an unusual phenomenon, as the basal septum is usually so aligned with the rest of the shell that its suture is not evident. At the suture the shell has a width of 25 mm. and a height of 22 mm. In 22 mm. this increases to 33 mm. and 28 mm., and in the remaining 9 mm. the shell contracts to the incomplete adoral end with a width of 29 mm. and a height of 22 mm. The shell expands over the basal two-thirds of the living chamber, the dorsum and venter diverging and being but slightly convex in profile. At the point of gibbosity the ventral profile became abruptly bent and is then nearly straight apparently to the aperture.

The basal septum is marked by a suture which is slightly but not markedly oblique. The septum itself is not so rounded as usual. It is on the basis of the suture that this species is assigned to *Schuchertoceras,* and it is even possible that the type may bear at its base the basal septum, and that the septum of truncation may have been lost, probably by weathering. In addition, three ascoceroid septa are preserved on the dorsum. These unite into a single suture laterally. These sutures are not preserved over the mid-ventral region; so it is uncertain whether, as in some other species, they separate at the mid-ventral region. The sutures form an angle where they begin their ascoceroid development on the lateral region. The first suture is transverse nearly over the dorsal half of the shell, the two later sutures form broad shallow lobes on the dorsum. Nothing is known of the internal structure of the species. An unusual feature of the type is the preservation of some of the shell near the adoral end. No surface markings are shown.

Discussion.—In the form of the sutures this species is more typical of *Schuchertoceras* than *S. obscurum.* The geniculate ventral profile and the gradual expansion of the shell to a point not far from the aperture followed by a rather abrupt contraction give this species a shape unlike that of any other described species, where the form is much more evenly rounded.

Type.—Holotype, collection of Dr. W. H. Shideler, Miami University.

Occurrence.—From the upper Whitewater beds, Beasley Creek, just below bridge north of Camden, Ohio.

Schuchertoceras rotundum Flower, n. sp. Plate 7, figs. 1, 2

The holotype is 56 mm. in length and slightly incomplete adorally. In vertical profile the dorsum is slightly convex, the venter more strongly curved, the curvature being apparently nearly uniform throughout on both dorsum and venter. The lateral outline is slightly convex. The venter is partially lost by weathering on the type. The shell expands from a blunt apex to a width of 33 mm. and an estimated height of 30 mm. in the basal 35 mm. of the specimen; 45 mm. above the base, the shell has contracted to 27 mm. and 21 mm. at the level of the last dorsal saddle.

The septum of truncation is apparently well blended with the outline of the shell. It is weathered in the type. The suture of of the basal septum is 14 mm. above the base on the dorsum and 5 mm. above the base on the venter. This is followed by three ascoceroid septa which develop dorsal lobes which expand laterally adorally from the lateral angle and are straight and transverse over the dorsal surface of the shell. The first saddle rises 11 mm. above the sutures of the basal septum on the dorsum, the second is 14 mm. farther, and the third 8 mm. beyond the second. The sutures of the last two are fused, but the suture of the first ascoceroid septum is close to but distinct from the others laterally and ventrally. The adoral dorsal saddles are wide and can be seen on the ventral side of the shell.

Discussion.—This species is distinctive in the very broad dorsal saddles, a feature which will distinguish it from the associated *S. discretum, S. distinctum,* and *S. prolongatum. S. geniculatum* has similar broad saddles, but the shell is much shorter, expands to a point of greatest diameter which lies much farther orad on the shell, is shorter in proportion to its diameters, and has the lateral part of the ascoceroid septa more strongly inclined ventrad. These two species are not at all similar in aspect. No described species of *Schuchertoceras* is very close to this one in size or aspect. The rounded form produces a superficial resemblance between this species and *Billingsites canadensis* (Billings) from the English Head formation of Anticosti. That species has no basal septum and is not congeneric with *Schuchertoceras.*

Unfortunately the only available representative of this species has the venter badly weathered, so much so that the siphuncle and the ventral parts of the sutures are lost.

Type.—Holotype, W. H. Shideler Collection, Miami University.

Occurrence.—From the upper Whitewater formation between the top of the Saluda and the *Rhynchotrema dentata* zone, McDill's Mills, Four Mile Creek, near Oxford, Ohio.

SECONDARILY CYRTOCHOANITIC CEPHALOPODS

Superfamily **ONCOCEROIDEA** Flower, new name

In the secondarily cyrtochoanitic cephalopods, those which show suborthochoanitic early stages followed by cyrtochoanitic segments in the ephebic siphuncle, are placed most of the cyrtoconic genera of the Ordovician. I have recognized in this group four main divisions which have already been noted in the discussion of the ancestral suborthochoanitic cephalopods. Tentatively, family names are employed for these divisions, even though they are of very unequal size, and one, the Oncoceratidæ, appears to have given rise to many other families in the Silurian and Devonian, while the remaining families either disappeared at the close of the Ordovician, or else gave rise to other types the relationship of which has not been established. The families may be summarized in their simplest terms as follows:

Allumettoceratidæ.—Exogastric shells of depressed section, ventral siphuncle, with segments which are cyrtochoanitic and empty. Conch faintly curved or secondarily straight.

Oncoceratidæ.—Exogastric shells with ventral empty siphuncles differing from the Allumettoceratidæ in a compressed section. Whereas the Allumettoceratidæ tend in their development to produce longiconic shells, approaching the *"Orthoceras"* type except in cross section and the marginal siphuncle, the Oncoceratidæ remain in the main curved shells and are frequently breviconic.

Valcouroceratidæ.—Exogastric compressed shells with ventral siphuncles, differentiated from the Oncoceratidæ by the development first of a thickening of the connecting ring, and finally the expansion of this thickening into actinosiphonate deposits.

Diestoceratidæ.—Compressed straight or faintly endogastric breviconic shells with marginal siphuncles characterized by discrete and frequently irregular "actinosiphonate" deposits.

Some of the problems involved in tracing the relationships of these families have already been discussed in connection with the suborthochoanitic cephalopods from which they are believed to be derived. Thus conclusion is based upon the prevalence of a suborthochoanitic siphuncle in the early growth stages of Allumettoceratidæ, Oncoceratidæ, and Valcouroceratidæ in the Chazyan, where, happily, a considerable number of very early stages of members of these families were found in a state of preservation suitable for careful study by means of sections. Generally such early portions of the shells are missing, and such Middle and Upper Ordovician forms as I have found retaining relatively early stages are very frequently recrystallized adapically so that the structure of the siphuncle cannot be made out clearly. There is also some indication that Mohawkian and Cincinnatian species have progressed tachygenetically beyond those of the Chazyan, so that the suborthochoanitic stages are pushed farther apicad if they are not completely lost.

The suborthochoanitic siphuncles found in the early stages of the Allumettoceratidæ, Oncoceratidæ, and Valcouroceratidæ, have short though not aneuchoanitic necks and thin connecting rings showing no differentiation of structure in different regions. They are essentially identical with the siphuncles found in the adult stages of the Chazyan *Eorizoceras, Graciloceras,* and the Canadian *Bassleroceras,* and indeed the early stages of these secondarily cyrtochoanitic cephalopods recapitulate the condition found in the adult, and continued so far as known, throughout the entire phragmocone, of the suborthochoanitic cyrtoceracones with ventral siphuncles. The suborthochoanitic types are known to appear as low as the *Lecanospira* zone of the Middle Canadian, and are probably actually even more ancient, and to decline after the close of the Chazyan, even though *Graciloceras* persists to the Cincinnatian. The secondarily cyrtochoanitic cephalopods on the other hand are not known prior to Chazyan time, where each of the families is represented by simple and apparently primitive types. They attain more diversity in the boreal Black River and lower Trenton faunas, a second development in the boreal late Trenton and Richmond, with secondary and apparently minor developments in the less well-known austral upper Trenton and Covington faunas. Certainly the Oncoceratidæ gave rise to further specializations in the Silurian, and it is not impossible that some actinosiphonate Silurian and Devonian types may be traceable to the Valcouroceratidæ. The relationship of Devonian genera is less well established, although it has been possible to trace one family, the Brevicoceratidæ to Silurian *Oonoceras* and thence to the Ordovician Oncoceratidæ. The ranges show that in contrast to the suborthochoanitic cephalopods, the secondarily cyrtochoanitic nautiloids were a relatively late development, and one which embrace most of the cyrtoconic genera of the Ordovician, Silurian, and Devonian. The range of the two groups and the ontogenetic progression of the Chazyan cyrtochoanitic genera indicate beyond any reasonable doubt the origin of the group in the suborthochoanitic cephalopods.

The next question which arises is whether the cyrtochoanitic structure is an indication of a common cyrtochoanitic ancestor of the four families, or whether parallel development might have occurred in various parts of the suborthochoanitic group which was highly diversified before cyrtochoanitic structure made its appearance. The Valcouroceratidæ were clearly derived from simpler compressed cyrtocones with thin-walled siphuncles, such forms as are clearly embraced in the Oncoceratidæ. Further, the oldest genera of each family are, in the adult, still quite similar in form, being exogastric brevicones inflated on or near the living chamber and more or less contracted at the aperture. More slender shells developed in each family later. The origin of the Diestoceratidæ is obscure, as there is scant adult morphological evidence and the early stages have not been found in a state suitable for detailed studies such as were possible for the other families. However, the siphuncles are known to become gradually more slender when traced apicad, which suggests that they too may have had a suborthochoanitic origin. Further, the similarity of the one young phragmocone known to *Valcouroceras* suggests a close relationship with the simpler Valcouroceratidæ. As there is at the present time no evidence which seems to oppose such a view, I have derived them from the Valcouroceratidæ, with which they agree in the compressed section, though their early exogastric condition is not always evident.

The Allumettoceratidæ present a different problem. Though unquestionably suborthochoanitic in ancestry, these shells show a strongly flattened section at the earliest stage observed. This suggests, though it does not necessarily prove, that they arose from some other suborthochoanitic stock, perhaps a group of suborthochoanitic cyrtoceracones in which the section had already become broad instead of narrow. However, it is necessary to recognize that other possibilities exist. It may be that the change in the cross section appeared cœnogenetically and dominated the whole shell suddenly. There is no evidence of a proterogenetic sequence. Further, at the present time no suborthochoanitic cyrtoceracones are known with a depressed section which are likely ancestors of these forms. *Onychoceras* of the Canadian is aneuchoanitic and has complex rings not unlike those of *Cyclostomiceras,* which the writer believes developed primarily and possibly completely in the eurysiphonate instead of the stenosiphonate line. Even this concept, however, may be considered open to question. In the diagram figure 9, the origin of the Allumettoceratidæ is left as uncertain, with both possibilities indicated.

Although it is believed by the writer that the present classification approaches very close to the genetic relationships of the genera concerned, nevertheless, the possibility arises that the taxonomic units may be homeomorphic. This matter is discussed in connection with the families themselves and occasionally, with reference to specific genera.

Family ALLUMETTOCERATIDÆ Flower, n. fam.

The family Allumettoceratidæ is erected for secondarily cyrtochoanitic shells which have ventral siphuncles, suborthochoanitic in the early stages, but cyrtochoanitic, though sometimes only slightly expanded throughout the greater length of the shell. In connection with the flattening of the shell, the sutures tend to develop lobes on the dorsum and venter. As the venter is commonly more flattened than the dorsum, the sutures generally form deeper lobes there. The cyrtoconic condition of these shells is slight and is best seen in the early growth stages of Chazyan species, though still evident in even the adults of many Mohawkian forms. The shells in general tend to develop toward an orthoconic rather than a cyrtoconic adult stage and the adoral parts of the shells may often be described as orthoconic. The cross section is always depressed.

Only four genera are assigned to this family with certainty at the present time. *Allumettoceras,* ranging from the Chazyan into the Black River and basal Trenton, is selected as the type genus of the family because it is much better known internally, due largely to the study of undescribed Chazyan material. Specimens of the genus are depressed in section, the venter flat, the dorsum broadly arched, the sides rather narrowly rounded but not angular.

Tripteroceras is unknown in the Chazyan proper but is rather widespread in the Middle Ordovician. The genus is discussed in more detail below in connection with the closely allied *Rasmussenoceras.* Typically, its section is subtriangular. As the shell is traced orad dorso-lateral grooves appear on the surface and widen until they serve to form flat or slightly concave faces separating a mid-dorsal ridge from the lateral angles, which are either so very narrowly rounded as to be subangular or actually angular. The siphuncle is not adequately described and illustrated for any species of *Tripteroceras.*

Rasmussenoceras, discussed in detail below, grades into *Tripteroceras,* having a keeled *Tripteroceras*-like stage in the young, sometimes persisting for half the length of the shell. The adult, however, loses the median ridge and the dorsum becomes a very slightly curved surface separated from the much flatter ventral surface by lateral angles. In fact, the internal mold of this genus presents the aspect of a *Lambeoceras* rather than that of a *Tripteroceras.* The siphuncle of the genotype (Troedsson, 1926) is narrow, longer than wide, and might almost be considered suborthochoanitic. This genus is known from the Middle and Upper Ordovician and appears to be strictly boreal in its distribution.

Tripterocerina Foerste differs from *Tripteroceras* in the development of numerous longitudinal ridges separated by depressions on the dorsal surface. It is known only from the genotype, *T. kirki* Foerste, of the Fremont limestone of Colorado.

No members of this family have been recognized in the Silurian. Some genera of similar aspect occur in the Devonian but may be only homeomorphic with the Allumettoceratidæ. The Devonian *Tripleuroceras* is an actinosiphonate genus superficially similar to *Tripteroceras* in gross features but distinguished by a much larger and more strongly cyrtochoanitic siphuncle and actinosiphonate deposits. (See Foerste, 1926, p. 308, pl. 32, fig. 4A-O; pl. 33, figs. 2A-B, 3A-C). Its affinities seem to be with the Jovelaniidæ, but the origin of this whole family is uncertain.

Eudoceras Hyatt (1884), based upon *E. pandum* (Hall) of the Schoharie grit, is superficially very similar to *Rasmussenoceras*, but absolutely nothing is known concerning its siphuncle except that it must have been very small and was probably marginal. It is possible that this genus may be related to *Rasmussenoceras*, but it is equally possible that it may represent a case of noncontemporaneous convergence from quite a different stock. It may even have developed from truly orthochoanitic orthoceracones.

Genus TRIPTEROCERAS Hyatt

Genotype.—*Orthoceras hastatum* Billings.

Tripteroceras Hyatt, 1884, Boston Soc. Nat. Hist., Proc., vol. 22, p. 287; Hyatt, 1900, Cephalopoda in Zittel-Eastmann Textbook Paleont., vol. 1, 1st ed.; Zittel, 1884, Handb. Paleont., vol. 2, p. 370; Miller, 1897, North Amer. Geol., Pal., 2d App., p. 788; Clarke, 1897, Geol. Minnesota, vol. 3, pt. 2, p. 791; Foerste, 1924, Denison Univ. Bull., Sci. Lab., Jour., vol. 20, p. 231; Foerste, 1926, *ibid.*, vol. 21, p. 311; Troedsson, 1926, Meddelelser om Groenland, vol. 71, p. 43; Foerste, 1929, Denison Univ. Bull., Sci. Lab., Jour., vol. 24, p. 305; Foerste, and Savage, 1927, Denison Univ. Bull., Sci. Lab., Jour., vol. 22, p. 46; Foerste, 1932, *ibid.*, vol. 27, p. 130; Foerste, 1935, *ibid.*, vol. 30, p. 48.

Tripteroceras consists of small straight or very slightly exogastric sheils of broadly depressed triangular section, the venter broad and flat, lateral angles acute, and the dorsum divided by a ridge or keel in the middle; the dorso-lateral regions being flat or slightly concave. The sutures describe broad rounded lobes on dorsum and venter. The siphuncle is small, close to the venter, and has been described as tubular though apparently the segments are very slightly expanded within the cameræ. The lines of growth are very faintly convex over the dorsum but have not been observed ventrally.

Discussion.—*Tripteroceras* has undergone a series of restrictions since its original description. Hyatt originally placed this Ordovician genus in the Eudoceratidæ and regarded this genus as a derivative of the Devonian *Eudoceras*, from which it differed mainly in the slight cyrtoconic condition of the shell. He presents it as a Silurian and Devonian genus, although the genotype is Ordovician, as are all of the species, at least all of those from America, which have currently or recently been placed here.

Foerste removed *Lambeoceras* based upon *Tripteroceras lambei* Whiteaves, a broadly depressed genus without a dorsal ridge which has a large cyrtochoanitic siphuncle and has subsequently been found to belong to the Actinoceroidea and to have no relation with *Tripteroceras*. Also Foerste (1926, p. 311) restricted *Tripteroceras* to species with strongly rounded or angular lateral angles, erecting the new genus *Allumettoceras* for species in which the lateral part of the shell is strongly rounded and the dorsum is convex in cross section and without any trace of a keel. This genus is well developed in the Chazyan and Black River.

Still remaining in *Tripteroceras* were species showing two types of section, one in which the section was triangular and the dorsum keeled. This group contains small species of the Middle Ordovician, largely the Black River. Other species, ranging from the Black River (Platteville) to the Richmond, show a section in which the dorsum lacks a keel but is only slightly more convex than the venter. Such species, except for the fact that their siphuncles are small, inconspicuous, and so fragile that they are usually not preserved, resemble *Lambeoceras* very closely.

Foerste (1933) erected the genus *Rasmussenoceras*, based upon *Lambeoceras*(?) *leveannulatum* Troedsson of the Cape Calhoun formation of Greenland, for the species which differed from *Lambeoceras* in having a slender suborthochoanitic or narrowly cyrtochoanitic siphuncle. In erecting this genus he pointed out the similarity of *Rasmussenoceras* with several species of *Tripteroceras*, in particular the Richmondian *T. xiphias* (Billings) of Anticosti, but retained that species in *Tripteroceras* for reasons which were not stated.

Tripterocerina Foerste (1935, p. 49) was separated from *Tripteroceras* for the reception of a single species in which the dorsum was not only keeled but fluted as in *Kionoceras*. It contains only *T. kirki* Foerste of the Bighorn formation.

In the present work *Tripteroceras* is being even more restricted and those species which resemble *Rasmussenoceras* in all known features, are removed to that genus. Enough information is not available concerning the siphuncles to determine the relationship of these genera with certainty, except of course for *Lambeoceras*, but the available information suggests close relationship within the Allumettoceratidæ.

Allumettoceras, as known from undescribed Chazyan species, is suborthochoanitic in its early growth stages, although later stages of the siphuncle become subspherical though always relatively small. *Tripteroceras, sensu stricto*, may be specialization derived from this genus, although from all accounts the siphuncle is not so broadly expanded as in *Allumettoceras*. The little known *Tripterocerina* seems to be a *Tripteroceras* in which the dorsum has become fluted, though again the needed confirmation of internal structure is lacking. *Rasmussenoceras* shows some ontogenetic features suggestive of *Tripteroceras*, in particular the presence of a very obscure but nevertheless recognizable keel on the dorsum in the early stages of growth of *R. variabile* of the Richmond of Ohio, which leads to the belief that *Rasmussenoceras* may be another specialized derivative from this group.

Eudoceras, which resembles *Rasmussenoceras* in most features, but may be distinguished best by the rapid lateral expansion of the shell and the relatively deep cameræ, is known only from the genotype from the Schoharie grit of New York. The structure of the siphuncle is unknown. The origin of this genus cannot be demonstrated. It might represent a Devonian derivative of this general line of descent but may also be an independent but convergent development from some completely unrelated stock. Inasmuch as no species are known in the entire Silurian which serve to bridge the very considerable stratigraphic gap between *Tripteroceras* and *Rasmussenoceras* of the Ordovician and the Devonian *Eudoceras*, a genetic connection does not seem very likely in the light of our present rather inadequate knowledge of these depressed orthoceracones.

No species of *Tripteroceras* occur in the Upper Ordovician of the Cincinnati region. *Lambeoceras richmondense* was originally described by Foerste at a time when he regarded *Lambeoceras* as a subgenus of *Tripteroceras.* In the manuscript descriptions of Cincinnatian cephalopods two species were described in terms of *Tripteroceras* by Foerste. Additional material has shown that they represent a single species, but one which shows marked and very deceptive changes in the rate of lateral expansion. On the basis of the section this species is placed in *Rasmussenoceras* rather than *Tripteroceras.*

The known American species of *Tripteroceras* as here restricted are as follows:

T. hastatum (Billings). Paquette Rapids beds, Ottawa River.

T. planoconvexum (Hall). Platteville limestone of Wisconsin, also recognized by Foerste in the Chaumont of Ottawa. The Ottawa form at least is a very typical *Tripteroceras.*

All other species appear to belong in *Rasmussenoceras.*

Genus RASMUSSENOCERAS Foerste

Genotype.—*Lambeoceras* (?) *leveannulatum* Troedsson (1926).

Rasmussenoceras Foerste, 1933, Denison Univ. Bull., Sci. Lab., Jour., vol. 28, pp. 1-2.

Conch straight, strongly flattened, dorsum and venter slightly convex but separated by sharp lateral angles. The sutures describe broad rounded lobes on dorsum and venter which are separated by prominent angular or subangular lateral saddles. The siphuncle is small, close to the venter, composed of small slender segments which expand only very slightly in the cameræ, the septal necks being essentially orthochoanitic. No deposits are known in the siphuncle or cameræ.

Discussion.—Foerste separated this genus from *Lambeoceras* on the basis of the form of the siphuncle. Indeed, it resembles that genus perfectly in all respects except the outline and structure of the siphuncle. Previously only the genotype has been placed here, *R. leveannulatum* Troedsson (1926) of the Cape Calhoun formation of northern Greenland. However, if the genus is to be recognized at all, it seems necessary to include within it, in addition, a large number of those species which have formerly been placed in *Tripteroceras,* but which agree with *Rasmussenoceras* and differ from typical *Tripteroceras* in that the dorsum is not divided by an angular ridge, and the section is digonal rather than trigonal.

Some species which are typical in form of *Rasmussenoceras,* including the Richmondian species described below, show affinities with typical *Tripteroceras* in the development of a faint dorsal keel in the earlier stages of the shell. This suggsts that *Rasmussenoceras* is a specialization grown out of *Tripteroceras,* and if this conclusion, strongly indicated by all of the available evidence which is, however, incomplete, is correct, there may be no natural dividing point between the two. Foerste in describing *Rasmussenoceras* compared it with *Tripteroceras xiphias* (Billings) and *T. schofieldi* Foerste pointing out similarities with those species, though indicating no differences, stating, however, that these species were to be retained in *Tripteroceras.* While the division between genera is often arbitrary, there seems to be no good morphological basis for arriving at Foerste's conclusion. If *Rasmussenoceras* is to be recognized as distinct from *Tripteroceras,* it must be used to include those species which agree with *R. leveannulatum* in section and differ from the genotype of *Tripteroceras* in having the dorsum rounded and convex, at least in the ephebic portion, but lacking a distinct mid-dorsal keel.

The morphological evidence is admittedly incomplete, for the siphuncle is only very poorly known in practically all of these species which I am transferring to *Rasmussenoceras* on the basis of the section of the shell. In the Richmondian species described below, the siphuncle is very small, suborthochoanitic, and its walls are so thin that the structure is preserved in only one of the specimens, and even the septal foramen is only rarely and faintly indicated on the best preserved of our specimens.

Rasmussenoceras may be distinguished on the basis of the very different structure of the siphuncle from the actinoceroid genus *Lambeoceras,* which it resembles strongly in section and sutures. It may be distinguished from *Tripteroceras,* as noted above, by the digonal rather than trigonal section. Greater difficulty is encountered in distinguishing it from the little known Devonian genus *Eudoceras,* the type of which is *Eudoceras pandum* (Hall) of the Schoharie grit. This is a digonal shell with sutures and section similar to those of *Rasmussenoceras* and *Lambeoceras.* The siphuncle is very small and its structure is unknown. Until the siphuncle is known, no other species can be assigned to this species with certainty. It may be added that the preservation of cephalopods in general and this species in particular in the Schoharie grit, to which formation it is confined, is such as to make the discovery of these essential morphological features an extremely unlikely contingency. It is not impossible that *Eudoceras* may represent the last survival of this stock in Devonian time, but such a hypothesis cannot be demonstrated conclusively without more knowledge of the structure of that genus, or at least in the absence of Silurian species which may bridge the stratigraphic gap between the Ordovician and the Devonian forms.

The following species, formerly assigned to *Tripteroceras* by Foerste, are placed in *Rasmussenoceras*:

Rasmussenoceras xiphias (Billings). (See Foerste, 1928, pl. 7, fig. 4A-C) of the English Head formation of Anticosti.

R. oweni (Clarke). (See Foerste, 1929, p. 306) of the Platteville limestone of Minnesota.

R. schofieldi (Foerste, 1929). Platteville limestone, Wisconsin.

R., sp. (*Tripteroceras,* sp., Foerste, 1929). Prosser limestone of Minnesota.

R., sp. indet. (*Tripteroceras,* sp. indet., Troedsson, 1926). Cape Calhoun formation, Greenland.

Rasmussenoceras variabile Flower, n. sp. Plate 48, figs. 1-8

Shell straight, very strongly depressed, the venter nearly flat, the dorsum arched, the dorso-lateral sides faintly concave in the young, but gradually merging into an evenly convex dorsum in the adult. The lateral angles are sharp as in *Lambeoceras,* which this species resembles strongly. The apical angle of the lateral sides is 22 degrees up to a width of from 35 mm. to 40 mm. where it decreases quite rapidly to one of between 13 and 14 degrees.

The smallest specimen observed increases in width from 11 mm. to 18 mm. in a length of 24 mm., and shows a well-arched dorsal surface with slight dorso-lateral concavities. These concavities are slightly more marked in a slightly larger specimen where they serve to bring out a vestigial dorsal keel which is, however, rounded and narrow. This shell expands from 18 mm. to 33 mm. in 38 mm. The next larger specimen shows an increase in width of from 24 mm. to 30 mm. in the basal 18 mm., while in the succeeding 36 mm. the width increases only to 33 mm. The largest fragment is an incomplete living chamber which expands from 36 mm. to 43 mm. in a length of 43 mm., and originally extended considerably farther orad. At a shell width of 25 mm., the dorsum becomes rounded and loses all trace of the dorso-lateral concavities and the mid-dorsal keel.

Few specimens consist of more than the living chamber. One individual, however, shows parts of eight cameræ attached to a complete living chamber. The eight cameræ occupy a length (lateral) of 17 mm. The sutures form subangular narrowly rounded lateral saddles separating a broad rounded dorsal lobe and a somewhat narrower and more angular ventral lobe. Although septa are not uncommonly preserved, only one specimen has been found which preserves more than the faintest indication of the siphuncle. This is small, close to the venter, and the segments are scarcely expanded within the cameræ. The septal neck is very slightly recurved, but the connecting rings present an essentially tubular condition.

The ratio of the height and width of the shell varies considerably, probably due as much to slight flattening as to variation within the growth stages. One shell shows a height of 6 mm. where the width is 14 mm. In the best preserved specimen the height is 11 mm. with the width of 25 mm.; farther orad in the same specimen the height is 19 mm. and the width 38 mm. The largest fragment shows a height of 18 mm. and a width of 42 mm., but this shell is apparently slightly flattened vertically.

The aperture has not been clearly observed. One shell shows lines of growth which form a broad low saddle on the dorsum, consisting of rather coarse transverse markings as in *Lambeoceras lambei* as shown by Leith (1942).

Discussion.—This species, because of the abrupt change in the rate of expansion, presents the aspect of two distinct species, for much of the extant material consists of rather incomplete living chambers. Indeed, Foerste had described in manuscript two species based upon this material, both of which he placed in *Tripteroceras*[10]. However, in his justification it should be stated that those specimens supplying the interval in the shell in which the change in rate of expansion occurs, were not available at the time of his uncompleted investigation. Further, evaluation of the proportions of the species is somewhat, though perhaps not greatly complicated by the flattening to which most of the shells observed have been subjected. Of the 14 specimens available at the time of the present study only four seem to be reasonably free from the effects of pressure.

This Whitewater species closely resembles *Lambeoceras richmondense* (Foerste) from which it can be distinguished with certainty only by the minute and elusive siphuncle. Whenever a septum of *Lambeoceras* is exposed the large slightly depressed septal foramen is a very conspicuous feature.

This species is similar in aspect to its congeners. The genotype is a much larger species in which both the dorsum and venter are convex in cross section (see Troedsson, 1926). *R. xiphias* (Billings) has the dorsum more arched and the cameræ considerably deeper. It is also a species which attains a considerably larger size than indicated by any known specimens of *R. variabile. R. oweni* and *R. schofieldi* are known from relatively adapical portions of shells. *R. schofieldi* at least lacks at this stage all traces of the keeled dorsum, and both are more rapidly expanding than are commensurate parts of the Richmond species.

Types.—Syntypes, Earlham Collection, No. 8203; Shideler Collection, eight specimens; two specimens in the collection of the University of Cincinnati Museum.

Occurrence.—From the Whitewater beds of Richmond, Indiana. The species is known from the cephalopod beds of the lower

10 This was written prior to his description of *Rasmussenoceras* (1933).

Whitewater of Dodge's Creek, Little Four Mile Creek, Flat Fork Creek, Camden, and from the upper Whitewater of Dodge's Creek and Camden, Ohio.

Family ONCOCERATIDÆ Hyatt, emend. Flower

The family Oncoceratidæ is here employed for secondarily cyrtochoanitic cephalopods with ventral, rather small, siphuncles which are free from any organic deposits. The shells are exogastric cyrtoceracones of compressed section, although a few of the genera are essentially circular in cross section, and it may prove that some depressed cyrtoceracones may be included here. The depressed Allumettoceratidæ may be readily distinguished, not only by the depressed section of the shell but by the faintness of the curvature and the gradual expansion of the shell to the aperture. Members of this family are not known to have either strong curvature or breviconic living chambers. The compressed Valcouroceratidæ and Diestoceratidæ are both distinguished by the development of actinosiphonate deposits. The Valcouroceratidæ may resemble the Oncoceratidæ in form, but the cross section is in general broader and tends to be more strongly flattened dorsally. The Diestoceratidæ are strongly breviconic, but the shells are either essentially straight or faintly endogastric in curvature.

Genera in the Oncoceratidæ are based essentially upon the shape of the shell and the condition of the aperture. The siphuncle shows some variation in the form of its segments among the species, but it has been described only for a small percentage of the known species, and therefore cannot be used as yet to clarify the classification.

The present status of the genera as established upon shell form raises many perplexities, for the prolific Oncoceratidæ of the Ordovician contain species which appear to intergrade between the genera so closely and so frequently as to indicate that the genera in their present condition are not natural genetic units. One such chain of species between natural genera may be expected, but where three or four such series can be established, as in the case of *Oncoceras* and *Beloitoceras,* it is apparent that the genera as at present defined are not natural groups. So close has the relationship been between genera in several instances, that only the large number of species involved has caused me to refrain from reducing several of the generic names to synonymy. Such a step may eventually be taken, but should, in the opinion of the writer, be delayed until it is ascertained whether internal structure may not supply better clues for the division of the Oncoceratidæ.

The siphuncles are suborthochoanitic in the early growth stages of Chazyan species of *Oncoceras* and *Beloitoceras*. Yet the adult segments of the same species may be slightly scalariform dorsally and straight ventrally (fig. 11F), or biconvex, a condition also found in the ephebic segments of the Black River genotype of *Beloitoceras* (fig. 11 E). Still other variations have been noted. Some segments are clearly scalariform with angular outlines in vertical section, while others are rounded and essentially oval in form. The septal necks are always quite short and are frequently difficult to detect in opaque sections.

In their present status, the genera composing the Oncoceratidæ may be defined briefly as follows:

Oncoceras.—Shell exogastric, a compressed brevicone, gibbous region typically located below the base of the mature living chamber, so that the shell contracts toward the aperture over the length of the living chamber. As shown more fully in the discussions of the genera and the analysis of the species, it is difficult to determine a clear point of separation between this genus and *Neumatoceras* and *Beloitoceras*. In its present scope *Oncoceras* ranges from the Black River to the Richmond, while the known Chazyan species are so close to the boundary between *Oncoceras* and *Beloitoceras* that they might be placed in either genus.

Beloitoceras.—Shell an exogastric compressed brevicone, either faintly gibbous, the dorsum straight or even faintly concave, or when more gibbous, the convexity of the dorsum lying on the living chamber rather than on the adoral part of the phragmocone. The more gibbous species are very close to *Oncoceras* and *Neumatoceras*. *Beloitoceras* is a very large genus in the Ordovician, ranging from the Chazyan to the top of the Richmond.

Neumatoceras.—A strongly gibbous compressed brevicone, the ventral outline humped over the dorsal end of the phragmocone, contracting rapidly toward the aperture. Dorsum straight or convex over the middle of the shell in profile. Species previously assigned to this genus appear to intergrade with both *Oncoceras* and *Beloitoceras,* leading to the belief that *Neumatoceras* is at present only a receptacle for strongly gibbous species derived from several genetic radicles, some of which are clearly defined

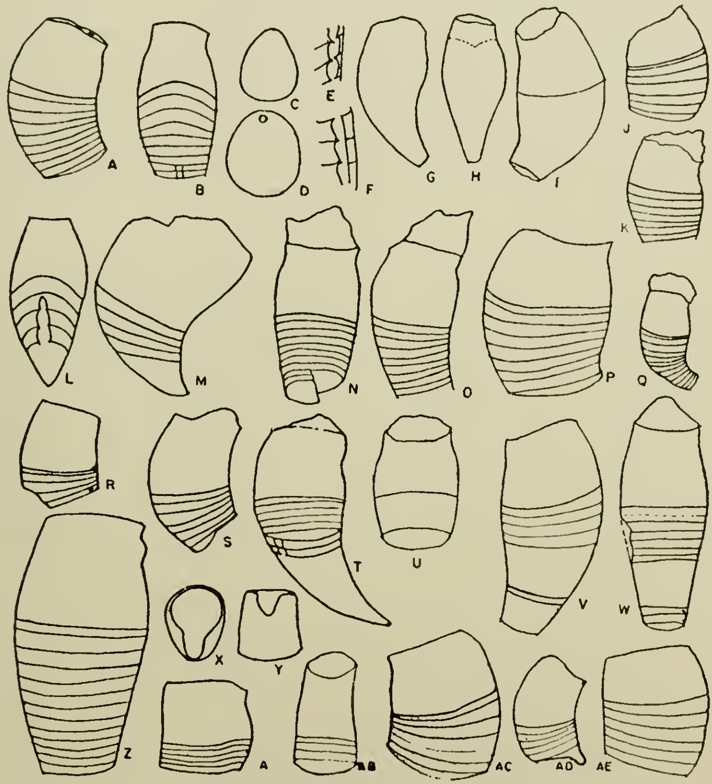

Figure 11. Outlines of species of *Oncoceras* and *Beloitoceras* showing genotype; intergradation of genera on basis of form; Cincinnati species and related Middle and Upper Ordovician representatives. F, J, K, and T-W are original. Others are drawn from Foerste's illustrations. A-E. *Beloitoceras pandion* (Hall), genotype of *Beloitoceras,* Platteville limestone, Wisconsin. A, lateral view; B, ventral view; C, cross section of aperture; D,

species groups. The genus appears later than *Oncoceras* and *Beloitoceras*, being essentially boreal, and probably none of the species are older than the Upper Ordovician.

Maelonoceras.—This genus is so little known that at present only the genotype can be assigned to it. That species is known only from a living chamber which contracts gradually toward a pear-shaped aperture (fig. 11, X-Y). Formerly Foerste regarded such shells as fig. 11 AD as typical, but these are not congeneric with fig. 11 X-Y, which is the specimen which Hyatt selected as the type of Billings' species, *Oncoceras praematurum,* at the time of the description of the genus *Maelonoceras.* Foerste subsequently extended *Beloitoceras* to include such specimens as fig. 11, AD.

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cross section near base; E, vertical section of siphuncle. F. Siphuncle of an undescribed Chazyan species, showing straight ventral and scalariform dorsal outline. Valcour limestone, Little Monty Bay, Chazy, New York. G-K. *Oncoceras constrictum* Hall, genotype of *Oncoceras,* showing size and form variation. G-H, lateral and ventral views of a type; I, lateral view of another type; J-K, lateral view of two specimens in the collection of the writer. Trenton limestone, Trenton Falls, New York. L-M. *Beloitoceras baffinense* (Schuchert), Frobisher Bay, Baffin Land, showing extreme of vertical expansion included in *Beloitoceras.* N-O, *Oncoceras collinsi* Foerste, Black River, Ottawa. N, dorsal and M, lateral views. P. *Oncoceras carletonense* Foerste, English Head formation, Anticosti. Lateral view. The gibbosity of the dorsum is high for *Oncoceras,* approaching the condition found in the more gibbous *Beloitoceras.* Q. *Oncoceras parvum* Foerste, Bighorn formation. Lateral. R. *Beloitoceras carveri* (Clarke), Platteville limestone, Minnesota. Lateral. S. *Beloitoceras* cf. *janesvillense* Foerste, Platteville limestone, Minnesota. Lateral. T-U. *Oncoceras foerstei* Flower, Leipers formation, Kentucky, T, lateral view with section of phragmocone appended and apex restored. U. Dorsal view. From holotype. V-W. *Oncoceras arlandi* Flower, Leipers formation, Kentucky. V, lateral view; W, dorsal view. X-Y. *Maelonoceras praematurum* (*Billings*), Black River limestone, LaCloche Island, Lake Huron. Living chamber, X, adoral and Y, ventral view. Z. *Oncoceras* (?) *ornatum* (Miller), Bighorn formation. Lateral view. A-AB. *Beloitoceras norwoodi* (Clarke), Platteville limestone, Minnesota. A strongly compressed species with low gibbosity, approaching *Oncoceras.* A, lateral; AB, ventral. AC. *Beloitoceras percurvatum* Foerste, Ellis Bay formation, Anticosti. Lateral aspect. AD. *Beloitoceras clochense* Foerste, Black River limestone, LaCloche Island, Lake Huron. Lateral aspect. AE. *Oncoceras* (?) *curvicameratum* Foerste, Ellis Bay formation, Anticosti. Lateral view. This species could as easily be placed in *Beloitoceras.*

Richardsonoceras Foerste was erected for shells which were less gibbous than *Beloitoceras*. Flower (1942) restricted the genus owing to its conflict in scope with *Oonoceras* Hyatt, to compressed cyrtoceracones with the living chamber curved, expanding or essentially tubular to the aperture, and with relatively deep cameræ. Ordovician species, formerly assigned to the genus which have a very gradual expansion, are only very slightly curved, have very shallow cameræ, and a somewhat more slender siphuncle than typical *Richardsonoceras*, were returned to *Oonoceras* Hyatt, a genus based upon a Silurian genotype from Bohemia. When Foerste described *Richardsonoceras* he regarded *Oonoceras* as practically confined to the genotype, a conclusion which does not seem to be justified by the morphological facts. *Richardsonoceras* as restricted grades into *Beloitoceras*, possibly through relatively slender and deep-chambered species such as *Beloitoceras murrayi*.

Oonoceras Hyatt is employed for very slender slightly curved cyrtoceracones with shallow cameræ and a relatively small and faintly expanded siphuncle. The interior of the shell is often constricted shortly before the aperture is attained, but there is no reason to believe that this constriction is anything more than a thickening of the interior of the shell. While the distinction between *Oonoceras* and *Richardsonoceras* is not great, there are no species which form a transition between the genera. However, both genera appear to intergrade with *Beloitoceras* although naturally through different groups of species in that genus.

Digenuoceras Foerste, known only from the genotype, *D. latum*, of the Red River series of Manitoba and *D.* cf. *latum* of the Bighorn formation of Wyoming, is regarded as a specialization derived from *Oonoceras* from which it differs in the cross section which is subangular on the dorsum as well as on the venter. *Exomegoceras* Miller and Carrier, known only from the genotype, *E. wyomingense* Miller and Carrier, of the Bighorn formation, is more angular in section than *Oonoceras* and has deeper cameræ. Nevertheless, in the absence of any internal differences, it does not seem to be sufficiently distinct from *Oonoceras* to merit the use of a new name.

Included in the Oncoceratidæ is that group of genera for which Hyatt erected the family Rizoceratidæ. These are *Cyrtorizoceras* and *Rizoceras*. *Cyrtorizoceras* is little known in the Ordovician, but the Ordovician species include the genotype. This is a compressed shell, expanding rapidly vertically after the manner of the early stages of *Beloitoceras* and some *Richardsonoceras*, but differing from those genera in the continuation of the rapid expansion to the aperture. The siphuncle is small, ventral, and apparently slightly expanded within the cameræ. The surface markings of the genotype have become fasciculate, producing incipient annulations. More Silurian than Ordovician species have been placed in this genus. However, there is a wide gap between the Ordovician and Silurian species which suggests that the genus at present embraces a series of convergent homeomorphs. The Silurian species are larger, more strongly curved, and have much more strongly expanded siphuncles. It is suspected that they developed independently of the typical Ordovician forms, possibly from Silurian *Oonoceras*.

The same anomalous situation surrounds the genus *Rizoceras*. Here the shell expands to the aperture, but except for a slight initial exogastric curvature, the greater part of the shell is essentially straight. The few Ordovician species appear to be closely similar to one another. None of them have as yet yielded internal structures which can be studied properly. The Silurian species, which include the genotype, are quite similar. Homeomorphy is suspected here, however, on the basis of a series of species from Bohemia connecting the genotype with approximately contemporaneous species of "*Cyrtorizoceras*" and *Oonoceras*.

The faintly costate condition of the genotype of *Cyrtorizoceras* suggests a strong similarity with shells of more nearly circular section and with slightly stronger costæ, which have been placed in *Zitteloceras*, and which are noted below as the group of *Zitteloceras billingsi*. From this group the other groups of *Zitteloceras* may have been derived, although as yet no species have been found showing an intergradation between the group of Z. *billingsi* to *Zitteloceras, sensu stricto*, or to the group of species for which Foerste established the generic name *Laphamoceras*. Nevertheless the differences are relatively minor, both among the three species groups of *Zitteloceras* and between Z. *billingsi* and *Cyrtorizoceras,* and seem to warrant placing *Zitteloceras* in the Oncoceratidæ with *Cyrtorizoceras.*

Two Ordovician cyrtoconic genera of circular section are also placed here, the strongly curved *Loganoceras* and the nearly orthoconic *Kentlandoceras. Kentlandoceras* is strikingly similar to the new genus *Miamoceras,* which differs from it mainly in a strongly compressed cross section and supplies a link between *Kentlandoceras* and *Beloitoceras.*

Previously (Flower, 1942, p. 30) the writer had extended this series to include exogastric shells of depressed section and indicated this by citing *Manitoulinoceras,* which was selected as one of the commonest and best known of these genera. Further study of *Manitoulinoceras* has shown that it is a member of the actinosiphonate family Valcouroceratidæ, although the relationship is not easily apparent, since the actinosiphonate deposits are not commonly displayed by *Manitoulinoceras.* Because of the strong similarity of *Staufferoceras* to *Manitoulinoceras,* that genus is placed tentatively in the same family. Probably *Fayettoceras* might be included there also, for it retains in the adult shell proportions, notably the rapid expansion of the conch and the deep cameræ, which are found only in the early growth stages of *Manitoulinoceras.*

There remain the depressed cyrtoconic genera *Schofieldoceras* and *Ehlersoceras* which are so poorly known internally that it is impossible to assign them to any family with certainty at the present time. *Winnipegoceras* is likewise inadequately known. It may belong to the Discosoroidæ, as proposed in the discussion of that group, but the possibility still remains that it might instead be a form deviation from the gibbous Oncoceratidæ.

The Oncoceratidæ, as here defined, do not seem to lend themselves to finer family divisions because of the very close relationships which the numerous species supply among the various genera. Hyatt used three families to include these genera. Some genera have been removed because of differences of internal structure. *Cyrtoceras,* which Hyatt put in the Ooceratidæ, is not related to *Oonoceras* (=*Ooceras*) being concavosiphonate and actinosiphonate. Its affinities are uncertain. Likewise, *Cyclostomiceras* and *Eremoceras* are removed from the Oncoceratidæ, since these pre-Chazyan genera are not cyrtochoanitic.

The large number of species which are so close to the boundaries between the genera of the Oncoceratidæ as here defined suggest overwhelmingly that the group is a genetic unit characterized by great plasticity of shell form in the Ordovician. In the present work an attempt has been made to retain as many of the existing generic names as possible, and in order to do so it has sometimes been necessary to draw rather fine and arbitrary lines between the genera. Clearly the Oncoceratidæ represent a rapidly expanding and highly plastic stock in the Ordovician.

The family is also present in the Silurian, where it underwent a second great period of expansion and form deviation. *Oonoceras, Rizoceras,* and *Cyrtorizoceras* as at present defined appear to pass from the Ordovician to the Middle Silurian. However, as already noted, there is reason to doubt that Silurian and Ordovician species of *Cyrtorizoceras* are actually congeneric. Further, the abundant cyrtoceracones of the Silurian of Bohemia supply such a gradational series running from the slender exogastric *Oonoceras* to the more rapidly expanding *Cyrtorizoceras* and the straighter *Rizoceras,* that it is doubtful whether two independent investigators undertaking the task of assigning the species, formerly placed in "*Cyrtoceras*", among these three genera, would complete their tasks with very closely similar results. In the Silurian other cyrtoconic genera appear which may or may not represent further expansion of the Oncoceratidæ. The depressed cyrtocones and brevicones are of the uncertain origin. It is possible that many, perhaps all of the phragmoceroids, may have developed from the oncoceroid stock. A fairly good transition is supplied from *Oonoceras* to the trochoceroid *Lechritrochoceras,* in which the siphuncle has become nearly tubular. Likewise, *Oonoceras* and the actinosiphonate *Oocerina* appear to be very closely allied. To Silurian *Ooceras* may be traced the family Brevicoceratidæ which attained its apex in the Middle Devonian, but much more study of well-preserved Silurian cyrtoceracones is necessary before the relationships can be traced much farther. Unfortunately most American Silurian cephalopods are preserved in saccharoidal dolomites which do not preserve internal structures properly.

The large number of undescribed species belonging to the Oncoceratidæ already encountered in the comparison of Cincinnatian with other and largely Middle Ordovician material, shows that probably many more await discovery. However, the stratigraphic range already is sufficient to indicate the trends of development within the family. No pre-Chazyan cephalopods are known which are referable to this family. Lower Chazyan cephalopods are still largely unknown. The Middle Chazyan has yielded a few small gibbous oncoceroids, close to the boundary between *Oncoceras* and *Beloitoceras.* The Upper Chazyan has yielded several species, largely undescribed, which are also close to the *Oncoceras-Beloitoceras* boundary, so close that it seems to be largely a matter of opinion as to which genus should contain them. Two specimens of the aspect of *Richardsonoceras* occur here, but these may not be mature shells. The Lowville oncoceroids are poorly known. Here again occur generalized gibbous species and a form of *Cyrtorizoceras* which also suggests *Zitteloceras.* The upper beds of the Black River contain more varied oncoceroids and *Beloitoceras.* In those beds and in the closely allied faunas which Kay considers Rockland in age, the oncoceroids attain their first peak of abundance and diversity. Here occur *Oncoceras* and *Beloitoceras* with *Cyrtorizoceras, Rizoceras, Zitteloceras, Richardsonoceras, Laphamoceras, Kentlandoceras,* but *Neumatoceras* and true *Oonoceras* are absent. The cephalopods of the middle and upper Trenton of the southern region are virtually unknown. In New York the Middle Trenton representatives of the oncoceroids are meagre and not startingly different from earlier types.

The upper beds of the Trenton, the Cobourg in the north, and the Cynthiana-Cathys faunas of the more southerly east-central area, exhibit a further expansion of the gibbous oncoceroids, forms appearing which approach the extreme in gibbosity generally considered characteristic of *Neumatoceras*. Here also *Oonoceras* appears.

These two genera attain their maximum Ordovician development in the boreal Ordovician, being best represented, however, in the Whitehead formation, the Bighorn formation, and the Fremont limestone, while they are not so well represented in the Red River fauna nor in the Cape Calhoun fauna farther north. Only a few very fragmentary oncoceroids occur in the Upper Ordovician of Oslo or the Lyckholm beds of Esthonia. These facts, together with a general absence or scarcity of cephalopods identifiable as members of the Oncoceratidæ in the British Ordovician or the Ordovician of Bohemia, suggest that the oncoceroids are essentially an American development in the Ordovician.

The Richmond proper, as known from the Cincinnati region and Anticosti, contains the species group of *Beloitoceras amoenum*. Few other oncoceroid types which are diagnostically Richmondian occur in these two regions. The *Oonoceras* species of the Cynthiana, as previously pointed out (Flower, 1942) have their closest affinities with Vaureal, Bighorn, and Fremont species, all supposedly Richmondian and generally regarded as faunas of boreal origin.

History of investigation.—Hyatt (1884, pp. 280-82) included in the Maelonoceratidæ *Maelonoceras* Hyatt, *Oonoceras* Hyatt, *Streptoceras* Billings, *Cranoceras* Hyatt, and *Naedyceras* Hyatt and placed in the Oncoceratidæ *Eremoceras* Hyatt, *Clinoceras* Mascke, and *Oncoceras*. Hyatt's next classification (1900) involves the family Rizoceratidæ, including *Rizoceras* Hyatt, placed by him in 1884 in the Orthoceratidæ, and the new genus *Cyrtorizoceras*. The Ooceratidæ, which should be named Oonoceratidæ, included *Ooceras* (more properly *Oonoceras*, as originally spelled), and *Cyrtoceras*. The Oncoceratidæ contained *Eremoceras, Cyclostomiceras, Oncoceras,* and Hyatt regarded *Maelonoceras,* its spelling changed to *Meloceras,* as a subgenus of *Oncoceras*. *Clinoceras* and *Streptoceras* are included in the next family Poterioceratidæ with *Poterioceras* and *Sycoceras.*

Eremoceras and *Cyclostomiceras* are Canadian genera and are not cyrtochoanitic. Ulrich, Foerste, and Miller (1942) have placed *Cyclostomiceras* in the Cyclostomiceratidæ and *Eremoceras* in the Cyclendoceratidæ. While this classification may be artificial, it is evident that these genera belong to a pre-Chazyan group of cephalopods which varied widely in form long before cyrtochoanitic structure appeared and have no real relationship with *Oncoceras*. The nucleus of the modern Oncoceratidæ therefore exists essentially in the species which Hyatt considered as belonging to *Oncoceras* in its broadest sense. Further inspection of these species will show that they grade into long slender uniformly curved cyrtoceracones, for which the Oonoceratidæ was erected, and also shells which are more rapidly expanding and less curved, such as were included by Hyatt in the Rizoceratidæ.

Foerste (1924) redescribed *Oncoceras* and *Maelonoceras*, refigured their genotypes, and added the new genus *Beloitoceras*. *Oncoceras* is here regarded as a compressed cyrtoceracone, the dorsum of which becomes convex adorally over the upper part of the phragmocone and the lower part of the living chamber. Where the dorsum is convex the lateral sides are convex, and from that point they approach each other toward the aperture. Foerste placed in *Oncoceras* the following species:

Oncoceras abruptum Hall, *Oncoceras cincinnatiense* Miller, *Oncoceras douglassi* Clarke, *Oncoceras pristinum* Ruedemann, *Orthoceratites trentonensis* Emmons, possibly identical with *Oncoceras constrictum*, and ? *Gomphoceras faberi* Miller.

Maelonoceras is redefined here though unfortunately on the basis of the selection of a specimen as the lectotype of the type species contrary to that previously designated by Hyatt (1884) so that further emendation was necessary. Indeed, *Maelonoceras praematurum* Foerste, 1924, is now *Beloitoceras clochense* Foerste, and true *praematurum* is described here as *Maelonoceras billingsi* Foerste. (See Foerste, 1933.)

The new genus *Beloitoceras*, based upon *Oncoceras pandion* Hall of the Platteville limestone of Wisconsin, was described as differing from *Oncoceras* "in lacking a distinct gibbosity along the upper part of the phragmocone and the lower part of the living chamber. If any gibbosity along the dorsal side is present, the maximum development of the gibbosity is distinctly above the level of the base of the living chamber. Moreover, compared with typical *Oncoceras* the conch is distinctly more flattened laterally." He regards the affinities of this genus as with *Maclonoceras* rather than *Oncoceras,* and with the stock from which *Maclonoceras* developed. The following species were placed in the genus at the time of its original description:

Oncoceras carveri Clarke, *Cyrtoceras fragile* Billings, *C. Houghtoni* Clarke, *C. huronense* Billings, *C. isodorus* Billings, *C. norwoodi* Clarke, and *C. schofieldi* Clarke.

Foerste (1926, pp. 317-318) reviewed these genera in connection with his study of actinosiphonate cephalopods but made no modifications in his earlier descriptions. Foerste (1928) referred *Oncoceras arcticum* Schuchert to *Beloitoceras,* also *Cyrtoceras cornulum* Schuchert and *C. baffinense,* regarding the generic position of the last species as dubious. In the same year, Foerste (1928A) noted the following representatives of these genera in Anticosti:

Beloitoceras fragile (Billings), *B. percurvatum* Foerste, *B. accultum* Foerste, *B. magisterium* Foerste, *B. obstructum* Foerste, *B.* (*?*) *jamesense* Foerste, *B.* (*?*) *fererectum* Foerste, *Oncoceras carletonense* Foerste, *O.* (*?*) *curvicameratum* Foerste. Those species for which the generic reference is dubious lie close to the boundary between the two genera.

Foerste (1932, '33) redescribed and considerably modified these genera and described some new ones. He noted here that his selection of a type species for *Maclonoceras* conflicted with Hyatt's earlier choice and found it necessary to revise his description of the genus. Unhappily Hyatt's lectotype of *M. praematurum* (Billings) is an anomalous and little known species. On the basis of the slender living chamber and the contraction of the shell over the adoral end, no species other than the genotype which can be placed in this genus is known at present, and *Beloitoceras* is expanded to include the species *Beloitoceras clochense,* based upon the specimen which Foertse in 1924 regarded as the lectotype of *Maclonoceras praematurum.* The new genus *Richardsonoceras,* based upon *Cyrtoceras simplex*, is described as "similar to *Beloitoceras,* but enlarging less rapidly in a dorso-ventral direction and hence more elongate. The dorsal outline of the living chamber tends to be more concave, in continuation of the concave outline of the phragmocone. The siphuncle tends to be a little larger, but the more elongate form of the conch and its more distinctly concave dorsal outline are the chief characters of the genus." Foerste placed here *R. simplex* (Billings), *R. beloitense* Foerste, *R. romingeri* Foerste, and *R. schofieldi* Clarke, and noted that other species, including *Richardsonoceras? falx* and *R. ? clarkei,* might belong here. Unfortunately, there does not seem to be a really clear distinction between *Richardsonoceras* and *Beloitoceras*. *Richardsonoceras* is more slender and typically the living chamber is faintly contracted at the aperture. These species grade into the more slender representatives of *Beloitoceras*. On the other extreme, species have been placed in the *Richardsonoceras* with essentially tubular living chambers which grade into *Oonoceras*. In the writer's revision of the genus (Flower, 1942), *Oonoceras* is recognized as occurring in the Middle and Upper Ordovician as well as in the Silurian. It differs from *Richardsonoceras* in having a much more slender shell, essentially tubular except for slight preoral constrictions of the living chamber, and has shorter cameræ than *Richardsonoceras*. The distinction is not, however, a good one, and it may prove advisable to reduce *Richardsonoceras* as a synonym of *Oonoceras*. Nevertheless the Middle Ordovician species which constitute the nucleus of *Richardsonoceras* are more curved, have slightly deeper cameræ, and slightly more expanded siphuncles than *Oonoceras*, and indeed look quite unlike it, though the differences are superficial. In having poor generic boundaries the genus is hardly in any worse state than most of its relatives, and therefore I have retained it here.

Beloitoceras is redefined as follows: "Conch relatively short, strongly compressed laterally, with the ventral side more narrowly rounded, moderately enlarging laterally. Margins of aperture arching moderately upward laterally or ventrolaterally, but curving downward rather strongly at the hyponomic sinus. Upper part of aperture often constricted by a thickening of the inner wall of the shell near the top of the living chamber. Sutures of septa curving slightly downward laterally, but rising at an increased angle in a ventrad direction on approaching the upper end of the phragmocone. Siphuncle of medium size, compared with related cyrtoceroids, and almost in contact with the ventral wall of the conch, especially among the lower half of the cameræ."

Compared with typical *Oncoceras*, the conch enlarges much less laterally at the top of the phragmocone and the base of the living chamber, and the dorsal gibbosity along the lower half or two-thirds of the living chamber, but in most cases this part of the dorsal outline merely tends to be straight, becoming slightly or more distinctly concave farther up. The following species are described and illustrated: *B. janesvillense, B. huronense, B. houghtoni, B. norwoodi, B. carveri, B. isodorus, B. clochense,* and *B. murrayi.*

In the same work, *Oncoceras* is defined as follows:

"Conch short, rapidly expanding, strongly curved lengthwise, with its maximum dimensions at the top of the phragmocone and the base of the living chamber, contracting thence to the aperture. Although the general outline of its dorsal side is concave, there is a gibbosity at the top of the phragmocone and the base of the living chamber which is more or less distinct along the dorsal side of the conch and usually also affects its lateral outline, producing more or less distinct inflation of the entire circumference of the conch here. The aperture is oval in outline, more narrowly rounded ventrally, and the hyponomic sinus is distinct but relatively shallow. The siphuncle is close to the ventral wall of the conch and its segments are narrowly fusiform." The species described here are *O. collinsi,* Foerste, *O. tetreauvillense* Foerste, *O. Douglassi* Clarke, and *O. Casei* Foerste.

A further revision of the genera (Foerste, 1935) involved some redefinition and the separation of the new genus *Neumatoceras. Beloitoceras* is described as follows:

"It was intended to include in the genus *Beloitoceras* relatively short curved conchs which were laterally compressed, attained their greatest dorso-ventral diameter at or above the base of the living chamber, and in which the lower part of the dorsal outline of the living chamber tended to be slightly convex or gibbous.

The siphuncle is located near, but not in contact with the ventral wall of the conch, its segments being elongated vertically, instead of subglobular or subnummuloidal in form. The typical specimens occur in the Beloit formation in the Upper Mississippi Valley, but similar specimens occur as far up as the top of the Richmond."

"The new genus *Neumatoceras* differs from *Beloitoceras* chiefly in being distinctly humped along the upper part of the ventral outline of the phragmocone, the maximum dorso-ventral diameter usually being at a distinct interval beneath the base of the living chamber ventrally. From this level of maximum dorso-ventral diameter the conch usually tapers conspicuously toward the aperture. The dorsal outline along the upper part of the phragmocone and all of the living chamber tends to be relatively straight, with faint incurvature at top and along the lower part of the phragmocone." *N. gibberosum* Foerste, *N. nutans* Foerste, *N. breviposticum* Miller, *N. canyonense,* and *N.* cf. *canyonense* are placed here. Also, the following are included in the genus with doubt: Two unnamed species of the Bighorn formation, *Oncoceras tumidum* Schuchert, *Westonoceras* (?) *contractum* Foerste and Savage, and also *Winnipegoceras,* sp. Foerste, of the Red River formation.

Oncoceras is discussed, but the definition is largely concerned with the genotype: "The holotype is a relatively small conch, curved distinctly gibbous on its dorsal side at the top of the phragmocone and base of the living chamber, where it also reaches its greatest lateral diameter, contracting then distinctly toward the aperture. This holotype occurs in the Trenton of New York, but the genus ranges upward into the top of the Richmond."

These descriptions are largely quoted in full in order to present Foerste's various views concerning the limits of these genera, a necessary matter since we need next to inquire into their boundaries to determine whether the genera represent natural and convenient groups as they stand, or whether revision is either desirable or possible.

After tracing three series which seem to involve species which have previously been assigned to these genera, as well as some new ones which have not been discussed before, it is quite evident that neither *Oncoceras, Beloitoceras* nor *Neumatoceras* are natural genera by themselves. The problem is made even more complex by the problems produced by shell distortion. Slight flattening of a shell may, particularly in limestone, alter the original section and shape enough to affect the generic position of the species on the basis of the present standards. Yet such flattening may not be obvious from the specimen itself if it has occurred without obvious distortion.

Genus ONCOCERAS Hall

Genotype.—*Oncoceras constrictum* Hall, 1847.

Oncoceras Hall, 1847, Paleontology of New York, vol. 1, p. 197; d'Orbigny, 1849, Prodr. de Paleont., vol. 1, p. 5; Hall, 1850, Regents of the Univ. (of the State of New York) on the condition of the State Cabinet of Natural History, 3d Ann. Rep., p. 180, pl. 3, fig. 3; Woodward, 1851, Manual of Mollusca, pt. 1, p. 90; Saemann, 1852, Palæontographica, vol. 3, pp. 157, 162; Pictet, 1854, Traité de Paléontologie, 2d ed., vol. 2, p. 646; Emmons, 1856, Amer. Geol., vol. 1, pt. 2, p. 148; Hall, 1861, Wisconsin Geol. Surv., Rep., p. 43; Billings, 1866, Canada Geol. Surv., Cat. Sil. Foss., Anticosti, p. 86; Barrande, 1867, Système Sil. du centre de la Bohême, vol. 2, pt. 1, p. 450; Hyatt, 1884, Boston Soc. Nat. Hist., Proc., vol. 22, p. 282; Miller, 1889, North American Geol. Pal., p. 445; Hyatt, 1900, Cephalopoda, *in* Zittel-Eastmann Textb. Paleont., vol. 1, 1st ed., p. 530 (reprinted in other editions, different pagination); Clarke and Ruedemann, 1903, New York State Mus. Mem., No. 5, p. 94; Grabau and Shimer, 1910, North American Index Fossils, vol. 2, p. 122; Foerste, 1924, Denison Univ. Bull., Sci. Lab., Jour., vol. 20, p. 239; Foerste, 1926, *ibid.*, vol. 21, p. 318; Foerste, 1933, *ibid.*, vol. 28, p. 109; Foerste, 1935, *ibid.*, vol. 30, p. 42.

Diagnosis.—Conch a compressed exogastric brevicone which expands fairly rapidly to a gibbous region which is located typically below the base of the living chamber. From there the shell contracts to the aperture. At the gibbous region the convexity of the venter is typically increased, the dorsum, concave adapically, becomes convex. Farther orad the venter and dorsum approach each other but become less convex, frequently becoming straight close to the aperture, and sometimes internal molds are concave at this region, due in part to the natural shape of the shell and in part to gerontic constrictions on the inside of the shell. The aperture in general slopes orad from dorsum to venter but bends ventrally to form a hyponomic sinus.

The section is compressed, the venter narrower than the dorsum. The septa are typically relatively flat. The sutures develop lateral lobes, which are, however, rarely very deep. Adorally the sutures tend to slope orad from dorsum to venter, such curvature being greatest in the more markedly exogastric species. The siphuncle is small and is located close to the venter. The segments are ovoid to scalariform, generally slightly longer than wide. The septal necks are short and recurved. The siphuncle has not been observed to possess organic deposits in any species. Gerontic internal molds show faint linear impressions which are molds of vestigial cameral deposits. The basal zone is usually only poorly developed if at all.

Discussion.—*Oncoceras* was formerly widely used for compressed exogastric brevicones with small ventral siphuncles and was employed in this way by Hall, Clarke, Hyatt, and Ruedemann. Foerste, however, restricted the genus on the basis of the form of the shell, distinguishing from it the closely allied *Neumatoceras* and *Beloitoceras*. If these genera are related, it is to be suspected that some species may bridge the gaps which separate them from one another. However, it is possible to recognize such form transitions in not one but in several species groups, a condition which suggests strongly that the genera in their present form are not natural genetic units but instead artificial form genera. At the present time it does not seem possible to improve the situation. The use of generic names for the various species groups seems unwise. It would complicate the nomenclature unnecessarily, and the new genera resulting would be perhaps more natural, but there would still remain species which are so close to the boundaries separating the various units that their generic position and nomenclature would be largely matters of individual opinion. Further, it is possible that when more is known of the interiors of these cephalopods, some useful guides to phylogeny may be found in the siphuncles which vary somewhat in form. However, such criteria cannot be employed at present simply because the siphuncles are not known in sufficient detail for more than a very few of the described species and are not known at all for several. Further, the number of described species belonging to these three genera represents only a small portion of those which exist in America, and until more material can be studied, and more of these species can be made known, revisionary attempts would be premature.

The early use of *Oncoceras* was somewhat too broad and generalized. Bassler (1915) lists about 30 species, although in all, 40 have been placed in this genus at one time or another. Foerste (1924) confined it to exogastric compressed shells in which the dorsal profile changed from concave to convex over the upper part of the phragmocone and the lower part of the living chamber. In tinct gibbosity along the upper part of the phragmocone and the lower part of the living chamber, although shells were included which were gibbous dorsally orad of the base of the living cham- contrast, *Beloitoceras* was employed for shells which lacked a dis- ber. At this time Foerste included in *Oncoceras*, *Oncoceras abruptum* Hall, *Gomphoceras cincinnatiense* Miller, *Oncoceras douglassi* Clarke, *Oncoceras pristinum* Ruedemann, and *Orthoceratites trentonense* Emmons, which may be a synonym of *Oncoceras constrictum*. He also noted that *Gomphoceras faberi* may belong in *Oncoceras*, though in it the dorsum becomes only slightly convex.

On the basis of the extent of gibbosity there is naturally variation between *Oncoceras* and *Beloitoceras*. Likewise, there is no clear boundary which can be drawn between those species which are convex on the dorsum on the upper part of the phragmocone and the lower part of the living chamber, and which therefore belong in *Oncoceras* as emended, and those in which the gibbosity is developed well on the living chamber. Foerste (1933, p. 98) says of *Beloitoceras*:

"Compared with typical *Oncoceras*, the conch enlarges much less laterally at the top of the phragmocone and the base of the living chamber, and the dorsal gibbosity is much less conspicuous. There is a faint tendency toward gibbosity along the lower half or two-thirds of the living chamber, but in most cases this part of the dorsal outline merely tends to be straight, becoming slightly or more distinctly concave farther up." Neither the lateral gibbosity of the shell nor the concavity of the dorsum near the aperture supply criteria which will eliminate the problem of species which are intermediate between the two genera.

Unfortunately it is to be doubted whether this distinction between *Oncoceras* and *Beloitoceras* is entirely natural. Shells which at one stage of growth have the gibbosity high on the living chamber and are therefore typical of *Beloitoceras* may, by the addition of a little more material to the aperture and the secretion of a few more septa, pass the bounds into *Oncoceras*. Further, if in the history of a species this change occurs, the older and simpler forms would be placed in *Beloitoceras,* while the more advanced essentially phylogerontic forms would fall within the limits of *Oncoceras*. Such inferences as to close relationship between species as can be drawn from similarities in outline, section, and sutures, suggest that such changes may have occurred in several different groups of species, indicating that the distinction between the genera is not natural. For this reason the actual disposal of species in *Oncoceras* and *Beloitoceras* has been decided, in the case of those forms close to the borderline between the two genera, largely upon the basis of the affinities of the species with others which are more typical representatives of one genus or the other.

Oncoceras likewise approaches the form of *Neumatoceras,* a genus which is typically more compressed, in which the ventral profile is more strongly bent over the gibbous part of the shell. The problem of such species is discussed under *Neumatoceras* but is noted here also, as it is relevant to the generic position of Cynthiana and Leipers species some of which are borderline cases, but which have been put in *Oncoceras* on the basis of their affiniies with Middle Ordovician species. Such forms as *Oncoceras bassleri* Flower, n. sp., have living chambers which alone cannot be distinguished from those of *Neumatoceras* yet are typical of *Oncoceras* in the convexity of the dorsum and the relatively slight gibbosity of the ventral profile. Typical *Neumatoceras,* however, seems to have developed from *Beloitoceras* rather than *Oncoceras*.

Oncoceras is more advanced than *Beloitoceras,* and it is not surprising to find that *Beloitoceras* predominates in the Chazyan. The writer would place *Oncoceras pristinum* Ruedemann in *Beloitoceras,* though it is one of the more convex and more gibbous species of this genus. Other undescribed Chazyan species fall largely within the limits of *Beloitoceras,* though a few are convex enough dorsally and have the gibbosity located low enough on the shell to be placed in *Oncoceras.* However, as at present defined, *Oncoceras* is known mainly from the Middle and Upper Ordovician. Several of the previously described species are illustrated in text figures 11 and 12 for comparison with Cincinnatian species. The described species are briefly listed below, with a few notes on their form and apparent affinities. However, a considerable number of Middle Ordovician species are as yet undescribed, and the list is far from exhausting the possibilities of Ordovician faunas of America.

Oncoceras constrictum Hall. Trenton limestone, New York. This is a highly variable species as shown in text figure 11 G-K. It is uncertain, however, whether the evident size variation indicates that the species as previously understood has been used too broadly, or whether it is a variable one, or whether sexual dimorphism may account for the size discrepancies.

O. pupæforme Ruedemann. Utica shale, New York. Gibbosity is high on this species which is rather close to *Beloitoceras.* The humped form, shown in Ruedemann's figures also suggests *Neumatoceras,* but this has been exaggerated by flattening. This species is the basis of Ruedemann's suggestion of sexual dimorphism among the cephalopods.

Oncoceras abruptum (Hall). Platteville limestone, Wisconsin. The gibbosity is rather high on this species, which is retained in *Oncoceras* by Foerste. It is a strongly gibbous species with the dorsum markedly convex.

O. carletonense Foerste. English Head formation, Anticosti. Shell gibbous just before the living chamber. Typical of *Oncoceras* (text fig. 11 P) but rather strongly compressed, suggesting the *amoenum* group of *Beloitoceras.* It is not closely allied to any other *Oncoceras.*

O. casei Foerste. Black River, St. Joseph Island. A small slender form, scarcely convex dorsally.

O. tetreauvillense Foerste. Black River, Quebec. Apparently intermediate between *O. carletonense* and *O. abruptum.*

O. parvum Foerste. Bighorn formation, Wyoming. (Text fig. 11 Q). A small shell, strongly gibbous adorally. The gibbosity is high enough on the living chamber that the species might be placed in *Beloitoceras* on the basis of Foerste's definitions.

O. (?) *curvicameratum* Foerste. Ellis Bay formation, Anticosti. (Text fig. 11 AE). This, like *O. carletonense* seems rather close to the *amoenum* group with *Beloitoceras.*

O. collinsi Foerste. Black River of Ontario. Gibbosity is greatest above the living chamber. The dorsum has a constriction near the aperture. (Text fig. 11 N-O).

O. foerstei Flower, n. sp. Leipers formation, Kentucky. Similar to *collinsi* in the prominent dorsal constriction but a less curved species in which the sutures extend higher and are more inclined adorally.

O. douglassi (Clarke) of the Prosser limestone of Minnesota. A typical rather compressed form with a faint concavity of the dorsum near the aperture.

The following Cincinnati species appear to be related.

O. carlsoni (Flower). Cynthiana limestone. This is smaller and broader in section but is otherwise quite similar to *O. douglassi.*

O. bassleri Flower, n. sp. This is a relatively small species of the Leipers in which the phragmocone extends farther orad and has more oblique sutures than in the above forms.

O. arlandi Flower, n. sp. Leipers formation. This approximates *O. douglassi* more closely in size than the other Cincinnatian species. It has sutures which extend farther orad on the venter.

O., sp. An unnamed *Oncoceras* from the Leipers, known from an incomplete living chamber. This is similar in shape to *O. bassleri* but is a much larger form.

Oncoceras fossatum Flower, n. sp., is a relatively straight form remarkable for the rapid change from transverse to oblique sutures in the adoral part of the shell.

Oncoceras covingtonense Flower, n. sp. Cynthiana limestone.

A small gibbous form which is essentially a larger edition of *O. abruptum* with more oblique sutures.

O. faberi (Miller). Maysville (Corryville?) beds. A small gibbous form of broad section.

O. cincinnatiense (Miller). Maysville (Corryville?) beds. A relatively slender form, closer to *Beloitoceras* in form than most species but with the low gibbosity of *Oncoceras.*

O. delicatulum Flower, n. sp. Waynesville, Ohio. Very similar to *O. cincinnatiense* but with deeper cameræ and apparently a broader section.

O. ornatum (Miller). Bighorn formation, Wyoming. Miller described this species as a *Dowlingoceras.* Foerste placed it in *Diestoceras.* The strong dorsal constriction of the aperture (text fig. 11 Z) suggests that this is an unusually straight shell related to *Oncoceras carletonense* and *O. foerstei.* No similar dorsal constriction is known in either *Dowlingoceras* or *Diestoceras.*

Oncoceras anomalum Flower, n. sp. Whitewater beds, Ohio. A relatively large and straight *Oncoceras* not closely related to other species.

Three small species of the Hitz beds of upper Whitewater age, *O. duncanæ, O. exile,* and *O. madisonense,* belong to the generalized stock close to those forms of *Oncoceras* which appear in the Chazyan. They seem to be the last survivors of the genus. *O. duncanæ* and *O. exile* are relatively straight forms. *O. madisonense* is more markedly exogastic, recalling *O. casei* in some details more than any other described species. *O. elkhornense* is the only known Elkhorn species.

Oncoceras carlsoni (Flower)

Neumatoceras carlsoni Flower, 1942, Bull. Paleont., vol. 27, No. 103 pp. 23-24, pl. 3, figs. 3-5; pl. 4, fig. 9.

As noted under description of *Neumatoceras,* this species approximates the form of that genus very closely. However, subsequent to its description, a closely allied species was found in the Leipers formation which, like *carlsoni,* appeared on the basis of the adoral part of the shell alone, to be a relatively slender *Neu-*

matoceras, but when the phragmocone became better known it was found that the form was instead that of an *Oncoceras*. The classification of this new species, *Oncoceras bassleri* as an *Oncoceras* rather than a *Neumatoceras* is a necessary step in view of the form of that species. Because *N. carlsoni* is evidently more similar to *N. bassleri* than any other known species, a generic transfer is necessary for this species.

No new material of this species has been obtained, and the reader is therefore referred to the original description and figures for all available information concerning it.

Oncoceras fossatum Flower, n. sp. Plate 35, fig. 5

Conch relatively slender and straight for an *Oncoceras*, but typical in the low position of the gibbous region over the adoral cameræ and base of the living chamber. Apex relatively slender and straight, the dorsum scarcely convex adapically and the venter essentially straight. The dorsum becomes slightly convex over the adoral part of the phragmocone and the base of the living chamber, becoming slightly less curved near the aperture, where the dorsum and venter converge slightly. The venter is likewise straight adapically, becoming more convex than the dorsum, and being straight on the adoral third of the living chamber where it approaches the dorsum. The sides are gibbous over the adoral part of the phragmocone.

The holotype increases from 13 mm. in height and 10 mm. in width at the base to a height of 23 mm. and an estimated width of 21 mm., in the basal 35 mm., and contracts to a height of 20 mm. at the aperture, 15 mm. farther orad. The 11 cameræ of the phragmocone occupy a length of 31 mm. ventrally and 29 mm. dorsally. The adoral sutures slope only slightly orad from dorsum to venter, and no clear lateral lobes are developed. The living chamber has a length of 11 mm. dorsally and ventrally. The aperture is approximately parallel to the suture at the base of the living chamber. The hyponomic sinus was evidently very small or wanting.

The internal mold bears fine rather distant shallow linear impressions, giving the phragmocone the aspect sometimes considered characteristic of *Westonoceras*. The cross section is slightly compressed, the greatest width dorsad of the center, but the venter is not strikingly narrowly rounded. The siphuncle lies close to the venter.

Discussion.—The Cynthiana species is more similar to *O. bassleri* of the Leipers formation than to any other form but is more generalized in several respects. The sutures are less strongly inclined orad on the venter and lack well-defined lateral lobes. The shell is less strongly compressed in section, the venter is not uniformly convex to the aperture on the living chamber, the phragmocone and the shell wall have not developed so far beyond the region of gibbosity, and the aperture is not strongly inclined to the plane of the septum at the base of the living chamber.

Type.—Holotype, U. S. National Museum, No. 59481.

Occurrence.—The specimen is labeled as doubtfully from the Trenton of Eddyville, Kentucky. The lithology suggests the Cynthiana or Leipers formation, only the Cynthiana being Trenton.

Oncoceras covingtonense Flower, n. sp. Plate 36, figs. 6, 7

This is a small obese *Oncoceras* characterized by the strong and uniform convexity of the ventral profile which has a radius of curvature of about 35 degrees. The holotype consists of the adoral part of a phragmocone and an incomplete living chamber. Venter uniformly convex, dorsum poorly preserved, probably originally slightly convex over the adoral part of the phragmocone, though nearly straight. Sides gibbous, the greatest width occurring well below the base of the living chamber. Section not strongly compressed, greatest width in the dorsal third, venter slightly more narrowly rounded than dorsum. The shell has a width of 17 mm. and a height of 20 mm. at the base of the type. In a length of 17 mm. the greatest width of 22 mm. is attained while the greatest height of 24 mm. is attained slightly farther orad approximately at the base of the living chamber. The phragmocone has a ventral length of 24 mm., a dorsal length of 16 mm. The living chamber has a ventral length of 17 mm. and is incomplete dorsally. At the base of the living chamber the height is 23 mm., the width, 21 mm. The height at the aperture is estimated at 20 mm., the width at 17 mm. The hyponomic sinus is small, shallow, and rather inconspicuous. The sutures develop only faint lateral lobes and slope increasingly orad on the venter as they are traced orad in the shell. Eight cameræ are present in the type which range from 2.4 to 3 mm. in depth. The last camera is slightly shorter than the others. The siphuncle is small, 1 mm. at the septal foramen and 2 mm. from the venter.

Discussion.—This species agrees in shape with *Oncoceras abruptum* Hall rather closely but is a considerably larger form. The ventral profile is somewhat more strongly and uniformly curved, and the sutures become more oblique in the adoral part of the shell. The conch is much more gibbous than that of *O. carlsoni.* The cameræ are shorter, less strongly inclined orad on the venter, and the ventral profile is more uniformly curved than in the Leipers species, *O. bassleri.*

Type.—Holotype, U. S. National Museum, No. 48391.

Occurrence.—From the Point Pleasant beds, Cynthiana limestone, West Covington, Kentucky.

Oncoceras, sp. Plate 40, fig. 11

Specimen 43 mm. in length ventrally, venter evenly convex, radius of curvature, 50 mm. Dorsum poorly preserved, straight, and diverging from venter to base of living chamber, missing farther orad but apparently becoming slightly convex. Section compressed but not markedly narrower on venter than on dorsum. The shell expands from 12 mm. in height and an estimated 10 mm. in width to 22 mm. and 21 mm. in a ventral length of 20 mm. Ten cameræ occupy a ventral length of 21 mm. Sutures straight, lacking lateral lobes, and become increasingly inclined orad on the venter as traced orad. The siphuncle is not exposed. The living chamber has a ventral length of 22 mm. but is too badly weathered to show the aperture.

Discussion.—This badly weathered specimen is figured here inasmuch as it obviously represents a Cynthiana species which is otherwise unknown. *O. covingtonense* is similar in general form, perhaps more so than any other species, but is more gibbous, larger, and has a much shorter living chamber.

Figured specimen.—Shideler Collection.

Occurrence.—From the Cynthiana limestone in a quarry 2½ miles from Winchester on the Ruckersville road, Ohio.

Oncoceras bassleri Flower, n. sp

Plate 11, figs. 1-2; Plate 17, figs. 4-6, 8, 10

Conch moderate in size, relatively straight adapically. Ventral profile slightly convex throughout, but more strongly curved adorally and nearly straight adapically. Dorsum nearly straight adapically, convex over adoral part of phragmocone, straight and converging toward venter over the living chamber. Sides faintly and nearly uniformly convex, converging gradually orad from the adoral part of the phragmocone.

The three specimens, from which this form is known, show some variation in proportions. The holotype (Pl. 17, fig. 10) is a relatively complete but somewhat weathered internal mold, 63 mm. long. At the earliest point where measurements can be taken, the apex being encrusted by Bryozoa, the shell is 12 mm., high and 11 mm., wide. In a ventral length of 40 mm. and a dorsal length of 35 mm. the maximum diameters of 19 mm. and 24 mm. are attained. The aperture lies 20 mm. farther on the venter and is 13 mm. in width and 16 mm. in height. The living chamber has a ventral length of 15 mm. and a dorsal length of 12 mm., and at the base, as measured along the strongly inclined suture, is 19 mm. wide and 23 mm. high. The sutures are clear only adorally, where they slope orad from dorsum to venter with shallow broad lateral lobes. Three ephebic cameræ average 3 mm. in depth; a fourth shorter camera is present just below the base of the living chamber. The siphuncle is not shown in the type. The aperture is strongly inclined orad from dorsum to venter but is not clearly preserved, and no hyponomic sinus is evident. The surface features are not preserved.

A second specimen (Pl. 11, figs. 1, 2; Pl. 17, fig. 8) consists of the extreme adoral end of a shell, a living chamber and three attached cameræ, which both Foerste and the writer independently regarded as *Neumatoceras*. This is a living chamber with three attached cameræ, somewhat weathered basally, and exposing the siphuncle on the first camera on the venter. The basal width is 20 mm., the height 24, probably originally 25 mm. Basal camera incomplete. Adoral two cameræ with a combined length of 2 mm. dorsally and 6 mm. ventrally. Sutures sloping orad from dorsum to venter with broad lateral lobes. Siphuncle obscurely outlined on weathered surface of venter, rounded, apparently slightly longer than wide. Living chamber, 11 mm. long dorsally, 17 mm. laterally, 15 mm. ventrally. Hyponomic sinus low, broad, poorly set off from the remainder of the aperture. Aperture 20 mm. high, 16 mm. wide, more inclined than the last septum. Cross section at base of specimen compressed, but not conspicuously narrowed on the venter (Pl. 17, fig. 8). This specimen differs from the holotype mainly in the larger aperture, a difference which may be in part due to poor preservation of the adoral end of the type, as otherwise the proportions of the two are extremely close.

A third specimen, (Pl. 17, figs. 4-6) an isolated living chamber to which a calcite-filled portion of a phragmocone (not figured) pertains, presents a very different aspect but has almost the same proportions. The living chamber is 19 mm. wide and 22 mm. basally and contracts in a ventral length of 17 mm. and a dorsal length of 10 mm. to the aperture which is 17 mm. high and 16 mm. wide.

Discussion.—The two specimens which retain the adoral part of the shell present the aspect of a *Neumatoceras* rather than an *Oncoceras*. The holotype, however, shows that the gibbosity of the adoral part of the phragmocone is not so marked as in typical *Neumatoceras,* the adapical part of the shell is less curved and more gradually expanding, and the hyponomic sinus is not so strongly developed as in *Neumatoceras.* Nevertheless, as can be seen by comparing this form, text figure 12U, with the lateral views of other species referred to *Neumatoceras* by Foerste, the difference is almost gradational from *Oncoceras* to *Neumatoceras,* while other species of *Neumatoceras* approach the form of *Beloitoceras.*

This species is closely allied to *Neumatoceras carlsoni* Flower of the Cynthiana limestone. It differs in that the section of *N. carlsoni* is more narrowly rounded on the venter, the venter is slightly more convex over the adoral part of the phragmocone and less curved over the most adoral part of the living chamber known, and the sutures develop slightly higher and sharper saddles on the venter. Nevertheless, the species are sufficiently similar to suggest that they ought to be placed in one genus.

Types.—Holotype, Univ. of Cincinnati, No. 24474. Paratypes, Univ. of Cincinnati, No. 24279, and one specimen in the collection of Dr. W. H. Shideler.

Occurrence.—From the Leipers formation of the Cumberland River, at Belk Island, and at Rowena, Kentucky.

Oncoceras ariandi Flower, n. sp. Plate 15, figs. 1, 2

Conch breviconic, exogastric, compressed, typical of *Oncoceras* in form, but a relatively slender species. The holotype is 60 mm. long, the venter almost uniformly convex, its radius of curvature varying from 52 mm. basally to 35 mm. near the region of greatest gibbosity and increasing to 70 mm. on the living chamber. The dorsal profile is slightly concave adorally, slightly convex over the basal part of the living chamber and the adoral part of the phragmocone, and nearly straight approaching the venter slightly over the adoral part of the living chamber. The shell increases from a height of 11 mm. and a width of 9 mm. near the base to 24 mm. and 27 mm. at the base of the living chamber, in a ventral length of 42 mm. and a dorsal length of 30 mm. The sutures curve from dorsum to venter adorally. Curiously, contraction of the shell is such that the height is the same at the extreme base of the living chamber normal to the shell and along the suture, which is inclined forward toward a part of the venter which is more contracted. The living chamber is 15 mm. long on the dorsum, 23 mm. on the venter. At the aperture, the height is 20 mm., the width 15 mm. The aperture is approximately parallel to the last suture, being inclined orad on the venter.

The sutures are straight and transverse basally, inclined orad on the venter adorally, but are without clear lateral lobes. Fifteen cameræ are preserved on the type exhibiting only a slight range of variation in depth. The siphuncle has not been observed.

Fragments of the shell fail to preserve any surface markings. The aperture is not clear ventrally, but there is no trace of a hyponomic sinus which must be small and poorly developed or absent.

Discussion.—This species is most similar to *Oncoceras douglassi* (Clarke) (see Foerste 1932, 1933) of the Prosser of Minnesota. It agrees with that species in general proportions, but the dorsum is less contracted on the living chamber, and the adoral sutures and aperture are much more inclined orad on the venter. No Upper Ordovician species are known which are closely similar.

Type.—Holotype, Univ. of Cincinnati, No. 24228.

Occurrence.—Leipers beds, Cumberland River, at Rowena, Kentucky.

Oncoceras foerstei Flower, n. sp. Plate 10, figs. 3, 4; Plate 16, fig. 2

Shell a small, strongly curved oncoceroid. The ventral profile is convex, the radius of curvature varying from 40 mm. at the base to 20 mm. at the gibbous region, and becoming uniformly 30 mm. near the aperture. The dorsum is convex over the preserved basal portion of the shell but must have become concave adapically. Orad of the center of the living chamber the dorsum bears a prominent constriction beyond which it flares slightly to the aperture. The holotype expands from 20 mm. and 18 mm. to 25 mm. and 22 mm. in the four adoral cameræ of the phragmocone, a dorsal length of 9 mm. and a ventral length of 12 mm. The living chamber has a dorsal length of 17 mm. and an estimated ventral length of 22 mm. The aperture, which is obscure ventrally, is 18 mm. wide and about 21 mm.

high.

The sutures slope orad slightly on the venter but do not develop clear lateral lobes. The septa are very shallow, almost flat. The cameræ are fairly uniform in depth. The siphuncle lies close to the venter. Three segments are exposed in the sectioned adapical portion of the holotype. They are relatively broad at the septal foramen, a segment 3 mm. long expanding from 1.6 mm. to 3 mm. The septal necks are free, recurved, but gently bent back rather than recumbent. The connecting rings form rounded segments without any marked areas of adnation. There are no deposits within the siphuncle.

The shell surface is not preserved. The aperture inclines orad from dorsum to venter and is obscure on the mid-ventral region where presumably a shallow hyponomic sinus develops.

Discussion.—The single specimen upon which this species is based consists of two parts. The adoral part, of which two views are shown, is a clearly preserved internal mold. The venter has been partially lost by weathering, however, and the ventral part of the aperture is not clearly preserved. The adapical part of the phragmocone was so encrusted by calcareous algæ that its surface could not be uncovered. In section, however, it yielded three segments of the siphuncle, and although distorted on the dorsum, retains the ventral profile for a considerably earlier part of the shell, showing that the complete conch was quite strongly curved and probably had a maximum length of less than 50 mm.

The species which are related to this one are discussed in connection with the genus. They form a group of Upper Ordovician species, not, however, completely distinct from some Middle Ordovician forms. Of these species, *O. foerstei* is distinctive in the strong curvature and its proportions. Those of its relatives which are similarly strongly curved are smaller, and the only larger form, *O. ornatum* (Miller), is less curved, so much so that its identity with *Oncoceras* is only evident through its similarity with this and other species. Part of *Neumatoceras*, at least, is close to this group of species in *Oncoceras*. The present form is suggestive of *N. nutans* Foerste (1935, pl. 2, figs. 1-2) but is less convex in ventral profile.

Type.—Holotype, Univ. of Cincinnati, No. 24229.

Occurrence.—From the Leipers beds, Cumberland River, at Rowena, Kentucky.

Oncoceras (?), sp. Plate 17, figs. 7, 9, 12

This is known only from a portion of a living chamber and is too fragmentary to serve as a type of a new species. It is illustrated and briefly described, since no associated species approaches it in general proportions. It consists of the basal part of the living chamber, evidently of a form similar to *Oncoceras bassleri* but very considerably larger, to which is attached one incomplete camera. The cross section at the base is faintly compressed, 25 mm. wide and 28 mm. high, with the greatest width at or just ventrad of the center of the section. Comparable stages of *O. bassleri* show a somewhat narrower venter and are much smaller. The siphuncle is circular in section, 2 mm. in diameter, 1.4 mm. from the venter. The incomplete camera has a depth of 3 mm. The living chamber, incomplete, has a length of 13 mm. dorsally and 14 mm. ventrally. It contracts orad both laterally and vertically. Nothing is known of the aperture. The sutures bear less prominent lateral lobes in this form than in the smaller *O. bassleri,* and from the present incomplete specimen the degree of their inclination forward from dorsum to venter is uncertain.

Discussion.—The proportions of this species, even from the inadequate information furnished by the single known specimen, show that it is not conspecific with any other form of the Cincinnati region but is most similar to the associated and much smaller *Oncoceras bassleri.*

Figured specimen.—Univ. of Cincinnati, No. 24280.

Occurrence.—From the pelecypod layer directly above the *Tetradium* beds of the Leipers, Rowena, Kentucky.

Oncoceras faberi (Miller) Plate 17, fig. 11; Plate 35, fig. 7

Gomphoceras faberi Miller, 1884, Cincinnati Soc. Nat. Hist., Jour., vol. 7, p. 19, pl. 4, fig. 2, 2a; James, 1886, *ibid.*, vol. 8, p. 244; Harper and Bassler, 1896, Cat. Foss. Trenton and Cincinnati periods occurring in the vicinity of Cincinnati, Cincinnati, p, 27; Nickles, 1902, Cincinnati Soc. Nat. Hist. Jour., vol. 20, p. 85; Bassler, 1915, U. S. Nat. Mus., Bull. 92, vol. 1, p. 560.

Oncoceras (?) *faberi* Foerste, 1924, Denison Univ. Bull., Sci. Lab., Jour., vol. 20, p. 239.

The holotype represents a living chamber and seven attached cameræ, 30 mm. in length. The venter is convex in profile, the curvature greatest shortly below the base of the living chamber. The dorsum is slightly convex in profile but nearly straight. The sides are convex, more curved adapically over the gibbous part, and become less curved as they approach each other toward the aperture. The specimen has a basal height of 17 mm., while the width, which cannot be determined from the material at hand, is probably about 15 mm. The greatest width lies dorsad of the middle, the venter being more narrowly rounded than the dorsum. In a ventral length of 13 mm. the greatest height of 20.5 mm. is attained. The phragmocone, consisting of seven cameræ, the basal one incomplete, has a ventral length of 20 mm. and a dorsal length of 14 mm. The adoral sutures become inclined orad from dorsum to venter. The living chamber has a ventral length of 15 mm. and a dorsal length of 10 mm. At its base the height is 20 mm., at the aperture it has contracted to 14 mm. The aperture is apparently not complete. The surface features are not shown. The siphuncle is close to the venter. The cameræ, except the last which is gerontically shortened, average 2 mm. in depth.

A hypotype, shown on Plate 17, figure 11, represents a somewhat crushed specimen displaying a slightly more complete living chamber. It is 33 mm. in length. At the second suture from the base the height is 20 mm. and contracts in the basal 10 mm. of the living chamber to 10 mm. The adoral part of the living chamber shows further contraction but is incomplete. The dorsal profile of this specimen becomes faintly concave just before the aperture. The specimen agrees with the type in the convexity of the shell and the relatively deep cameræ.

Discussion.—This is a rare species generally regarded as coming from the Corryville beds. The above description is based upon a plastoholotype in the collections of the U. S. National Museum, since the type could not be found at the time when this study was made. The species differs from *Oncoceras cincinnatiense* in the deeper cameræ, the broader section, and in particular, in the strongly gibbous condition of the sides, a feature not shown at all in the original illustrations or description. James considered *G. faberi* and *G. cincinnatiense* conspecific. They are quite distinct, differing markedly in form. Foerste (1924) placed *cincinnatiense* in *Oncoceras*, while including *faberi* in the genus only with doubt. A restudy of the material shows that *G. faberi* is really more typical of *Oncoceras* than is *G. cincinnatiense*, the latter being slender in form and belonging to a group of species which approach the form of *Beloitoceras*.

Types.—Holotype, Univ. of Chicago, No. 8769. Plastoholotype (here figured in the absence of the holotype), U. S. Nat. Mus., No. 67448. Hypotype, Univ. of Cincinnati, No. 23906.

Occurrence.—The holotype is regarded by Harper and Bassler, Nickles, and Bassler, cited above, as from the Corryville horizon. Our hypotype is from the Maysville of Maysville, Kentucky. The species has not been collected by the writer.

Oncoceras cincinnatiense (Miller) Plate 35, figs. 2, 3

Gomphoceras cincinnatiense Miller, 1884, Cincinnati Soc. Nat. Hist., Jour., vol. 7, pl. 4, figs. 1, 1a.

Gomphoceras cincinnatiense Harper and Bassler, 1896, Cat. Foss. Trenton and Cincinnati periods occurring in the vicinity of Cincinnati, Cincinnati, p. 27; Nickles, 1902, Cincinnati Soc. Nat. Hist., Jour., vol. 20, p. 85; Bassler, 1915, U. S. Nat. Mus., Bull. 92, vol. 1, p. 560.

Oncoceras cincinnatiense Foerste, 1924, Denison Univ. Bull., Sci. Lab., Jour., vol. 20, p. 239.

Ventral profile scarcely convex adapically, curved over the adoral part of the phragmocone and the living chamber. Dorsum slightly concave over adapical part of phragmocone, becoming faintly convex at base of living chamber and remaining convex to aperture though becoming more nearly straight. A plastotype of the holotype is 32 mm. in length. The height increases from 13 mm. to 19 mm. in a ventral length of 18 mm. and contracts to 15 mm. in a length of 18 mm. more. The base of the living chamber lies well above the gibbous part of the conch. Its height is 19 mm. along the slightly oblique basal suture. Its ventral length is 12 mm., the dorsal length 8 mm. The aperture is obscure and apparently not quite complete. The sides expand gradually to the gibbous region and contract more rapidly to the aperture. The cross section is considerably more compressed than in *O. faberi.*

The sutures are essentially straight with only vestigial lateral lobes but become slightly more oblique at the adoral end of the phragmocone sloping slightly orad from dorsum to venter. Nine cameræ are present which are subequal in length. The phragmocone has a dorsal length of 15 mm. and a ventral length of 20 mm.

The only other specimen available (Pl. 35, fig. 2) is a badly flattened shell from the Ulrich collection of the U. S. National Museum. This specimen, 30 mm. long, expands to 21 mm. and contracts to a slightly oblique aperture of 13 mm. Distortion has affected the sutures, which form slight rounded saddles on the side exposed and lobes on the opposite side, a sign of oblique flattening. The depth of the cameræ and the length of the living chamber are similar to those shown on the holotype.

Discussion.—This species is redescribed on the basis of a holoplastotype and one hypotype. It is a very rare form apparently of Maysville age, attributed by Nickles and Bassler to the Corryville. The original description indicates that the type is from "the middle part of the Hudson River group near the tops of the hills at Cincinnati." The species is relatively slender for an *Oncoceras* but has the low gibbosity which is used as a criterion of this genus in contrast to *Beloitoceras.* This species is, however, admittedly one of several which are on the borderline between the genera. The original illustration like that of *G. faberi* is misleading as to proportions and aspect of the holotype. This shell is more slender and the cameræ are shorter than in the presumably associated *G. faberi,* and the section is much more compressed. More similar to *O. cincinnatiense* is the next species, *O. delicatulum,* of the Waynesville, a species which has slightly deeper cameræ and a longer living chamber, and also one which is not so narrow in cross section.

Types.—Holotype, University of Chicago, No. 8770. A plastotype which is the basis of our figure is U. S. Nat. Mus., No. 67449. The flattened specimen, figured here as a hypotype, is No. 4883896.

Occurrence.—Probably from the Corryville beds of Cincinnati, as indicated by Nickles (1902) and Bassler (1915).

Oncoceras (?), sp. Plate 35, fig. 4

This is a badly weathered portion of a brevicone 39 mm. in length, associated with *O. cincinnatiense*. Only one side of the shell of the specimen is preserved, retaining 10 cameræ and a part of a living chamber. The shell expands from 13 mm. to 21 mm. in the basal 30 mm. and contracts to 19 mm. in the next 10 mm. The phragmocone is 32 mm. long consisting of 10 cameræ. The venter is slightly curved becoming more convex over the gibbous region. The dorsum is straight apically becoming convex over the adoral part. The gibbous region is well below the base of the living chamber, which is incomplete.

Discussion.—This form is distinctive in the relatively deep cameræ and the slight convexity of the dorsum and appears very different from any other brevicone of the Maysville. It is known only from this one specimen, which is too incomplete to serve as the type of a new species.

Type.—U. S. National Museum, No. 48396.

Occurrence.—From the Corryville beds, Cincinnati, Ohio. This specimen was associated in the collection of the U. S. National Museum with the specimen used here as the hypotype of *Oncoceras cincinnatiense*, the two bearing the same number.

Oncoceras delicatulum Flower, n. sp. Plate 32, figs. 1-7

Section compressed, the venter scarcely more narrowly rounded than the dorsum. The ventral profile is slightly and nearly uniformly convex, but with a radius of curvature varying from 35 mm. to 60 mm. probably due in a large part to distortion. The dorsum is concave adapically, but nearly straight, becoming convex over the adoral phragmocone and basal living chamber, and is straight approaching the venter, over the greater part of the length of the living chamber. The sutures lack clear lateral lobes but slope increasingly orad on the venter when traced toward the living chamber.

The most complete specimen, (Pl. 32, figs. 7,8) though badly flattened adorally, expands from 12½ mm. and 14 mm. at the base to 16 mm. and 19 mm. ventrally. The succeeding 15 mm. on the venter is a crushed continuation of the phragmocone, estimated to contain seven cameræ, at the adoral end of which the height is 23 mm. and the width only 11 mm. because of compression after burial. The succeeding living chamber has a maximum length of 19 mm. and attains a height of 26 mm.

Another specimen, representing a better phragmocone but retaining less of the living chamber (Univ. of Cincinnati, No. 24410, Pl. 32, fig. 1), is selected as the holotype. In the phragmocone, 16 mm. ventrally and 12 mm. dorsally, the shell expands from 15 mm. and 13 mm. to 21 mm. and 16 mm. The ensuing portion of the living chamber is 18 mm. long and partially crushed. The phragmocone consists of 10 cameræ. The septa are nearly flat. The siphuncle is small and marginal. A third specimen, consisting only of a phragmocone, increases from 11 mm. and 13 mm. to 17 mm. and 18 mm. in a ventral length of 16 mm. and a dorsal length of 13 mm., the interval embracing 10 cameræ. The dorsal profile here is straight adapically and faintly convex adorally. Another specimen, uniformly compressed and showing an abnormally small curvature for the venter, has a height of 20 mm. and a width of 15 mm. at the base of the living chamber which is 16 mm. long and appears to attain a part of the aperture ventrally, suggesting a well-developed hyponomic sinus in the species.

The siphuncle has short thick septal necks, scarcely if at all recurved, segments which expand rapidly beyond the neck to a maximum width orad of the middle of the segment and contract more gradually apicad, meeting the next septal neck with no area of adnation. The segments are obscurely heart-shaped and have no organic deposits.

The small fragments of the shell which remain fail to show any surface features. The exterior was apparently smooth.

Discussion.—This species is particularly characteristic of the trilobite shales of the lower Waynesville where, however, it is not a particularly abundant species and where it is always represented by incomplete shells in which the living chamber is either missing or very badly crushed. This is a short rather plump species, though the gibbosity is slight, and is one of the numerous borderline species close enough to *Beloitoceras* that its generic position rests upon arbitrary boundaries. No described forms are particularly close to this species, however, the closest being probably *Oncoceras cincinnatiense* (Miller) which has shorter cameræ, a more slender shell, and a living chamber which appears to contract much more strongly to the aperture. It is distinctive in the reduced gibbosity, the absence of good lateral lobes, and the shallow subequal cameræ.

Types.—Holotype, Univ. of Cincinnati, No. 24410. Paratypes, Univ. of Cincinnati, Nos. 24411-24413, and one specimen from the collection of Miss Carrie Williams.

Occurrence.—From the *"Orthoceras duseri"* beds, uppermost Fort Ancient, lower Waynesville. Found in the vicinity of Clarkesville and Fort Ancient in Stony Creek, Penquite Hollow, and other streams in the region.

Oncoceras anomalum Flower, n. sp. Plate 42, fig. 1

The holotype is a nearly straight shell, 60 mm. in length, apparently slightly flattened by pressure. The venter is faintly and nearly uniformly curved throughout. The dorsum is essentially straight adapically, slightly convex over the adoral end of the phragmocone and the base of the living chamber, and shows a faint concavity near the adoral end. The sides appear to have been slightly and nearly uniformly convex. The shell increases in height from 20 mm. at the base to 29 mm. in a length of 30 mm., and decreases to 25 mm., 20 mm. farther, the farthest point at which the shell is complete dorsally. Ventrally the aperture lies 60 mm. beyond the base, but slopes apicad from venter to dorsum so that the plane of the aperture is inclined to the normal cross section. The height of the shell at the aperture is estimated at 25 mm. The sutures show broad low inconspicuous lateral lobes, and scarcely slope orad from dorsum to venter. The basal 35 mm. of the shell consists of the phragmocone. The cameræ are subequal in depth, the last three occupying a length of 10 mm. The siphuncle is unknown. The aperture is obscure, but shows a well-developed hyponomic sinus. The cross section is distorted, but in its present condition the shell is 25 mm. wide where it is 30 mm. high at the gibbous portion, and the venter does not appear to have been more narrowly rounded than the dorsum.

Discussion.—This appears as a rather generalized and noncommital species, but in the profile and in the relatively straight and transverse sutures, it is distinct from all of its congeners. Most species of *Oncoceras* are more rapidly expanding, more curved, and have shorter living chambers. The low position of the gibbous region requires that this form be placed in *Oncoceras* rather than *Beliotoceras*, as does the convexity of the dorsal surface. *Oncoceras ornatum* (Miller) of the Bighorn dolomite may be related but is distinguished readily by the more marked inflection of the shell on the dorsum near the aperture.

A second specimen of the same species has been found in a much flattened condition in the Saluda beds above the coral zones at Versailles, Indiana. Flattening has increased the height of the shell and also the length, but the two agree closely in the spacing of the septa, the development of lateral lobes, curvature, and general proportions. The living chamber on this specimen is slightly longer, having a maximum lateral length of 33 mm. Even here the aperture is not clearly retained.

Types.—Holotype, collection of Dr. W. H. Shideler, Miami University.

Occurrence.—From the Whitewater beds, just below the *Rhynchotrema dentata* zone, Dodge's Creek, Oxford, Ohio, and from the Saluda beds above the coral zones, essentially the same horizon at Versailles, Indiana.

Oncoceras duncanæ Flower, n. sp. Plate 36, fig. 4; Plate 37, fig. 4

This is a moderate-sized straight *Oncoceras*. The venter has a radius of curvature of about 70 mm. and is curved uniformly throughout the known part of the shell. The sides are slightly convex, the greatest width being attained apicad of the greatest shell height, 25 mm. below the aperture. The dorsum is incompletely known, but is faintly concave near the aperture, and faintly convex 15 mm. below the aperture, the earliest part at which it is preserved. The type is 38 mm. long, but weathered basally; 15 mm. before the aperture the height is 23 mm. and the width 18 mm. At the aperture the height is 21 mm. and the width 16 mm. The venter is more narrowly rounded than the dorsum, but the greatest width is essentially at the mid-height of the shell.

The basal 20 mm. of the specimen represent the phragmocone. The course of the sutures is essentially transverse, and lateral lobes are not well developed. The siphuncle is small and close to the venter. The surface of the shell bears transverse rugose markings. These slope downward on the venter indicating the presence of a hyponomic sinus.

Discussion.—This species, represented in our material by the holotype and one rather poor fragment, is larger and broader than *O. exile* and also somewhat more gibbous. The species is relatively slender for *Oncoceras* but is placed here due to the low position of the gibbosity, particularly the lateral gibbosity, on the conch.

Holotype.—Univ. of Cincinnati, No. 24481.

Occurrence.—In the upper part of the Saluda, in an association which is essentially that of the Hitz fauna of Madison, Indiana, though less dwarfed, at Canaan, Indiana.

Oncoceras exile Flower, n. sp. Plate 32, figs. 13-14; Plate 39, figs. 1-2

This is a small extremely slender species, scarcely gibbous, but the slight inflation of the shell lies on the phragmocone, as is typical of *Oncoceras* rather than *Beloitoceras*. The ventral profile is faintly convex throughout. The dorsum is faintly concave adapically, as shown by a paratype, becomes slightly convex adorally and is nearly straight, approaching the venter very slightly over the greater part of the length of the living chamber. The holotype has a maximum length of 37 mm. At the base it is compressed, the dorsum slightly more broadly rounded than the venter, and is 11 mm. wide and 12 mm. high. In 18 mm. the greatest diameters of 19 mm. and 16 mm. are attained. Near the aperture, 30 mm. beyond the base, the height is 18 mm. the width 14 mm. The aperture is incomplete but has essentially these measurements. The adoral cameræ are obscure, but apparently the living chamber has its base 15 mm. above the base of the specimen, giving it a basal height of 19 mm., a width of 14 mm., and a ventral length of 23 mm.

The sutures are essentially normal to the axis of the shell and develop only faint lateral lobes. At the base of the type the cameræ are about 1.3 mm. in length. The siphuncle is small, ventral, and scarcely expanded within the cameræ.

A paratype, in the collections of the U. S. National Museum, shows the earlier part of the shell, in which the dorsum is faintly concave. This specimen, 8 mm. wide and 9 mm. high at its base, expands to 14 mm. and 16 mm. in a length of 15 mm., the dorsum changing from slightly concave to slightly convex.

Discussion.—This species is unique in its very slender form and nearly straight shell. *Oncoceras duncanæ* is a larger form, slightly more gibbous, but the only type which agrees at all closely with *O. exile* in general form. The siphuncle as observed in a paratype is extremely slender and close to the suborthochoanitic form found in comparable stages of Chazyan species.

Types.—Holotype, Shideler Collection. Paratypes, two specimens, U. S. National Museum.

Occurrence.—All specimens are from the Hitz layer, of Madison, Indiana.

Oncoceras madisonense Flower, n. sp. **Plate 39, figs. 4, 5, 8, 9**

Under this name I include small exogastric species of *Oncoceras* which show such variation that no two have precisely the same proportions. The holotype, Univ. of Cincinnati, No. 17179, is a shell 32 mm. long. Near the base the section is nearly circular being 11 mm. high and 10 mm. wide. Here the dorsum is faintly concave and the venter is convex in profile. The dorsum then becomes convex, the venter more gibbous, so that in a length which is 8 mm. dorsally and 15 mm. ventrally the height is 17 mm.

and the width 14 mm. In a dorsal length of 10 mm. and a ventral length estimated at 14 mm., the aperture is reached. This is incomplete, but the height close to it is 15 mm. and the width is probably close to 13 mm. The smooth shell covers most of the specimens and the sutures are for the most part obscured. The septum at the base of the living chamber is exposed by weathering on one side, showing that the living chamber has a maximum length of 16 mm., and its base lies slightly orad of the most gibbous part of the shell. The siphuncle has not been observed.

A second specimen, which I tentatively include under this name, is similar in form but smaller and less strongly compressed. It increases from 7 mm. and 8 mm. at the base to 15 mm. and 16 mm. in 22 mm. As above, the dorsum changes from concave to convex. In 15 mm. more the aperture is reached which is only 13 mm. wide and has an estimated height of 15 mm. The adoral part of the shell is weathered; basally the shell obscures the phragmocone.

Discussion.—The two specimens upon which this description is mainly based represent two forms which are similar but apparently do not intergrade, although other specimens are admittedly quite fragmentary. It is possible that the slight variation in size and shape may be due to sexual dimorphism and not to inherent variation within a species. No forms from the Middle Ordovician or from elsewhere in the Cincinnatian of Ohio or Indiana are known which are particularly close to this shape or size. *Oncoceras parvum* Foerste is not unlike this species adorally but adapically is much more abruptly curved.

Types.—Holotype, Univ. of Cincinnati Museum, No. 24495. Paratype, U. S. National Museum.

Occurrence.—Hitz bed, Madison, Indiana, in the uppermost Saluda.

Oncoceras elkhornense Flower, n. sp Plate 31, figs. 3, 5

This is a small, short, strongly gibbous compressed shell. The holotype, the most complete specimen, is slightly crushed laterally. In its present form it is 22 mm. in length. The venter is more convex than the dorsum throughout most of the shell, but becomes faintly concave at the aperture, while the dorsum becomes straight at this point. The shell expands from a height of 18 mm. and a width of 11 mm. to a height of 20 mm. and a width of 15 mm. in the basal 13 mm., and contracts to an aperture of 19 mm. and 13 mm. The adoral four cameræ occupy a length of 9 mm. and are subequal in length. The sutures lack lateral lobes and are anomalous in that they slope slightly apicad from dorsum to venter, the reverse of the usual condition. The greatest gibbosity is attained at about the level of the base of the living chamber which has a length of 11 mm. on the venter. The aperture develops a broad and shallow but clearly recognizable hyponomic sinus on the venter. The siphuncle has not been observed.

Discussion.—This species is represented in our material by three specimens, all from the same locality. The holotype, the best preserved form, is slightly compressed by pressure. Of the other specimens one is very roughly preserved, and the other is very badly weathered. In form this species falls within the genus *Oncoceras,* but is without close relatives in it, and is unusual in the small size, extremely gibbous form, and the direction of the sutures. The shell is oriented on the basis of the hyponomic sinus. No trace of the siphuncle has been found, although the ventral side of the holotype was ground after the specimen was photographed. The septa are poorly preserved internally and the siphuncle could not be found.

Types.—Holotype and two paratypes, Shideler Collection.

Occurrence.—From the middle Elkhorn, exposures in a creek south of College Corner, Ohio, near the Indiana border.

Genus **BELOITOCERAS** Foerste

Beloitoceras Foerste, 1924, Denison Univ. Bull., Sci. Lab., Jour., vol. 20, p. 244; Foerste, 1926, *ibid.*, vol. 21, p. 317; Foerste, 1933, *ibid.*, vol. 28, p. 98; Foerste, 1935, *ibid.*, vol. 30, p. 28.

The shells of this genus are exogastric compressed brevicones, the inflation of the shell relatively slight in comparison with *Oncoceras,* the aperture usually gently contracted, and with a hyponomic sinus. The dorsum may be concave adapically but is generally either straighter or slightly convex over parts of the living chamber. The more gibbous species appear to grade into *Oncoceras*, but typical forms differ from that genus in having the gibbosity when developed well on the living chamber, where both the greatest width and greatest height are attained. In *Oncoceras*, on the other hand, the greatest height and width are both typically found well below the base of the mature living chamber. The sutures tend to slope increasingly orad from dorsum to venter when traced orad from the beginning of the shell and develop lateral lobes. The siphuncle lies close to the venter; it is typically composed of rather slender cyrtochoanitic segments, but there is considerable variation in the form of the segments observed in the various species. Early stages of Chazyan species which are practically on the borderline between *Beloitoceras* and *Oncoceras* are suborthochoanitic. A few species show segments which are scalariform, while the most typical condition is that of elongate oval segments, usually greater in length than in diameter. No organic deposits are known in the siphuncle. Vestigial cameral deposits may be present in some species appearing as faint longitudinal impressions on the internal molds of the phragmocones. In mature shells the basal zone may be developed.

Discussion.—*Beloitoceras* was originally set apart from *Oncoceras* for shells which were relatively slender, lacking gibbosity completely, or having it developed high up on the living chamber instead of on the adoral part of the phragmocone. Under this definition the genus has come to embrace more species ranging from the Chazyan to the Richmond, than *Oncoceras* itself. Twenty-four species have been included in the genus by Foerste. In the present work additional Cincinnatian species are described. A considerable number of Middle Ordovician species awaits description.

The species which have been assigned to the genus previously form a group showing considerable variation in form and general appearance. Originally it was confined to shells in which the dorsum was faintly gibbous, shells being referred to *Maelonoceras* Hyatt, in which the dorsum was straight or concave. However, Foerste (1933) noting that his selection of a genotype of *Maelonoceras* was opposed by Hyatt's earlied selection of a lectotype for *Phragmoceras praematurum,* revised his concept of the genus, and renamed his *Maelonoceras praematurum* (1924), *Beloitoceras clochense.* This resulted in an expansion of the concept of *Beloitoceras* and a restriction of *Maelonoceras.*

The genus in its present form is probably not a natural one. Attempts to rectify the problems presented by apparent intergradation in several species groups into *Oncoceras, Oonoceras,* and *Neumatoceras* have not been very successful. Recognition of finer generic divisions would increase rather than decrease the problems represented by the species which appear to be intermediate between genera, some being so close to the boundaries that on the basis of the present criteria it would seem highly probable that two independent investigators might easily come to conflicting decisions on the matter. However, owing to the large number of species and the variations of form which they exhibit, the described forms are summarized here in terms of species groups. It must, however, be emphasized that these groups are not sharply set off from one another and are employed here largely because of the necessity of attempting differentiation within this large and unwieldy genus. Some of these groups seem to possess faunal unity which leads the writer to believe that they may be natural. However, gradation between the groups and a close approach to the form of other genera appear frequently, indicating that these groups are not clear cut divisions.

I. Group of *Beloitoceras clochense.* (Fig. 11 AD). Dorsum concave but with the shell faintly gibbous.

B. clochense Foerste. Black River beds, La Cloche Island, Lake Huron.[11]

B. murrayi Foerste. Black River beds, St. Joseph Island, Lake Huron.

[11] The LaCloche Island fossils are of Rockland age (Kay, 1937) while most of the material from St. Joseph Island is Chaumont (Kay, *fide litt.*), though some Rockland is present there also. Pending proper clarification of the origin of some of these specimens I have retained Foerste's horizon designations.

B. isodorus (Billings). Black River beds, St. Joseph Island, Lake Huron.

B. huronense Foerste. Black River beds, St. Joseph Island, Lake Huron. This form has a nearly straight dorsum approaching the next group.

B. janesvillense Foerste. Black River beds, St. Joseph Island, Lake Huron. (Fig. 11 S.)

B. carveri (Clarke). Platteville limestone, Minnesota. (Fig. 11 R.)

B. fragile Foerste. Ellis Bay formation, Anticosti. Some specimens have a straight dorsum approaching the next group in form.

Beloitoceras houghtoni (Clarke). Platteville limestone, Minnesota. Specimens assigned to this species vary from those typical of this group (Foerste, 1933, pl. 30, figs. 9-10) to those with a straight dorsum. (Foerste, 1933, pl. 28, fig. 7.)

Maclonoceras reclinatum Troedsson. Gonioceras Bay formation, Greenland. A gigantic but typical member of this group.

Beloitoceras bucheri Flower, n. sp. Lower Whitewater of Ohio. Dorsum nearly straight.

Beloitoceras chapparsi Flower, n. sp. Upper Whitewater, Ohio and Indiana.

B. transiens Flower, n. sp. Upper Whitewater, Ohio. This form is so slender that it approaches the condition of *Oonoceras*.

II. Group of *B. norwoodi*. Dorsum straight.

B. norwoodi (Clarke). Platteville limestone, Illinois. (Fig. 11 AA, AB.)

B. lycum (Hall). Black River, Beloit, Wisconsin. Distinctive in the constriction at the adoral end of the living chamber.

B. popoagiense Foerste. Bighorn formation. Suggestive of *Oncoceras* in its faint gibbosity.

B. landerense Foerste. Bighorn formation. Dorsum straight along phragmocone, concave over entire living chamber. A-typical of any group.

B. ulrichi Flower, n. sp. Elkhorn beds, Indiana.

III. Group of *B. pandion*. Dorsum faintly convex.

B. pandion (Hall). Platteville limestone, Wisconsin. (Fig. 11.)

B. plebium (Hall). Platteville limestone, Wisconsin. (Fig. 11.)
B. janesense Foerste. English Head formation, Anticosti.
B. fremontense Foerste. Fremont limestone, Colorado.

IV. Group of *B. amoenum*. Species with elongate slender phragmocones, attaining greatest shell height on phragmocone. Adoral sutures extend far forward, suggesting that these species are phylogerontic in relation to the preceding group. The dorsum is only faintly convex on the living chamber. This closely knit series of species approximates *Oncoceras* in definition, and also approaches *Neumatoceras*, but it is retained in *Beloitoceras* because it is typical of neither of these other genera, but appears to grade into typical *Beloitoceras* of the preceding group more completely than into any other group of species.

Beloitoceras amoenum (Miller). Upper Whitewater, Ohio and Indiana.
B. cumingsi Flower, n. sp. Lower and upper Whitewater, Ohio and Indiana.
B. cf. *cumingsi* Flower. Elkhorn beds, Indiana.
B. ohioense Flower, n. sp. Lower and upper Whitewater, Ohio and Indiana.
B., sp. Flower. Lower Whitewater, Ohio.
B. whitneyi (Hall). Maquoketa shale, Iowa.
B. magisterium Foerste. Vaureal formation, Anticosti.

This species group seems to be confined to faunas identified as Richmond.

V. Inadequately known species.

B. (?) *baffinense* (Schuchert). Known only from a slender phragmocone from the Ordovician of Frobisher Bay, Baffin Land.
B. (?)*cornulum* (Schuchert). Known only from a compressed strongly curved phragmocone rapidly expanding adorally and suggestive of *Neumatoceras*. Frobisher Bay, Baffin Land.
B. ? discrepans Foerste. Maquoketa shale. A phragmocone and the dorsum of a living chamber. Probably belonging to the group of *B. amoenum*.

VI. Species which have been removed to other genera.

B. arcticum (Schuchert). Placed in *Beloitoceras* by Foerste (1928) but here removed to *Cyrtorizoceras*.
B. breviposticum Miller. A Bighorn species removed by Foerste to *Neumatoceras* at the time of the description of that genus.
B. obstructum Foerste. Vaureal formation, Anticosti. Placed in *Oonoceras* (Flower, 1942).
B. fererectum Foerste. Ellis Bay formation, Anticosti. A shell which is essentially tubular to the aperture, here placed in *Oonoceras*.

VII. Aberrant species, retained in *Beloitoceras*.
B. geniculatum Flower, n. sp. Probably a highly modified derivative of group III. Whitewater beds, Ohio.
B. protractum Flower, n. sp. Probably a phylogerontic type, but one without close affinities. Immature shells would approximate mature representatives of group III.

Cincinnatian species.—The Cincinnatian species of *Beloitoceras* are divisible into two readily distinguished groups. The large forms of the group of *B. amoenum* are readily distinguished as a group by the strongly oblique adoral septa which give isolated living chambers the appearance of those of *Neumatoceras*. They lack, however, the exaggerated gibbosity and geniculate ventral profile of that genus, and are retained in *Beloitoceras*. Three species are recognized, *B. amoenum*, a large form with a relatively slender phragmocone, *B. cumingsi*, a slightly smaller form with a more rapidly expanding phragmocone and a ventral profile which is more convex, and *B. ohioense*, which is still smaller and has a slender phragmocone as in *B. amoenum*. *B. ohioense* and *B. cumingsi* are found in both the lower and upper Whitewater; *B. amoenum* is known only from the upper Whitewater beds. A solitary living chamber represents a smaller and broader species belonging to this group. This is described as *Beloitoceras*, sp. Specimens, tentatively identified as *B. amoenum* and *B. cumingsi*, have been found in the Elkhorn but are represented there by specimens too poorly preserved for close comparison.

Two of the species included in *Beloitoceras* are anomalous and without any particular close relatives. *B. protractum* is characterized by the tubular extension of the living chamber beyond the gibbous part of the shell. It is to be regarded as one of the peculiar phylogerontic developments within the genus, and I have preferred to leave it here rather than to erect a new genus for its reception. *B. geniculatum* is an abruptly bent species, in which the high narrow living chamber recalls *B. bucheri,* but the sutures have well-developed lateral lobes and the cameræ are deep.

The remaining species are slender forms belonging to the groups of *clochense* and *norwoodi* and indicative of modified Platteville elements in the Richmond fauna. *B. chapparsi* and *B. transiens* of the upper Whitewater are evidently quite closely related, differing mainly in size and the degree of gibbosity. Yet *chapparsi* is a typical species of the *clochense* group, while *transiens* is so slender that it might as easily have been placed in *Oonoceras. B. bucheri* of the lower Whitewater has an essentially straight dorsum and is typical in form of the group of *norwoodi.* It is distinctive in the very shallow cameræ and the loss of the lateral lobes of the sutures.

Beloitoceras amoenum (Miller)

Plate 32, figs.15, 17; Plate 34, figs. 4, 5; Plate 37, fig. 9; Plate 38, fig. 6; Plate 42, figs. 2, 5.

Cyrtoceras amoenum Miller, 1879, Cincinnati Soc. Nat. Hist., Jour., vol. 1, p. 105, pl. 3, fig. 8; Ulrich, 1880, Cat. Foss. Cincinnati Group., Cincinnati, p. 22; James, 1886, Cincinnati Soc. Nat. Hist., Jour., vol. 8. p. 247; Harper and Bassler, 1896, Cat. Foss. Trenton and Cincinnati Periods, Cincinnati, p. 27; Cumings, 1908, 32nd Ann. Rep. Indiana Dept. Geol. Nat. Res., p. 1027, pl. 49, fig. 1; Nickles, Cincinnati Soc. Nat. Hist., Jour., vol. 20, p. 95; Bassler, 1915, U. S. Nat. Mus., Bull., 92, vol. 1, p. 349.

This is a relatively large *Beloitoceras* of somewhat variable proportions, the known representatives of which show variation in rate of expansion, depth of cameræ, form of dorsal profile, and length of living chamber. Distortion is sufficiently widespread in specimens of this form to make it uncertain how much of the variation is natural.

The holotype (Univ. of Cincinnati, No. 106) presents one well-preserved lateral surface, the opposite side being poorly preserved adorally and missing adapically. The shell has a maximum length of 86 mm. The venter was apparently uniformly convex, with a radius of curvature of 65 mm. The dorsum is faintly concave. The height of the shell increases from 23 mm. to 29 mm. in the basal 30 mm. on the venter and a dorsal length of 28 mm.; in the remaining 50 mm. of the phragmocone the height increases to 33 mm. parallel to the septum at the base of the living chamber. The living chamber has a maximum length of 28 mm. laterally, but is apparently incomplete adorally, and it is not certain that even where it is longest that the aperture is attained. The greatest height of the shell is attained 20 mm. apicad of the base of the living chamber. There the shell height is 35 mm. The sutures slope increasingly orad from dorsum to venter as they are traced adorally, but do not develop conspicuous lateral lobes. The cameræ increase gradually in depth from the apex, where four occur in a length of 10 mm., to the adoral part of the shell where four occur in a length of 18 mm. The last five cameræ are gerontically shortened, occupying a length of 9.5 mm. Siphuncle and surface markings are not preserved.

The width of the shell is 30 mm. where the height is 34 mm. It is not certain that even here there may not be slight compresstion. (Pl. 32, fig. 17.)

The best preserved specimen (Earlham Collection, No. 7944), likewise preserving only one side of the shell, differs from the holotype and agrees with the majority of the specimens in that the phragmocone expands relatively rapidly. This shell increases from 18 mm. to 31 mm. in the basal 30 mm. as measured on the venter, and a length of only 22 mm. on the dorsum. The maximum height of 34 mm. is attained 45 mm. beyond the apex, and then the shell contracts slowly to 33 mm. in height at the base of the living chamber which is 65 mm. from the apex ventrally and 42 mm dorsally. The living chamber is incomplete, with a maximum lateral length of 18 mm. At its dorsal end the shell height is 28 mm. This specimen lacks the extensive development of gerontic cameræ noted in the type, and shows a slight adoral increase in the rate of curvature of the ventral profile, but agrees with the type in size and in depth of cameræ. Slight flattening of the type, greater adapically than adorally, could account for these differences. (Pl. 42, fig. 2.)

The surface features are shown only by one flattened specimen, one which increases from 33 mm. in height at the base to 43 mm. at the base of the living chamber in a ventral length of 46 mm. and a dorsal length of 33 mm., and contracts to 30 mm. at the aperture in a ventral length of 24 mm. and a dorsal length of 22 mm. The shell is so flattened that the width is nowhere more than two-thirds of the height. This shell shows coarse transverse markings which slope strongly apicad toward the venter and are clearest at the base of the specimen. This form, incidentally, was named by Foerste in manuscript as a new species of *Neumatoceras*. However, a plaster mold taken from a cast of the exterior of the preceding specimen, which was first flattened, produced a shell almost identical in proportions, showing beyond doubt that flattening could produce this form type in *B. amoenum*. (Pl. 42, fig. 5.)

A rough but essentially complete living chamber of this species (Univ. of Cincinnati, No. 24416) has a basal height of 36 mm. and a width of 26 mm. It has a dorsal length of 25 mm. and a ventral length of 20 mm., and at the aperture is 26 mm. high and 25 mm. wide. This shell is somewhat compressed, but shows better than any other specimen the strong adoral contraction of the living chamber and the strong obliquity of the adoral septa.

Typical in other respects, there is a group of specimens which ranges into a smaller size than those noted above, and in which the greatest height of the shell varies from 31 mm. to 28 mm. One such specimen, a shell with a height of 31 mm., has a living chamber 30 mm. high at its base, which is complete dorso-laterally in a length of 17 mm. In this shell the dorsum is essentially straight in profile. Other specimens, however, show a concave dorsum, and this feature does not seem to be uniform among the species of either size group. (Pl. 37, fig. 9.)

Most of the specimens in the Shideler Collection from McDill's Mills, near Oxford, show longer living chambers, together with a somewhat less strongly contracted aperture, but agree with the holotype in the rate of expansion of the phragmocone and in general proportions in other respects. The best of these specimens is figured here. The shell expands from 28 mm. and 22 mm. at the base to 34 mm. and 28 mm. in the basal 17 mm., then contracts to 34 mm. and 26 mm. at the base of the living chamber which is 45 mm. beyond the base ventrally, and 25 mm. beyond the base adorally. The living chamber has a ventral length of 17 mm., a ventro-lateral length of 20 mm., and a dorsal length of 16 mm.

One other variation remains to be noted. Two specimens, both somewhat flattened, agree with the typical forms in most respects except that the cameræ are deeper, three occurring in a length of 20 mm. near the base of the living chamber, prior to the appearance of contracted gerontic cameræ, where four are present in typical shells.

Discussion.—This species is such an extremely variable one that it has been necessary to prepare the description in terms of individual specimens, which have been selected to show the essential variations from the condition shown by the holotype. Outside of the Cincinnati area there is only one form closely allied to *Beloitoceras amoenum.* This is *Beloitoceras magisterium* Foerste (1928, p. 307, pl. 50, fig. 2; pl. 52, fig. 1) of the Vaureal formation of Anticosti. This is a somewhat larger species, though more similar in general outline to *B. amoenum* than any other. Rather similar, but smaller and with the dorsum more concave over the base of the living chamber, is *B. accultum* Foerste (1928, p. 306, pl. 50, fig. 1; pl. 51, fig. 1) of the English Head formation of Anticosti. This species in turn seems to be closely allied to smaller species in which the gibbosity occurs slightly lower on the conch and which have therefore been placed in *Oncoceras* rather than *Beloitoceras.* These are *Oncoceras carletonense* Foerste, (1928, p. 309, pl. 50, fig. 5) and *O.* (?) *curvicameratum* Foerste (1928, p. 310, pl. 50, fig. 6) the former from the English Head formation and the latter from the Ellis Bay formation of Anticosti. The Maquoketa *Beloitoceras* approximate *B. amoenum* in size, but the variable *B. whitneyi* (Hall) (see Foerste, 1935, pl. 37, figs. 1-3) is much more slender and has a longer phragmocone, almost approaching *Oonoceras* in aspect. *B. discrepans* Foerste (1935, pl. 37, fig. 8) is incompletely known, the type consisting of a phragmocone and part of a living chamber which may not represent a mature individual. It is more rapidly expanding than *B. amoenum*.

In the strict sense of the divisions between *Oncoceras* and *Beloitoceras* on the basis of the position of the point of gibbosity, *B. amoenum* might be placed in *Oncoceras* instead of *Beloitoceras*. However, it agrees with *Beloitoceras* in the vestigial condition of convexity which is absent in some individuals, and clearly the same generic disposition must be made of this species as has been made for *Beloitoceras magisterium*. The extant evidence shows that these large but faintly gibbous species of *Beloitoceras* are confined to the Upper Ordovician and might serve as useful horizon markers. Such species are known from Ohio, the Maquoketa shale of the upper Mississippi Valley, and from Anticosti, but have not been found in the arctic faunas nor in the Whitehead of Gaspé, and seem to have no close relatives in the Upper Ordovician of Europe.

B. amoenum is an abundant species, if brevicones can be said to be abundant, in the Whitewater and Saluda, though specimens are often crushed or fragmentary. The shell is larger than other associated forms and may be distinguished from *B. cumingsi*, which is closest in form, by the relatively slender phragmocone as well as the larger size.

Types.—Holotype, Univ. of Cincinnati, No. 106. Paratypes, Univ. of Cincinnati, Nos. 24416, 24417. Earlham College, Nos. 7744, 1944; Shideler Collection, two specimens.

Occurrence.—From the Saluda beds, McDill's Mills, near Oxford, and from the upper Whitewater at various localities: McDill's Mills, Dodge's Creek near Oxford, Ohio, Richmond, Indiana, including the holotype; Halderman Mill, 2.5 miles south of West Alexandria, Preble County, Ohio. One portion of a phragmocone appearing to belong to this species, but is too incomplete for certain identification, is from the Elkhorn beds of Harper's

Branch, Oldenburg, Indiana.

Beloitoceras cumingsi Flower, n. sp.

Plate 32, fig. 16; Plate 34, fig. 2; Plate 35, figs. 6-8

This species, close in outline and aspect to *Oncoceras,* has a convex venter, an essentially straight dorsum, with the greatest shell height well below the base of the living chamber. The holotype, the least distorted specimen, increases from 20 mm. and 17 mm. at the base to a maximum height of 26 mm. and contracts slightly in the adoral 5 mm. of the phragmocone to a height of 27 mm. and a width of 22 mm. The dorsal length of the phragmocone is 16 mm., the ventral length 30 mm. The living chamber is 7 mm. long ventro-laterally and dorso-laterally, but is 7 mm. long on the venter owing to the development of a rather deep hyponomic sinus. The aperture has a height of 25 mm.

The paratype, apparently a thicker specimen, is actually different largely due to the compression of the shell. It increases from 18 mm. and 25 mm. in a ventral length of 40 mm. and a dorsal length of 20 mm. to 32 mm. and 23 mm. The living chamber is 11 mm. long laterally, and apparently 7 mm. long on the venter. The maximum height of the shell is 32 mm. The cameræ of both specimens occur three in a length of 12 mm. adorally with little variation. The siphuncle is small and located close to the venter. The septa are relatively flat when exposed. The sutures develop only vestigial lateral lobes. The surface is not preserved.

Discussion.—This species is distinctive in the strongly compressed section, the straight dorsum, and the slightly curved venter. It is easily distinguished from the allied *B. amoenum,* both by the slightly smaller diameter of the living chamber and by the much more rapid rate of expansion of the phragmocone. The closest relatives of *B. cumingsi* are three species from the Ordovician of Anticosti Island, two of which are sufficiently gibbous on the dorsum that Foerste placed them in *Oncoceras* instead of *Beloitoceras.* These are *Oncoceras carletonense* (Foerste, 1928, p. 309, pl. 50, fig. 5) and *O.* (*?*) *curvicameratum* Foerste (1928, p. 310, pl. 50, fig. 6). The former is a somewhat larger species in which the dorsum is convex at the base of the living chamber, and in which the lateral lobes of the sutures are well developed. It is from the English Head formation. The second species, from the Ellis Bay formation, is scarcely convex dorsally, smaller, differing again from *B. cumingsi* chiefly in the well-developed lateral lobes. *Beloitoceras percurvatum* Foerste, of the Ellis Bay formation, has well-developed lateral lobes and a living chamber considerably longer than that of *B. cumingsi*. The two species are very similar in profile as seen in lateral aspect. No other close relatives of *B. cumingsi* are known.

Types.—Holotype and paratype, collection of Dr. W. H. Shideler. Paratype, Univ. of Cincinnati, No. 24414.

Occurrence.—Lower and upper Whitewater formations. The holotype is from the lower Whitewater of Little Four Mile Creek, near Oxford, Ohio. The paratypes are from the upper Whitewater of McDill's Mills, near Oxford, a second specimen from the Whitewater near Oxford, precise horizon unknown, and other specimens represent Richmond, Indiana, Dodge's Creek, Oxford, Ohio, and Camden, Ohio.

Beloitoceras cf. cumingsi Flower Plate 37, fig. 6

Under this name I include a single specimen from the Elkhorn of Indiana which agrees with *B. cumingsi* in general form but differs in the shallower cameræ. The specimen is badly flattened so that its height is greatly exaggerated. In its present state it is 28 mm. high at the base. The phragmocone is 26 mm. long on the venter, 13 mm. on the dorsum, and consists of eight cameræ. The basal camera is 4 mm. deep on the venter, the succeeding cameræ become progressively shallower, the last two occupying a ventral length of 3 mm. The living chamber is not complete. It is 27 mm. high at its base. Dorsally it is 10 mm. long. Ventrally it is obviously incomplete. The shell contracts toward the aperture.

Discussion.—This species appears to be distinct from *B. cumingsi* on the basis of the marked development of gerontic septa, which appear at a much earlier growth stage than in true *B. cumingsi.* The lateral lobes are more strongly developed than in *B. cumingsi,* and the living chamber appears to contract more rapidly and may have been shorter. The only specimen, however, is too poor to serve as the type of a new species.

Figured specimen.—Shideler Collection.

Occurrence.—From the top of the Elkhorn, Harper's Branch, Oldenburg, Indiana.

Beloitoceras ohioense Flower, n. sp.

Plate 32, fig. 16; Plate 34, fig. 3; Plate 37, fig. 7

A small *Beloitoceras* with the venter nearly uniformly convex, the dorsum concave adapically and adorally but straight in the middle. The holotype increases from 18 mm. and 22 mm. in the length of the extant part of the phragmocone to 22 mm. and 27 mm. The greatest height of the shell is essentially at the base of the living chamber, while the greatest width is slightly farther apicad. The living chamber is 12 mm. long dorsally, 15 mm. laterally, and 8 or 9 mm. long ventrally due to the presence of a hyponomic sinus. The aperture has a height of 24 mm. The septa are nearly flat. The sutures are essentially straight and transverse at the apical end of the type, but slope orad from dorsum to venter and develop slight lobes adorally. The eight cameræ preserved vary from 4 mm. to 5 mm. in depth. A paratype (Univ. of Cincinnati, No. 23914) retains more of the phragmocone but is incomplete adorally. The shell increases from 18 mm. and 23 mm. to 26 mm. and 23 mm. in a ventral length of 35 mm. and a dorsal length of 20 mm., in the nine basal cameræ. This is followed by two cameræ in an estimated ventral length of 5 mm., and an incomplete living chamber which is 16 mm. long laterally and 14 mm. long dorsally. A third specimen is figured here as an aid in identification inasmuch as it presents a peculiar and deceptive aspect of this species due to poor preservation of the adoral cameræ. This shell, somewhat compressed, is 26 mm. high and 20 mm. wide basally. At the last septum, which is incomplete, the height is 24 mm. and the width 18 mm. The living chamber has a lateral length of 14 mm., suggesting that either some of the adoral cameræ have been completely lost or that the specimen was abnormal. (Pl. 32, fig. 16.)

Discussion.—This species is considerably smaller than *B. amoenum* and *B. cumingsi.* The very gradual expansion of the phragmocone suggests almost *Oonoceras,* but the adoral part of the shell is typical of *Beloitoceras* and not distant from the genotype, from which it may be distinguished by the relatively deep cameræ as well as differences in shell proportions. The slender phragmocone distinguishes it readily from *B. cumingsi*; also the living chamber shows a less strongly convex ventral profile.

Types.—Holotype, Shideler Collection. Paratypes, Univ. of Cincinnati, No. 23914, and one specimen from the Shideler Collection.

Occurrence.—From the lower and upper Whitewater beds. The holotype is from Harper's Branch, near Oldenburg, Indiana. Paratypes are from the lower Whitewater of the Flat Fork of Caesar's Creek, near Oregonia, Ohio, and from Dodge's Creek, Oxford, Ohio. The horizon of the last specimen is given as doubtfully middle Liberty. In the opinion of the writer the form on the basis of lithology is from the lower Whitewater. Other specimens are from the lower Whitewater of Little Four Mile Creek, and the upper Whitewater of McDill's Mills.

Beloitoceras, sp. **Plate 37, figs. 2, 3**

An essentially undistorted living chamber from the lower Whitewater of Oxford represents a species of the *B. amoenum* group which is obviously different in proportions from any of the other known species in being considerably smaller and also broader in section. The septum at the base of the specimen is strongly oblique to the axis of the shell, and is peculiar in having its greatest depth well dorsad of the center of the shell. The height in the plane of the suture is 24 mm., the width 23 mm. Normal to the axis of the conch the width must be at least as great as the height of the shell. One camera 2 mm. deep is preserved. The siphuncle is ventral and obscure. The living chamber is 18 mm. long dorsally, where it is concave at the base, but straight near the aperture. The venter is 15 mm. long, its profile very faintly convex adapically and essentially straight near the living chamber. The hyponomic sinus is not well displayed although the aperture is essentially complete with a height of 15 mm. and a width of 17 mm.

Discussion.—This living chamber is obviously comparable to those of other species of the *amoenum* group in *Beloitoceras,* showing the sutures which swing strongly forward on the venter and the aperture which slopes in the opposite direction so that the mature living chamber may be shorter ventrally than dorsally. The cross section is abnormally wide for *Beloitoceras,* but the form is so evidently related to the group of *amoenum* that this species should evidently be considered as congeneric with it.

Type.—Univ. of Cincinnati, No. 20804.

Occurrence.—From the lower Whitewater beds near Oxford, Ohio, probably from the cephalopod beds of the lower Whitewater.

Beloitoceras geniculatum Flower, n. sp. Plate 33, figs. 3, 4

This species is characterized by the abrupt bend of the venter at the base of the living chamber and the slight adoral contraction. The ventral profile is only slightly convex apicad and orad of this bend. The dorsum is faintly concave over the phragmocone, slightly convex over the basal half of the living chamber and slightly concave near the aperture. Lateral profile with greatest width at the base of the living chamber, otherwise only slightly curved; expanding moderately over the phragmocone and contracting slowly to the aperture. The type has a maximum length of 45 mm. At the base the shell is 15 mm. high and 13 mm. wide. This increases to 26 mm. high and 20 mm. wide at the base of the living chamber, in a ventral length of 28 mm. and a dorsal length of 12 mm. The living chamber has a dorsal length of 24 mm. and is incomplete ventrally, but was evidently over 20 mm. in length. The height of the aperture was probably under 25 mm. The condition of the hyponomic sinus is not known.

Only the adoral sutures are preserved. These are essentially normal to the living chamber, sloping only slightly orad on the dorsum with respect to the profiles of the living chamber itself. The last camera is 3 mm. deep ventrally, the penultimate one, 5 mm. Farther apicad the sutures are not preserved, but on the venter the siphuncle can be seen obscurely. The segments are slender, longer than wide, and only slightly expanded within the cameræ.

Discussion.—This strongly geniculate shell is quite distinct from other species of *Beloitoceras* in the strong bend at the base of the living chamber and the rapid expansion of the phragmocone in contrast to the relatively gentle contraction of the living chamber. In the basal 15 mm. the living chamber increases from 25 mm. to 26 mm. in height and decreases to 24 mm.

Type.—Holotype, Shideler Collection.

Occurrence.—From the cephalopod beds of the lower Whitewater, Little Four Mile Creek, near Oxford, Ohio.

Beloitoceras protractum Flower, n. sp. Plate 33, figs. 5, 6

The basal part of this shell consists of a fusiform conch, gently contracting about equally orad and apicad of the region of greatest diameters, faintly exogastric, compressed, to which is appended a living chamber which is very nearly tubular and which presents a strong contrast to the rest of the shell. The shell expands from 17 mm. in height and 14 mm. in width at the base, to 22 mm. in height and 17 mm. in width in a ventral length of 10 mm., and contracts to a height of 20 mm. and a width of 16 mm. and 24 mm. above the base. The contraction lies just orad of the base of the living chamber. The adoral part of the shell is complete only dorsally, where it extends nearly straight for 17 mm. after a slight initial expansion. The width of the shell is 16 mm. near the middle of this region. Adorally the shell is too incomplete for the width to be measured. The condition of the venter over this part of the shell is not known.

The sutures curve downward on the sides forming rounded broad lateral lobes. The cameræ are subequal in depth, five occupying 10 mm. Obscure lines of growth on the dorsum are straight and transverse. The condition of the surface markings on the venter is not indicated.

Discussion.—This small species, known from a single incomplete specimen from the lower Whitewater beds, is unlike any other oncoceroid of the Ordovician in the sudden change in form from a fusiform oncoceroid shell to the development of an essentially tubular living chamber. If the form is abnormal, as seems not impossible from its peculiar shape, it is remarkable that no normal shells which compare closely with the phragmocone have been found.

Type.—Holotype, Shideler Collection, Miami University, Oxford, Ohio.

Occurrence.—From the lower Whitewater beds, Little Four Mile Creek, near Oxford, Ohio.

Beloitoceras bucheri Flower, n. sp. Plate 39, fig. 6

This is a relatively slender *Beloitoceras* belonging to the group of *janesvillense,* slightly more gibbous than *B. chapparsi.* The holotype, probably somewhat flattened by pressure, is a shell 40 mm. long which is 19 mm. high and 12 mm. wide at its base. The dorsum is faintly concave, almost straight. The venter is more strongly and uniformly curved with a radius of 50 mm. The greatest lateral width is attained orad of the base of the living chamber, as is the greatest height of the shell. The six cameræ of the phragmocone show sutures which have no lateral lobes. They occupy a length of 12 mm. on the dorsum and 16 mm. on the venter. At the base of the living chamber the shell height is 23 mm., the width 15 mm. The living chamber has a maximum (ventro-lateral) length of 25 mm., a dorsal length of 22 mm. The shell attains a height of 25 mm. in the basal third, and contracts gradually to 22 mm. The aperture and the hyponomic sinus are obscured by weathering. The surface of the shell is not preserved. The siphuncle is small, ventral, and its segments are apparently relatively narrow, though they cannot be seen clearly.

Discussion.—This species is remarkable for its slender form, very shallow cameræ, and the relatively slight curvature. The allied *B. chapparsi, B. ulrichi,* and *B. transiens* are more slender and all are more curved and possess much deeper cameræ.

Type.—Holotype, Shideler Collection.

Occurrence.—Lower Whitewater beds, Elk Run, near Winchester, Ohio.

Beloitoceras chapparsi Flower, n. sp. Plate 32, figs. 9-11

This species is represented by a complete living chamber and three cameræ. The holotype is 32 mm. in length, slightly curved, the venter almost uniformly convex, with a radius of curvature of about 40 mm., the dorsum nearly straight below, slightly concave near the aperture. The sides are faintly convex, contracting to a point near the aperture and then becoming subparallel. The section is strongly compressed, the width 14 mm. where the height is 19 mm. The venter is slightly more narrowly rounded than the dorsum, but the greatest width is more markedly dorsad of mid-height of the shell. At the base of the living chamber the height is 20 mm., the width remaining at 14 mm. The living chamber has a ventral length of 25 mm., and a dorsal length of 17 mm. The aperture is 18 mm. high and 12 mm. wide. The hyponomic sinus is vestigial.

The phragmocone has sutures with only faint lateral lobes, and the septa slope only slightly orad from dorsum to venter. The three cameræ have a ventral length of 10 mm. and a dorsal length of 5 mm. The siphuncle is not exposed.

Discussion.—This small species retains the faint gibbosity of the shell typical of the most slender species of *Beloitoceras* and is reminiscent of *Beloitoceras lycum* (Clarke) of the Platteville limestone and also *B. carveri* (Clarke) but is smaller, more slender, and slightly less gibbous. The species is known to me only from the holotype.

Occurrence.—Upper Whitewater beds, Shera farm, near Oxford, Ohio.

Beloitoceras transiens Flower, n. sp. Plate 32, fig. 12

The holotype is a slender cyrtocone, consisting of a living chamber and six cameræ. The ventral profile is slightly and quite uniformly convex, the radius of curvature about 40 mm., the venter is faintly convex over the lower part of the specimen, and becomes slightly more concave near the aperture. The sides are very faintly convex, slightly straighter near the aperture. At the base of the specimen the section 17 mm. and 19 mm. high. To the length of the phragmocone, 18 mm. on the venter and 10 mm. on the dorsum, the width is 18 mm., the height 22 mm. The living chamber has a dorsal length of 18 mm., a ventral length of 26 mm. The aperture is incomplete, but the height is estimated at 22 mm. and the width at 15 mm. The last four cameræ occupy a ventral length of 13 mm. and a dorsal length of 7 mm. The last camera is slightly shorter than the others. The siphuncle is obscure but ventral.

Discussion.—This form is very similar to *B. chapparsi* in the length of the living chamber. It is broader in section, the living chamber is considerably higher in proportion to its length, and a third difference is found in the profile of the dorsum, which is not straight over the base of the living chamber, but sufficiently concave that were these species not so similar this form would have been placed in the genus *Richardsonoceras.* Yet these two forms, approximately from the same horizon, are sufficiently closely related and so similar in aspect that it seems highly undesirable to place them in separate genera on the basis of the necessarily artificial criteria used for the distinction of these form genera.

Holotype.—Shideler Collection, Miami University.

Occurrence.—Upper Whitewater beds, coral banks, west of Oxford, Ohio.

Beloitoceras ulrichi Flower, n. sp. **Plate 35, fig. 1**

Section strongly compressed, venter not much more narrowly rounded than dorsum, greatest width near center of section. Venter convex, nearly uniformly so, but somewhat weathered in the type producing a deceptively inflated appearance of the living chamber in contrast to the phragmocone. Dorsum essentially straight to aperture. Greatest shell height slightly below the middle of the living chamber. The phragmocone of three cameræ has a ventral length of 11 mm., a dorsal length of 7 mm. The width is 13 mm. at the base, the height estimated at 18 mm., part of the venter being lost by weathering. At the base of the living chamber the height is 21 mm., the width 16 mm. The living chamber has a ventral length of 22 mm. and a dorsal length of 17 mm. It expands to 22 mm. and 16.5 mm., and contracts to a width of 14 mm. and an estimated height of 20 mm. at the aperture which is considerably inclined to the plane of the last septum. The ventral siphuncle is lost by weathering. The sutures exhibit slight lateral lobes but are essentially normal to the curving axis of the shell.

Discussion.—This is a typical *Beloitoceras,* related to the associated *B. transiens* and *B. chapparsi,* but slightly more gibbous and therefore more typical of true *Beloitoceras.* The shell is somewhat less curved and the cameræ slightly deeper than in the middle Ordovician species which are most similar, as in *Beloitoceras janesvillense.*

Type.—Holotype, U. S. National Museum.

Occurrence.—Elkhorn beds, Versailles, Indiana.

Genus MAELONOCERAS Hyatt

Genotype.—*Phragmoceras præmaturum Billings.*

Maelonoceras Hyatt, 1884, Boston Soc. Nat. Hist., Proc., vol. 22, p. 280.
Meloceras Foord, 1888, Cat. Foss. Ceph. British Museum, vol. 1, p. 262, footnote, p. 269.
Maelonoceras Miller, 1897, North American Geol. Pal., 2d App., p. 775.
Meloceras Hyatt, Zittel-Eastmann Textbook Paleont., vol. 1, 1st ed., p. 530. (Reprinted with different pagination in later editions.)
Maelonoceras Grabau and Shimer, 1910, North American Index Fossils, vol. 2, p. 118; Foerste, 1924, Denison Univ. Bull., Sci. Lab., Jour., vol. 20, p. 242; Foerste, 1926, *ibid.*, vol. 21, p. 317; Foerste, 1933, *ibid.*, vol. 28, p. 89; Troedsson, 1926, Meddelelser om Gronland, Bd. 71, p. 91.

Although Hyatt originally described this genus for shells which were faintly gibbous but more slender than *Oncoceras,* in selecting the type he referred to a specific figure. Foerste (1933) correctly points out that this is equivalent to selecting the original of his figure as the lectotype of the genotype. This specimen happens not to be conspecific with the other and more complete specimens originally attributed to the species. The shell is known only from a living chamber which is nearly parallel-sided vertically, but which contracts gradually laterally to the aperture which closes over the adoral surface slightly and is pear-shaped owing to the prominent development of a large rounded hyponomic sinus. The siphuncle is small, ventral, and close to the margin of the shell. The sutures appear to be straight and transverse. No species other than the genotype can be placed in *Maclonoceras* at the present time. Troedsson (1926) included Ordovician species in the genus which in the light of Foerste's (1933) correction of his previous diagnosis of the genus, must be placed elsewhere, apparently in *Beloitoceras*. Foerste (1924) named the specimen which Hyatt had selected as the type of Billings's species, *Maclonoceras billingsi*. *M. præmaturum* Foerste, 1924, was renamed *Beloitoceras clochense* (Foerste, 1933). That this species is a typical *Beloitoceras* and not closely related to *Maelonoceras* proper, can be seen from the figures. (Foerste, 1924, 1933.)

Genus NEUMATOCERAS Foerste

Genotype.—*Neumatoceras gibberosum* Foerste.

Neumatoceras Foerste, 1935, Denison Univ. Bull., Sci. Lab., Jour., vol. 30, p. 31; Roy, 1941, Field Museum Nat. Hist., Geol. Mem., vol. 2, pp. 144-146; Flower, 1942, Bull. Amer. Paleont., vol. 27, No. 103, pp. 22-23.

Original definition.—The genus *Neumatoceras* differs from *Beloitoceras* chiefly in being distinctly humped along the upper part of the ventral outline of the phragmocone, the maximum dorso-ventral diameter usually being at a distinct interval beneath the base of the living chamber ventrally. From this level of maximum dorso-ventral diameter the conch usually tapers conspicuously toward the aperture. The dorsal outline along the upper part of the phragmocone and all of the living chamber tends to be relatively straight, with faint incurvature at top and along the lower part of the phragmocone.

Foerste described species which he placed in this genus, from the Bighorn formation, the Fremont limestone, and the Whitehead formation of Gaspé. Roy recognized the genus in Baffin Land, and Flower placed in it a species from the Cynthiana limestone of Kentucky. Further study has convinced the writer that the genus is a most unsatisfactory one, for on the basis of the extant definitions it intergrades equally well with *Beloitoceras* and with *Oncoceras*. Further, the diversity of form of the species and the affinities of the species with others currently placed in *Oncoceras* and *Beloitoceras* suggest that it is composed at the present time of independent genetic radicles arising, perhaps independently for each species, from these two older and somewhat more generalized form genera. *Neumatoceras* is, then, only a convenient name embracing a variety of species which attained an extreme of gibbosity in late Trenton and Richmond time, and which seem to be largely concentrated in the boreal Ordovician faunas of America. As a genetic unit, it has no real value. Consequently the recognition of a species as falling within the previously accepted form limits covered by *Neumatoceras* does not necessarily imply that it is related to other species which have been placed there. These species are not all as closely related among themselves as they are to some others currently retained in *Oncoceras* and *Beloitoceras*. Therefore it is unsafe to base stratigraphic or paleogeographical conclusions upon the presence of a *Neumatoceras* in any association, but it is necessary to investigate instead, the affinities of the species in question with others not only in *Neumatoceras,* but also in *Oncoceras* and *Beloitoceras*. Admitting the possibility of form convergence, it follows that except for strikingly peculiar species, and perhaps even there, correlation based upon specific affinities may be regarded with suspicion.

Unhappily revision of the genus cannot be effected on the basis of the present knowledge of the species concerned. Internal structure is poorly known. Those few forms for which the siphuncle is known show some variation in the form of the segments, and there are, as in other Oncoceratidæ, no accessory deposits which might serve as guides. Further, internal structure is known for only a very few of the species concerned. Another inadequately investigated problem is that of variation within the species. This requires larger suites of material than are at present available for any one of the species concerned.

The wisest course, then, has seemed to be a conservative treatment of the genus, with as few nomenclatorial changes as possible, and to attempt instead an analysis of the morphological affinities of the species concerned insofar as the present data permit. The following discussion deals, first, with a short analytical summary of the species previously either placed in *Neu-*

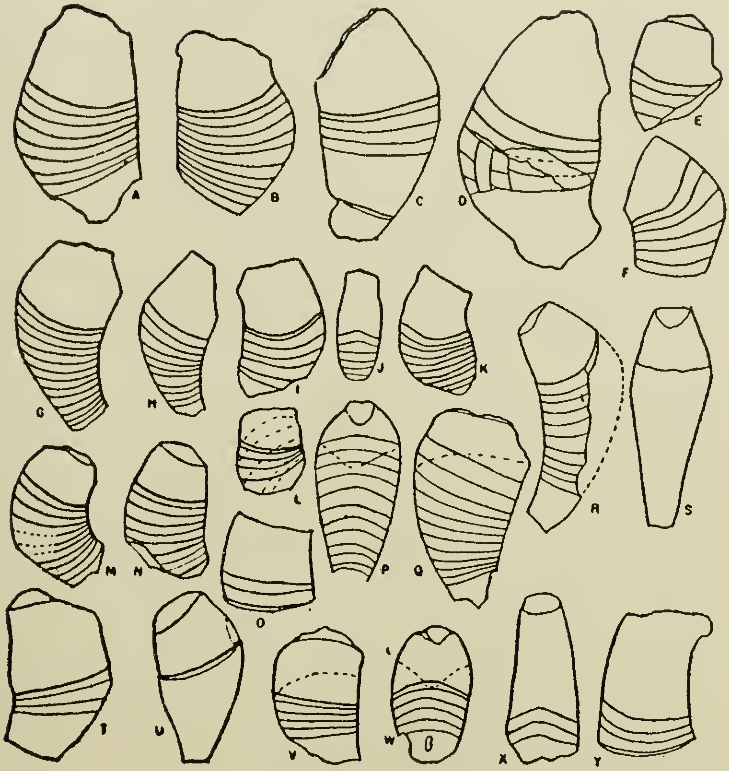

Figure 12. Gibbous Oncoceratidæ. A-B. *Neumatoceras gibberosum* Foerste. Bighorn formation, Wyoming. Lateral views of two species showing size variation. *C. Neumatoceras dartoni* Miller and Carrier. Bighorn formation, Wyoming. Lateral view. (After original figure of Miller and Carrier) D. *Neumatoceras nutans* Foerste. Bighorn formation, Wyoming. Lateral view of type, partly sectioned to show siphuncle. E. *Neumatoceras,* sp. Foerste. Whitehead formation, Gaspé. F. *N. cf. canyonense* Foerste. Bighorn formation, Wyoming. Lateral view. G. *Neumatoceras (?) milleri* Foerste. Bighorn formation, Wyoming. H. *Neumatoceras striatum* Foerste. Whitehead formation, Gaspé. I-L. *Neumatoceras breviposticum* (Miller) Bighorn formation, Wyoming. I. Paratype; J-K, ventral and lateral views, holotype; L, specimen attributed to this species by Foerste. (I-K are after Miller). M. *Neumatoceras percense* Foerste. Whitehead formation, Gaspé. Lateral view. N. *Neumatoceras latilineatum* Foerste. Whitehead formation, Gaspé. Lateral view. O. *Onoceras,* sp. Flower. Holotype, an incomplete living chamber with essentially the proportions of those of a *Neumatoceras.* Cyn-

thiana—Leipers formation. Southern Kentucky. P-Q. *Neumatoceras conicum* Flower, n. sp.; P, ventral; Q, lateral view of holotype. Whitewater formation, Ohio. R-S. *Neumatoceras canyonense* Foerste. Fremont limestone, Colorado, R, lateral view with venter restored; S, dorsal view. T. *Beloitoceras geniculatum* Flower. Lower Whitewater, Ohio. U. *Oncoceras bassleri* Flower, n. sp. Leipers formation, southern Kentucky. Lateral view of living chamber with phragmocone restored on basis of fragments not otherwise illustrated here. V-W. *Neumatoceras chrysalis* Flower, n. sp. Lower Whitewater beds, Ohio. Evidently very close to *N. conicum* Flower (see P-Q above). V, lateral aspect; W, ventral aspect. X-Y. *Neumatoceras* (?), sp. Foerste. Fremont limestone, Canyon City, Colorado. Atypical of the genus and comparable to specimens shown on figure 13 and to *Winnipegoceras laticurvatum* (Whiteaves; Roy, 1941, p. 144, fig. 105). X, ventral view; Y, lateral view.

All figures slightly less than one-half. O-Q., T-W are from original specimens. Others are drawn from figures of Foerste, Miller, and Miller and Carrier.

matoceras or suspected of having affinities with it. Secondly, these species are arranged in groups on the basis of form. Finally, the Cincinnatian species, those with which the work is primarily concerned, are discussed here, even though some of them are not placed in *Neumatoceras* because their obvious affinities are with species of *Beloitoceras* and *Oncoceras*. Only those belonging with the genotype of *Neumatoceras* (Group I, of the following classification) are actually described as members of this genus. The problems attendant upon a form classification are further shown by the accompanying text figures which show the form of most of the important species previously described, with which the Cincinnatian species are compared.

Text figure 12 is devoted to the outlines of various members of *Neumatoceras* together with some species treated in the present work which approach the genus in form but which have been excluded from it for some reason, usually because of obvious affinities with known *Oncoceras* and *Beloitoceras* species. The shells are compressed exogastric brevicones in common with *Oncoceras* and *Beloitoceras*. In general, they attain an extremity of compression not found in those genera, but gradation is evident in this character. The region of gibbosity lies low, below the base of the mature living chamber, which distinguishes most species of *Neumato-*

ceras from *Beloitoceras*, but gradation occurs in this feature also. Further, difficulties are encountered in the use of this character unless it can be confined to fully mature specimens in both genera. The genotype has a dorsal profile which is straight, but in other species it is concave and in still others, slightly convex. These last grade into *Oncoceras*. However, generic distinction in *Neumatoceras, Oncoceras*, and *Beloitoceras* is so unsatisfactory that only two courses are open: (1) to retain the genera as form genera with as little revision as possible and (2) to return all of the species to *Oncoceras*, the first of these genera to be described. Properly, in the present state of our knowledge, or lack of knowledge, of many of the species involved, the second course is the more desirable one. I have not followed it because, in view of the immense number of species involved, it seems that somewhat unsatisfactory distinctions are better than none at all. The species which have been placed in *Neumatoceras* are therefore discussed here. New species are added, but only those new forms from the Richmond of Ohio and Indiana which are obviously similar to the genotype in form and are typical are placed here. Other species are removed to *Oncoceras*, and a few to *Beloitoceras*. The Cynthiana and Leipers species, here placed in *Oncoceras*, were originally included under *Neumatoceras* in manuscript at least by both Foerste and the writer. Study of more complete shells showed that they graded into *Oncoceras*. Among the species described in the manuscript on the Upper Ordovician cephalopods of the Cincinnati region was one placed in *Neumatoceras*. The type specimen showed all of the typical features of the genus. Yet comparison of this with more material showed that it was only a specimen of *Beloitoceras amoenum* which had been further compressed by pressure after death and had therefore assumed the form pattern of a perfectly typical *Neumatoceras*. Indeed, the specimen was duplicated by first taking a cast of a typical undistorted representative of the species. The cast was then flattened to the desired degree, and a plaster mold was made of it. This mold was identical not only in form but in the features of the sutures with the natural specimen. (Pl. 42, fig. 5.)

Species previously assigned to Neumatoceras.—I. Typical species, with a strongly convex ventral profile and a straight dorsal profile, at least in the adoral part of the shell, since only the living chamber and adoral part of the phragmocone are known for some species. Adapically the dorsum is concave in some species. Others are so strongly gibbous adorally as to suggest that the dorsum may be straight throughout, but actual confirmation of this is lacking. This group of species differs from *Beloitoceras* in having the gibbous region located below the base of the living chamber at least on the ventral side. It differs from *Oncoceras* in having the dorsal profile straight or rarely faintly concave but never convex. This group of species is regarded as a specialization springing from *Beloitoceras*. Here may be placed the following:

N. gibberosum Foerste (genotype). Bighorn formation, Wyoming. (See text fig. 12 A-B.)

N. latilineatum Foerste. Whitehead formation, Gaspé. (Text fig. 12 N.)

N. (?) *milleri* Foerste. Bighorn formation, Wyoming. (Text fig. 12 G.) The dorsum is obviously concave adapically and the form here is close to *Beloitoceras.*

N. dartonæ Miller and Carrier. Bighorn formation, Wyoming. (Text fig. 12 C.) The sutures are little inclined orad on the venter adorally, and the form is very close to *Beloitoceras.*

N. cf. *canyonense* Foerste. Bighorn formation, Wyoming. (Text fig. 12 F.)

II. Species intergrading with the above, but less strongly compressed and less gibbous on the venter. The dorsal outline may be apparently straight adorally. The adapical portion is, when known, either straight or concave dorsally. The adoral sutures slope strongly orad from dorsum to venter.

Neumatoceras drummuckense Teichert. Drummuck group, Scotland. The dorsal profile varies from straight adorally to slightly concave throughout. The greatest gibbosity is almost at the base of the living chamber.

N. striatum Foerste. Whitehead formation, Gaspé. (Fig. 12

H.) This seems intermediate between *N* (?) *milleri* (fig. 12 G) and *Beloitoceras* (?) *geniculatum* Flower (fig. 12 T).

III. Species in which the dorsum is clearly concave throughout. These forms grade into *Beloitoceras* and are less gibbous in general than those in group I.

N. cf. *canyonense* Foerste. Bighorn formation, Wyoming. (Fig. 12 F.) An anomalous species with the adoral cameræ becoming curved laterally quite suddenly and a faintly concave dorsum.

N. canyonense Foerste. Fremont limestone, Colorado. (Fig. 12 R-S.) The sutures insofar as they are known are more uniform and less variable in the later growth stages than the preceding. The living chamber alone is very similar in aspect to that of some species of *Oncoceras.*

N. percense Foerste. Whitehead formation, Gaspé. (Fig. 12 M.) Very close to typical *Beloitoceras.*

IV. Species with the dorsum more or less clearly convex at or apicad of the base of the living chamber. These are regarded as grading into *Oncoceras.*

Neumatoceras, sp. Foerste. Whitehead formation, Gaspé. (Fig. 12 E.) The internal mold, at least, bears an emargination not unlike that of *Oncoceras foerstei* of the Leipers. Indeed, this species may, when known from more complete material, prove to be an *Oncoceras.*

N. breviposticum (Miller). Bighorn formation, Wyoming. (Fig. 12 I-L.) Somewhat variable in profile and in the spacing and configuration of the sutures. Variable in the convexity of the dorsum also.

N. latilineatum Foerste. Whitehead formation, Gaspé. Except for the great height of the shell at the gibbous region, this form is very close to *Oncoceras.*

V. Anomalous species, very slender adorally, which have been placed in *Neumatoceras* or for which affinities with the genus have been suggested.

Neumatoceras (?), sp. Foerste. Fremont limestone, Colorado. (Fig. 12 X, Y.) The slender contracting living chamber suggests *Winnipegoceras.*

N. tumidum (Schuchert). Frobisher Bay, Baffin Land. Roy (1941, pp. 145-6) presents figures of this form suggesting that it may be closely allied to the Leipers species here placed in *Oncoceras* on the basis of more complete specimens. The extant portion of this species does, however, suggest *Neumatoceras* as suggested earlier by Foerste (1935, p. 32). It is comparable with *N. canyonense,* differing mainly in its much greater size, but is also close to comparable portions of *Oncoceras bassleri* Flower.

Maelonoceras reclinatum Troedsson. Cape Calhoun formation, Greenland. This is not a *Maelonoceras* as delimited by Foerste (1933) but is a large slender cyrtocone, faintly contracting vertically toward the aperture, which appears to be allied to the above and also to the smaller species identified as *Winnipegoceras laticurvatum* (Whiteaves) by Roy (1941, p. 144). Flower (1942, p. 23) suggested that this might be a primitive *Neumatoceras.* However, in view of the apparent polyphyletic nature of *Neumatoceras* and the recognition of the genera of the Oncoceratidæ as form genera, a genetic classification does not seem possible in the light of our present knowledge. These species might be placed in *Winnipegoceras* or might be considered as belonging to either *Beloitoceras* or *Richardsonoceras.*

Cincinnatian species of the aspect of Neumatoceras.—The above summary shows the complex and sometimes contradictory relationships suggested for the various species of *Neumatoceras* on the basis of the extant information. The Cincinnati species which present the aspect of *Neumatoceras* have been disposed as follows and are described in detail in the following pages.

I. A group of moderately gibbous species with poor or vestigial development of the hyponomic sinus, characteristic of the Cynthiana and Leipers. The living chambers and adoral parts of the phragmocones suggest *Neumatoceras,* as the living chamber contracts conically, and the adoral sutures are strongly inclined forward on the venter. However, one of these species, when known from relatively complete material, proved to be a perfectly typical *Oncoceras, O. bassleri.* Therefore, the entire series has been placed in that genus. One I originally described as *Neumatoceras carlsoni,* regarding it as showing arctic affinities. The change of name does not alter the conclusions based upon affinities with other species, and this form is very close to *N.* (?) *tumidum* as developed in Baffin Land and is comparable also with *N. canyonense.*

Oncoceras carlsoni (Flower). Cynthiana limestone, Cynthiana, Kentucky.

Oncoceras bassleri Flower, n. sp., Leipers formation, Rowena, Kentucky. This is a slightly variable species, but one very similar to *O. carlsoni.* (Text fig. 12 U.)

Oncoceras (?) sp. A little known form from the Leipers formation of Rowena, Kentucky. (Text fig. 12 O.)

II. Species fairly typical of *Neumatoceras* in form. Here I place two Whitewater species which are strongly gibbous, have the dorsal profile essentially straight, and have, in contrast to the preceding species, a strongly developed hyponomic sinus. *Neumatoceras conicum* Flower, n. sp., and *N. chrysalis* Flower, n. sp. (See text figure 12 P-Q and V-W.)

III. Species which are strongly geniculate and, therefore, suggestive of *Neumatoceras,* but relatively slender, and with the gibbosity at or above the base of the living chamber. One such species *B. geniculatum,* (text fig. 12 T) from the Whitewater beds is placed in *Beloitoceras.* I have grouped it with the species of *Neumatoceras* in my text figure because of its similarity of profile with some of these forms. If a few more cameræ were to be added to this form, which might have occurred, as it is by no means certain that the type is a fully grown shell, the appearance would be very close to *Neumatoceras.*

Neumatoceras chrysalis Flower, n. sp. Plate 45, figs. 2, 3

Conch small, an exogastric brevicone, known from a complete living chamber and about half of the phragmocone. The dorsal profile is nearly straight with a faint suggestion of convexity over the middle of the living chamber and an equally faint suggestion of concavity on the phragmocone. The ventral profile is convex with a fairly uniform radius of curvature of 30 mm. over the greater part of the shell. At the base of the specimen there is a slightly greater curvature, but the venter appears to be less curved in the extreme extant apical portion. At the adoral end of the living chamber the venter becomes much more strongly curved close to the aperture. The lateral profiles are slightly and fairly uniformly convex. The greatest width of the shell, 19 mm., is attained orad of the base of the living chamber. The greatest height, 22 mm., is attained apicad of the base of the living chamber on the venter but is maintained over a considerable interval in the middle part of the shell. The living chamber has a basal height of 22 mm. and a width of 19 mm. It is 14 mm. long dorsally, 15 mm. laterally and 13 mm. ventrally. The short ventral height is due in part to the sutures which slope forward on the venter and in part to the deep hyponomic sinus of the aperture. The aperture, which is not very clearly preserved, has a height of 19 mm. and an estimated width of 13 mm.

The phragmocone has a ventral length of 14 mm. and a dorsal length of 9 mm. and consists of six cameræ. The sutures bear slight lateral lobes, as usual in the Oncoceratidæ, and slope forward from dorsum to venter, the obliquity being greatest near the living chamber. The siphuncle is obscurely exposed at the base of the type, where it is close to the venter and composed of elongate segments, much longer than wide, which are fusiform in outline. The cameræ of the type decrease in depth orad, measuring 3 mm., 2 mm., 2 mm., 2mm., 2 mm., and 1.5 mm., respectively.

The internal mold retains on its surface lines of growth which show that the aperture was strongly inclined apicad on the venter forming a deep hyponomic sinus.

Discussion.—This is a small species, typical of *Neumatoceras* in general aspect, in the features of the aperture, and of the sutures. The humped appearance characteristic of the genus is not so evident as in some other species as the venter is not so strongly gibbous in profile. However, there is evidence that near the base of the type there is a definite increase in curvature of the ventral profile. Most of the congeners of this species are more convex on the venter. The species is rather close in form to *Neumatoceras* (?) *milleri* Foerste (1935, pl. 4, fig. 4) of the Bighorn formation) but has the living chamber less rapidly contracting and is not at all convex over the adoral part of the phragmocone on the dorsum. In failing to contract vertically on the living chamber it also differs from *Neumatoceras strigatum* Foerste (1936, p. 380, pl. 56, figs. 11-12) and *N. latilineatum* which is somewhat closer in the proportions of the living chamber but is a much more strongly curved species. These species are from the Ordovician Whitehead formation of Gaspé. Probably closer than any American species, in that the venter is not markedly gibbous and the living chamber is not strongly contracted in the venter until very close to the aperture, is *Neumatoceras drummuckense* Teichert (1940) from the upper part of the Drummuck group of the Girvan district of Scotland. That species is a much smaller one, and even there the living chamber is somewhat more contracted vertically toward the aperture.

The species is evidently close to the tenuous boundary which separated *Neumatoceras* from *Beloitoceras*, but no species of the latter genus resemble this species as closely as do the species of *Neumatoceras* noted above.

Type.—Holotype, collection of Dr. W. H. Shideler, Miami University, Oxford, Ohio.

Occurrence.—From the cephalopod beds of the lower Whitewater, Little Four Mile Creek, near Oxford, Ohio.

Neumatoceras subconicum Flower, n. sp. Plate 40, figs. 9, 10

Conch exogastric, compressed, expanding conically to a point very close to the aperture and then contracting rapidly on both dorsum and venter. The holotype is 49 mm. long, increases in 35 mm. on the venter and 34 mm. on the dorsum from a height of 11 mm. and a width of 10 mm. to a height of 29 mm. and a width of 23 mm., and contracts at the aperture 12 mm. farther ventrally and an estimated 10 mm. farther dorsally, to a height of 22 mm. and an estimated width of 10 mm. The sutures are faintly incised on the type, and it is uncertain whether one faint line is correctly interpreted as the last one. If so, the living chamber is bounded basally by a suture which slopes strongly orad from dorsum to venter, is 10 mm. long on the venter, estimated at 14 mm. in length of the dorsum, and has a mid-lateral length of 19 mm. The ventral profile is slightly convex with a radius of curvature of about 35 mm. up to a point where the last septum meets the venter, where the shell becomes humped and then less curved toward the aperture, though with the venter approaching the dorsum rapidly. The dorsal profile is faintly concave adapically, but straight adorally, though missing on the adoral part of the living chamber.

Ten cameræ of the phragmocone are preserved. These show little variation in length, ranging from 4 mm. to 5 mm., and the last cameræ show no sign of the usual contraction. The siphuncle is not preserved.

Although the aperture is obscure, lines of growth are impressed on the internal mold indicating that the aperture slopes strongly apicad on the lateral regions from dorsum to venter, and a well-developed hyponomic sinus must have been present.

Discussion.—This species appears to have no very close relatives from other formations, differing mainly in that the apical portion is slightly curved and conically expanding, and that the gibbosity of the venter occurs higher in the shell than in all comparable forms. It may be that the type is not quite mature, but even with due allowance made for this possibility, the species is not similar in proportions to any described form.

This species is associated with *N. chrysalis* from which it may be readily distinguished by the much larger size, more rapid expansion of the initial part of the shell, the more gibbous venter, and also the more rapid contraction of the living chamber toward the aperture.

Type.—Holotype, Univ. of Cincinnati Museum, No. 24329. From the collection of Charles L. Faber.

Occurrence.—From the lower Whitewater beds, Little Four Mile Creek, near Oxford, Ohio.

Genus OONOCERAS Hyatt

Genotype.—*Cyrtoceras lentigradum* Barrande.

Oonoceras Hyatt, 1884, Boston Soc. Nat. Hist., Proc., vol. 22, p. 280.
Oocerás Foord, 1884, Cat. Foss. Cephalopoda, British Museum, vol. 1, p. 262.
Oonoceras Hyatt, 1894, Amer. Phil. Soc., Proc., vol. 32, pp. 447, 520.
Ooceras Hyatt, 1900, Cephalopoda, *in* Zittel-Eastmann Textbook Paleont., vol. 1, 1st ed., p. 529; Ruedemann, 1906, New York State Museum, Bull. 90, p. 495; Grabau and Shimer, 1910, North American Index Fossils, vol. 2, p. 195.
Oonoceras Foerste, 1926, Denison Univ. Bull., Sci. Lab., Jour., vol. 21, p. 321; Flower, 1942, Bull. Amer. Paleont., vol. 27, No. 103, pp. 24-31.

The problems connected with the recognition of the scope and boundaries of this genus have already been discussed in some detail by the writer (Flower, 1942). The genus is here employed for slender cyrtoceracones of compressed section, very gradual expansion, and relatively slight curvature. The sutures typically develop lateral lobes. The siphuncle lies close to the venter. The segments are nummuloidal but typically rather slender, small, and free from any known organic deposit. The cameræ are very closely spaced in typical species. The aperture bears a hyponomic sinus which is preserved in growth lines throughout the shell.

Problems affecting the recognition and scope of the genus involve nearly all of these features. The genotype is annulated externally and Foerste (1926) proposed to restrict the genus to such forms. However, associated with the genotype in the Middle Silurian (Étage E2) of Bohemia, are other forms with only fasciculate exteriors which supply a perfect gradation to essentially smooth-shelled forms. Further, even in the genotype there is not a true development of annuli, since the apparent annuli are only external thickenings of the shell and are not expressed internally as are true annuli in such genera as *Spyroceras, Gorbyoceras,* and *Tofangoceras.* Even in the Middle Silurian of Bohemia this feature cannot be used with any satisfactory results.

Moreover, it is known that three divisions can be made in these slender cyrtoceracones of the Silurian on the basis of the segments of the siphuncle, two of which are best placed in *Ooceras.* while a third constitutes the genus, *Oocerina* Foerste (1926). The writer designated these as *Oonoceras* I and *Oonoceras* II.

Oocerina has broad siphuncular segments occupied by actinosiphonate deposits. It is known only from the Middle Silurian of Bohemia at the present time. *Oonoceras* II differs from *Oocerina* only in the absence of these deposits and has broad rounded segments. *Oonoceras* I, which actually is connected with *Oonoceras*

Figure 13.—Slender compressed Oncoceratidæ, *Richardsonoceras* and *Oonoceras*. *A-C. Richardsonoceras simplex* Billings. A, cross section; B, lateral view of holotype (in solid lines) on which is superimposed a tracing from another specimen in broken lines showing variation of curvature within the species; C, ventral view of another specimen sectioned to

show the siphuncle. D-E. *Richardsonoceras beloitense* Foerste. Platteville limestone, Wisconsin. D, lateral view; E, ventral view. A gently curved slender species approaching the condition of *Oonoceras*, and the only species known suggesting such gradation. F-G. *Oonoceras acutum* Flower. Lens in Cynthiana limestone, Cynthiana, Kentucky. F, lateral view; G, cross section. H-I. *Oonoceras multicameratum* Flower. Lens in Cynthiana limestone, Cynthiana, Kentucky. H, lateral view; I, cross section. J-K. *Oonoceras triangulatum* Flower. Lens in Cynthiana limestone, Cynthiana, Kentucky. L. *Oonoceras triangulatum* var. *cylindratum* Flower. Lens in Cynthiana limestone, Cynthiana, Kentucky. Cross section from base of holotype. M-N. *Richardsonoceras* (?) *clarkei* Foerste. Platteville limestone, Wisconsin. M, lateral view; N, ventral view. Species atypical in the very shallow cameræ and narrow siphuncle. O. *Oonoceras obstructum* (Foerste). Vaureal formation, Anticosti. Lateral aspect. All drawings are from the original figures by Foerste and Flower. One-half natural size.

II by a number of intermediate species in the Silurian of Bohemia, is typically distinguished by the more slender and much less expanded segments of the siphuncle. In the Silurian of Bohemia these three together make up a compact unit which might well be regarded as a single large genus. In all groups there is found variation in the rate of expansion, curvature, cross section, ornament, and other features, but except for the marked development of fasciculate exteriors in some *Oonoceras* I, none of these characters seem to characterize any of the groups as determined by the characters of the siphuncle.

Many Ordovician forms appear to be congeneric with *Oonoceras* as defined above. Foerste (1926) restricting *Oonoceras* to annulated shells, a conclusion with which the writer cannot agree, and employing *Oocerina* only for actinosiphonate shells, did not find either genus in the Ordovician, but was obliged to employ other generic names for such species. However, these forms, which belong to *Oonoceras* II, with relatively broad segments of the siphuncle, cannot be distinguished generically from forms of the same group in the Bohemian Silurian. Since such forms also grade into typical *Oonoceras* it has seemed wisest to use this generic name to include all of these species.

Foerste (1928) placed some slender compressed species in *Cyrtorizoceras*, including *Cyrtoceras filosum* Conrad of the Trenton of New York. Later somewhat similar forms with gerontic constrictions were placed in *Beloitoceras,* and later (1932) *Richardsonoceras* was erected for similar forms. Difficulties attend the recognition of a clear line of separation between *Oonoceras* and various of these genera.

Typical *Beloitoceras* is quite distinct from *Oonoceras* in appearance, having a much more rapidly expanding phragmocone, followed by a slightly but definitely gibbous region, from which the shell contracts to the aperture. *Oonoceras* is a longiconic cyrtoceracone, but one which may have a short living chamber bearing internal constrictions, and living chambers alone may approach those of the more slender species of *Beloitoceras.* In fact, a few of these species which are close to the boundary between the genera on the basis of form, could be assigned to either and indicate clearly a gradation between the two form genera. It is not unnatural that this should be found, since *Oonoceras* very probably developed from the older *Beloitoceras,* but the affinities, as recognized on the basis of series of similar species, appear to pass the boundary between the genera several times, suggesting that *Oonoceras* may represent several parallel lines of descent from the more breviconic oncoceroids included in *Beloitoceras.*

Much difficulty attends the recognition of *Richardsonoceras* as a genus distinct from *Oonoceras.* Foerste erected this genus for species which were slender cyrtocones in contrast to the more breviconic *Beloitoceras* and included in it a number of Ordovician species. At this time *Oonoceras* was not considered in connection with *Richardsonoceras,* since Foerste regarded that genus as restricted to Silurian annulated cyrtoceracones. This procedure, however, leaves without any valid resting place a large number of Silurian cyrtoconic shells, which we have included in *Oonoceras.* It also necessitates the inclusion in the same genus of a number of Ordovician forms which are obviously congeneric with these Silurian species. Such shells differ slightly from typical *Richardsonoceras,* in being less strongly curved and in having relatively closely spaced cameræ. Therefore, the writer has recognized *Richardsonoceras,* though restricting it to the more strongly curved and more deeply chambered species, removing the others to *Oonoceras* (Flower, 1941). That this procedure may have some value is indicated by the fact that *Richardsonoceras* in its present form is confined to the boreal Middle Ordovician type which is not known to persist either into the typical Cincinnatian or into the Red River faunas in the broadest sense of the term.

Digenuoceras Foerste (1935, p. 43) based upon *Oxygonioceras* (?) *latum* Foerste (1929, p. 218, pl. 18, figs. 1-2; pl. 19, fig. 2) of the Red River beds of Manitoba, also identified with doubt by Foerste from the Bighorn formation (Foerste, 1932, p. 44, pl. 19, fig. 5) differs from *Oonoceras* in its extremely compressed section in which both the dorsum and venter are angular in cross section. The shell is probably a cyrtoceracone rather than a trochoceroid and probably represents an extreme of compression in *Oonoceras* but seems sufficiently distinct to warrant the recognition of the genus.

Exomegoceras Miller and Carrier (1942, p. 541), based upon *Exomegoceras wyomingense* Miller and Carrier, is very doubtfully distinct from *Oonoceras.* The genus is distinguished from *Digenuoceras* by its authors by the fact that the cross section is angular on the venter but not on the dorsum. Neither *Oonoceras* or *Richardsonoceras* were discussed in connection with the genus. Although the genotype is somewhat more strongly curved than typical *Oonoceras,* it does not appear that it should be separated generically from other members of the genus.

The writer (Flower, 1941) has previously removed the following species to *Oonoceras*: *O. obstructum* Foerste of the Vaureal limestone of Anticosti, *O. subcuneatum* Foerste and *O. wyomingense* Foerste of the Bighorn formation, *O. shamattawense* and *O.* sp. Foerste of the Shamattawa limestone of Hudson Bay.

Species of Oonoceras in the Cincinnati region.—The species of *Oonoceras* in the Cincinnati region fall into two widely separated stratigraphic groups. One group of species occurs in the Cynthiana limestone of Kentucky and is apparently represented also in the Cathys limestone of Tennessee, though our material from there has been too fragmentary for proper study. Most of the Cynthiana material is from a concentration of cephalopods in a single lens exposed in the Poindexter quarry at Cynthiana. No more of this material was available when the locality was revisited by the writer in 1942, the lens having been completely removed by quarrying, and as a consequence no new information is available concerning these species. Therefore, they are only briefly noted in this work since a repetition of the original figures and descriptions will serve no useful purpose. To these is added only one new form, *Oonoceras curviseptatum,* from the upper part of the Cynthiana limestone probably from West Covington, Kentucky.

The Cynthiana species are remarkable mainly for their affinities with species of the boreal "Richmond" faunas, the Vaureal formation of Anticosti, the Bighorn dolomite of Wyoming and the Fremont limestone of Colorado. The affinities of these species may be summarized as follows:

O. planiseptatum Flower. Close to *O. wyomingense* (Foerste) of the Bighorn formation.

O. acutum Flower. Closest to *O. subcuneatum* (Foerste) of the Bighorn formation.

O. curviseptatum Flower, n. sp. Similar to *O. planiseptatum,* but more compressed and even closer to *O. wyomingense.*

O. multicameratum Flower. Essentially a smaller and more slender edition of *O. obstructum* (Foerste) of the Vaureal formation of Anticosti.

O. gracilicurvatum Flower. Intermediate between *O. multicameratum* and broader and more generalized forms. Preoral constriction continues from dorsum to venter.

O. triangulatum Flower and *O. triangulatum* var. *cylindratum* are more generalized types but without any close relatives in the Ordovician. The same is true of *O. orthoforme* Flower.

Although siphuncles have not been illustrated for most of these species, the outline of the segments is known in most cases. The segments are small and relatively slender, though not quite so slender as in typical Silurian *Oonoceras,* and no organic deposits are known within the siphuncle. Some Cynthiana forms of *Faberoceras* are similar in form, but the broadly expanded siphuncles contain annular deposits.

No *Oonoceras* has yet been found in the interval from the top of the Cynthiana limestone to the Whitewater formation, where five species have been recognized. *O. rectidomum* is a small form, nearly straight, with relatively deep cameræ, found in both the lower and upper Whitewater. *O. insuetum* Flower is an anomalous species with a constricted living chamber and exceedingly shallow cameræ and a very broadly expanded siphuncle, known only from the Saluda beds. *O. fennemani* is a strongly compressed shell with the adoral cameræ shallow, in which the venter is scarcely more narrowly rounded than the dorsum. *O. shideleri* is less compressed, exhibits a venter much more narrowly rounded than the dorsum, and is a considerably larger shell, with a long series of abbreviated cameræ and a short living chamber with a preoral constriction.

O. rejuvenatum agrees with *O. shideleri* in its slender form, but is closer to *O. fennemani* in its slight curvature. It differs from both in possessing a series of abbreviated cameræ followed by normal cameræ, and a final series of short cameræ ends the sequence. Two preoral constrictions develop in the shell. All three of these species, together with a considerable number of fragments too poor for identification, occur in the upper Whitewater beds.

Oonoceras curviseptatum Flower, n. sp. Plate 13, fig. 1

Conch cyrtoconic, slightly curved, and strongly compressed. The type and only known specimen preserves one lateral surface. It expands from 58 mm. to 62 mm. in height in a ventral length of 90 mm. The width is not known at any point, but clearly the adoral width could not have been over 45 mm. The sides are strongly flattened though slightly and evenly convex in cross section, while the venter was narrowly rounded, more so than the dorsum, and probably subcuneate.

The cameræ are deeper in proportion to the shell height than in most related species, there being seven or eight cameræ in a length equal to the adoral height of the shell. In the length of the type the 11 preserved cameræ vary from 7 mm. to 9 mm. in depth as measured ventrally. The sutures form broad lateral lobes, which are convex apicad, and slope forward appreciably on the ventral side. The siphuncle has not been clearly observed, internal structure having been completely destroyed. There is a faint indication of it close to the venter where it was evidently quite small. Only the extreme basal part of the living chamber is retained in the type. Nothing is known of the shell surface, although a few poorly preserved shell fragments are retained on the type. A smooth surface is suggested but the proof of this is not conclusive in view of the poor preservation of the small fragments of the shell wall.

Discussion.—This is a large strongly compressed species, very suggestive of *Oonoceras wyomingense* (Foerste, 1935, p. 40, pl. 3, fig. 1) and approaching it both in size and in the depth of the cameræ. The sutures slope more strongly forward on the ventral side in *O. curviseptatum.* In *O. wyomingense* they are essentially transverse. Curvature of the shell is slight in both species and the section is very strongly compressed. In the extreme compression and rather deep cameræ this form is easily separated from *O. acutum* of the Cynthiana limestone. *Exomegoceras wyomingense* is perhaps approached more closely by this species than any other, but has deeper cameræ, greater curvature, and probably the cuneate condition of the venter is less marked in *O. curviseptatum.*

The large cyrtoconic shell resembles rather strongly some species of *Faberoceras.* While very little is known of the siphuncle of the present species it was evidently not only close to the venter but also very small, and further, evidently fragile. Even the simpler Cynthiana species of *Faberoceras* show siphuncles which are somewhat larger in comparable growth stages of the phragmocone, more broadly expanded, and further would be more readily preserved owing to the extensive deposition of at least annulosiphonate deposits.

Type.—Holotype, Univ. of Cincinnati Museum, No. 23972. From the collection of the Cincinnati Society of Natural History.

Occurrence.—No label accompanied the specimen upon which this species is based. Happily, however, the lithology and mode of preservation are very distinctive of the upper layers of the Cynthiana limestone as developed along the banks of the Ohio River close to Cincinnati. Since such material is best exposed on the Kentucky side, the specimen is probably from the vicinity of Covington, Kentucky.

Oonoceras planiseptatum Flower

Oonoceras planiseptatum Flower, 1942, Bull. Amer. Paleont., vol. 27, No. 103, p. 31, pl. 1, figs. 9-10; pl. 2, fig. 6.

A large species characterized by the closely spaced sutures and nearly flat septa. From the cephalopod lens of the Poindexter quarry, Cynthiana, Kentucky, in the Greendale member of the Cynthiana limestone.

Oonoceras acutum Flower

Oonoceras acutum Flower, 1942, Bull. Amer. Paleont., vol. 27, No. 103, p. 32, pl. 2, figs. 3-5.

This is a somewhat smaller and more slender species, with closely spaced nearly transverse septa and a strongly compressed cross section, cuneate ventrally. Known only from the cephalopod lens of the Poindexter quarry, Cynthiana, Kentucky, in the Greendale member of the Cynthiana limestone. (Fig. 13, F-G.)

Oonoceras (?) brevidomum Flower

Oonoceras (?) *brevidomum* Flower, 1942, Bull. Amer. Paleont., vol. 27, No. 103, p. 33, pl. 2, figs. 1-2.

This species is distinguished readily by its large size, broad section, and short living chamber. The breviconic aspect of the type has been augmented by crushing. However, slight original breviconic tendencies cause this to be slightly atypical for *Oonoceras,* and, therefore, it is referred to this genus with doubt. There is, however, little reason to believe that it is not quite closely related to associated forms. It is from the same locality and horizon as the preceding species.

Oonoceras multicameratum Flower

Oonoceras multicameratum Flower, 1942, Bull. Amer. Paleont., vol. 27, No. 103, p. 34, pl. 3, figs. 1-2.

This is essentially a smaller edition of *Oonoceras obstructum* of the Vaureal limestone, differing, however, in its smaller size, less curved sutures, closer septa, and the less pronounced constriction of the living chamber. From the same locality and horizon as the above. (Fig. 13, H-I.)

Oonoceras gracilicurvatum Flower

Oonoceras gracilicurvatum Flower, 1942, Bull. Amer. Paleont., vol. 27, No. 103, p. 35, pl. 4, figs. 3-5.

This is closely allied to *O. multicameratum* but is slightly more curved, more deeply septate, and the constriction occurs on the ventral as well as on the dorsal side of the living chamber. From the same association as the above.

Oonoceras triangulatum Flower

Oonoceras triangulatum Flower, 1942, Bull. Amer. Paleont., vol. 27, No. 103, p. 36, pl. 4, figs. 6-8.

A relatively simple small species without a preoral constriction and with a subtriangular section. The rate of expansion is gradual. From the cephalopod lens of the Greendale member of the Cynthiana limestone in the Poindexter quarry, Cynthiana, Kentucky.

Oonoceras triangulatum var. cylindratum Flower

Oonoceras triangulatum var. *cylindratum* Flower, 1942, Bull. Amer. Paleont., vol. 27, No. 103, p. 37, pl. 1, figs. 3-4.

This agrees closely with the preceding form in all features except the rate of expansion. As the name implies, the shell expands so slowly as to be nearly cylindrical. From the cephalopod lens of the Poindexter quarry, in the Greendale member of the Cynthiana limestone. (Fig. 13L.)

Oonoceras suborthoforme Flower

Oonoceras suborthoforme Flower, 1942, Bull. Amer. Paleont., vol. 27, No. 103, p. 38, pl. 1, fig. 11.

This is a small species, nearly straight, with prominent lateral lobes. From the same association as the above species.

Oonoceras fennemani Flower, n. sp. Plate 33, figs. 1-2

The type of this species is a phragmocone 94 mm. in length, very slender, very strongly compressed, but with the ventral side of the section not much more narrowly rounded than the dorsal side. Curvature is slight, the radius for the ventral profile being about 150 mm. on an average, though even greater for the basal three-fourths of the shell. Possibly the apparent adoral increase in curvature is not normal.

Expansion of the shell is uniform. In the basal 80 mm. the shell increases from 17 mm. and 23 mm. to 23 mm. and 28 mm. Lateral lobes of the sutures are poorly developed, but the sutures tend to slope rather strongly orad on the venter in the later growth stages. There are 33 recognizable cameræ which increase only very gradually in depth when traced orad. The basal 10 cameræ occupy a length of 25 mm. Near the adoral end, at an adoral shell height of 28 mm., 10 cameræ occupy 30 mm. At the extreme adoral end the cameræ are more poorly preserved, and the extreme tip of the specimen may represent the base of the living chamber.

Discussion.—This species may readily be distinguished from *O. shideleri* since it is more strongly compressed in cross section, and the venter is not more rounded than the dorsum. The curvature of the shell is less marked. The rate of expansion is more uniform. The septa are not crowded adorally, the sutures are less oblique and show a poorer development of lateral lobes in spite of the more compressed condition of the cross section. The siphuncle is poorly indicated but lies close to the venter. Its position shows that the shell has been slightly distorted, but apparently has not been greatly compressed by pressure. Several more poorly preserved fragments are assigned to this species with doubt, but are not well enough preserved for certain identification.

Type.—Holotype, collection of Dr. W. H. Shideler.

Occurrence.—Transition zone between Saluda and Whitewater, 5 miles west of Oxford, Ohio, on small eastern tributary of Indian Creek. A second specimen is from the Whitewater formation, Devil's Backbone, Camden, Ohio.

Oonoceras shideleri Flower, n. sp. Plate 33, fig. 7

This is a slender gently curved cyrtoceracone moderately compressed in section with the venter markedly more narrow than the dorsum. The type has a maximum ventral length of 80 mm. and a ventral radius of curvature of about 140 mm. It expands moderately, increasing from 19 mm. and 21 mm. near the base to 21 mm. and 26 mm. 40 mm. beyond. In the next 17 mm. the shell is more tubular, increasing to 27 mm. and 20 mm., which is followed by a constriction at least on the internal mold, and the aperture apparently lay very shortly beyond.

The living chamber has a ventral length of about 20 mm., with a basal height and width of 26 mm. and 21 mm. The phragmocone is about 50 mm. in length, and preserves at least in part, 25 cameræ. The basal cameræ are relatively deep, increasing from 2 mm. to 3 mm. in depth as traced orad. In the adoral 15 mm. of this interval five cameræ occur. Succeeding cameræ are markedly abbreviated, seven to eight occurring in the next 15 mm. and 10 in 20 mm., which together constitute the whole series of abbreviated chambers. The sutures form shallow lateral lobes and adorally tend to slope orad on the ventral side of the shell. The siphuncle has not been observed. The living chamber has a ventral length of 17 mm., a dorsal length of 18 mm., but the aperture is not preserved.

Discussion.—The type evidently represents a mature shell as judged by the preoral constriction and the shallow adoral cameræ. The species is distinctive in the curvature, the variable spacing of the septa in the growth stages, and the preoral constriction of the shell. Probably the living chamber is nearly complete, as judged from comparable species such as *O. multicameratum* of the Cynthiana limestone and *O. gracilicurvatum* of the same formation. This species is probably more closely related to these two than to any others. It is larger than *O. gracilicurvatum,* less uniform in rate of expansion and spacing of the cameræ, and less strongly curved. *O. multicameratum* is even smaller, the constriction is confined to the dorsum, and that species also is apparently uniform in the rate of expansion and lacks the long series of abbreviated adoral cameræ. In these features *O. shideleri* is apparently a gerontic manifestation of the same general stock to which these Cynthiana species belong.

Type.—Holotype, Shideler Collection, Miami University.

Occurrence.—Upper Whitewater beds, from left fork of Bensley Creek, just above bridge, north of Camden, Ohio.

Oonoceras rejuvenatum Flower, n. sp. Plate 33, figs. 8-11

This species is known largely from isolated and frequently distorted fragments. The conch is only very slightly curved, the ventral profile having an estimated radius of curvature of at least 15 mm. The cross section is compressed, the venter subcuneate. The best preserved fragment shows a width of 21.5 mm. at a height of 26 mm. The sutures show only a faint development of lateral lobes but slope increasingly forward on the venter as they are traced orad on the shell.

The shell expands only very gradually and in this respect is comparable to *O. jennemani.* Expansion of the early stages is unknown. At the region of the first series of closely spaced cameræ the shell is nearly tubular. Well orad of this lie two zones of gentle constriction, beyond which the shell is tubular to the aperture.

The basal septa are apparently widely spaced up to a shell height of about 26 mm. Here occurs a series of shallow cameræ over a length of about 7 mm. at the most, three cameræ here occupying a length of 5 mm. Orad of this for an interval of at least 25 mm. deeper cameræ occur; three are found in a length of 10 mm. Still farther orad the septa again become crowded, three to two occupying a length of 5 mm. Presumably this represents the maximum development of the phragmocone in this species. The living chamber is imperfectly known but appears to be relatively short. In one shell, a flattened specimen with a living chamber 25 mm. long, the width of the shell at the base of the living chamber is 25 mm.

The various specimens by which this species is represented suggest that even when due allowance is made for distortion by pressure, there must have been a rather appreciable amount of variation in the actual proportions of the shell, particularly in reference to the spacing and occurrence of the constrictions, and the intervals of closely spaced septa.

The least distorted specimen shows a basal height of 26 mm. and a width of 22 mm. At its base are closely spaced septa showing the free part of the septum as markedly curved. The segments of the siphuncle have a maximum diameter here of 3 mm. and are apparently broad, short, and abruptly contracted at the septa, very much as in *Manitoulinoceras.* No trace of actinosiphonate deposits can be found. The three basal cameræ on this specimen occupy a length of 5 mm. while the next three occupy 9 mm. On this specimen the dorsum is essentially straight, the venter slightly convex, contracting orad, the height decreasing in 15 mm. from 26 mm. to 24.5 mm. A more complete though badly flattened specimen shows that this contraction represents the first of the two constricted zones of the shell, presumably representing the aperture of the shell at the time of the secretion of the closely spaced cameræ. No such correlation is possible, however, for the second constriction, which is well shown on this specimen (Pl. 33, fig. 8) and which is somewhat shallower.

Discussion.—This species is erected for the reception of a number of specimens which are fragmentary and usually somewhat distorted and yet may be distinguished from the two species described above by the presence of relatively deep cameræ following a series of abbreviated cameræ. The shallow cameræ were evidently preceded by a series of normal cameræ, as in *O. shideleri,* although these are poorly shown in our material. *O. rejuvenatum* is similar to *O. shideleri* in cross section but is less strongly curved. Further, in *O. shideleri* the abbreviated cameræ occupy a much longer interval and occur at a slightly later growth stage. They occupy an interval of shell length about twice that occupied by abbreviated cameræ in *O. rejuvenatum.* In *O. shideleri* the abbreviated cameræ persist to a shell height of 27 mm. or 28 mm., while in *O. rejuvenatum* they give way to "rejuvenated" deep cameræ at a shell height of 26 mm. These small differences in shell height do, however, represent appreciable differences in the distance from the apex, for the expansion of the shell is exceedingly gradual in commensurate portions of the conch of both species.

O. fennemani is more similar to *O. rejuvenatum* in the slender form of the shell and the very slight curvature. However, this species retains normal expansion of the conch and spacing of the septa to a growth stage much later than that of *O. rejuvenatum* which is characterized by the abbreviated cameræ. Further, *O. fennemani* has a more strongly compressed section, in which the venter is much less narrowly rounded.

Types.—Holotype and paratype, collection of Dr. W. H. Shideler.

Occurrence.—From the upper Whitewater beds, Dodge's Creek, Oxford, Ohio, and from the Devil's Backbone, Camden, Ohio. Distorted fragmentary specimens tentatively placed here are from the upper Whitewater, McDill's Mills, near Oxford, and from west of Oxford, Ohio.

Oonoceras rectidomum Flower, n. sp. Plate 40, figs. 6-8

This is a small *Oonoceras* which is nearly straight. The holotype, 48 mm. in length, is compressed in section, the venter only slightly more narrowly rounded than the dorsum. The dorsal and ventral profiles are nearly straight. The sides are likewise nearly straight but show a very faint contraction in the lower part of the living chamber which may be artificial. The shell expands from 17 mm. and 20 mm. at the base to 21 mm. and 18 mm. in the 20 mm. of the phragmocone. The living chamber has a length of 25 mm. on the venter and is not quite complete elsewhere. Near the aperture it has a height of 21 mm. and a width of 18 mm. The eight cameræ of the phragmocone occupy 20 mm. and are subequal in depth. The sutures slope orad from dorsum to venter rather uniformly and have slight lateral lobes. The siphuncle, aperture, and surface markings are not shown.

Discussion.—This species is highly distinctive in the tubular nearly straight shell and the relatively deep cameræ. The holotype lacks the usual adoral contraction of the cameræ and may not be mature. However, it may be distinguished from other species by the less curved form of the shell, no associated forms being at all closely similar in this respect.

Holotype.—University of Cincinnati, No. 24484.

Occurrence.—Lower Whitewater beds, Flat Fork Creek, north of Fort Ancient, Ohio.

Oonoceras insuetum Flower, n. sp. Plate 36, fig. 5; Plate 37, fig. 8

The holotype represents the adoral portion of a compressed cyrtocone of evidently very slender form. The section is strongly compressed, the venter subangulate, the dorsum more broadly rounded. The dorsum and venter are apparently subparallel and slightly curved. The shell is faintly gibbous over the adoral end of the phragmocone, contracting to a point near the middle of the living chamber and then expanding slightly to the aperture. The ventral profile is slightly and uniformly curved. The dorsum is largely missing but is nearly straight near the aperture and may have been faintly convex over the lower part of the living chamber. The sides are convex over the adoral part of the phragmocone, constricted at the middle of the living chamber, and flaring slightly to the aperture. The shell attains a width of 21 mm. and a height of 28 mm. at the base of the living chamber, contracts in the next 18 mm. to 17 mm. and 27 mm. and expands at the aperture, in the next 15 mm., to 19 mm. and 24 mm. The aperture has a well-developed hyponomic sinus, well shown on the surface by the rather coarse lines of growth.

The cameræ are exceedingly shallow. The sutures develop lateral lobes separated by a rather low crest on the venter. The sutures are approximately normal to the axis of the shell. The 13 cameræ occupy a length of 17 mm. and are slightly variable in depth. The siphuncle lies close to the venter. The segments are short, very broad, the outlines of the segment strongly convex. Accessory calcite occurs in the section obscuring any original organic deposits which may have been there.

Discussion.—The lateral profiles of this species serve to distinguish it from other species of *Oonoceras,* the constriction of the living chamber being exceptionally prominent. The broad segments of the siphuncle suggest those of *Manitoulinoceras,* but similar segments which appear to intergrade between typical *Oonoceras* and *Oocerina* are known in Bohemian Silurian species. Among the Middle Silurian species described by Barrande no clear division is possible between those species with relatively slender siphuncles and those in which the segments of the siphuncle are broadly expanded as in this species. Unfortunately none of the associated Richmond species of *Oonoceras* have yielded good sections, though it is possible that *O. shideleri* and *O. fennemani* may have similar siphuncles. The exceedingly shallow cameræ appear to be a gerontic feature. *O. rejuvenatum* has similar cameræ though over a shorter interval of the shell. *O. fennemani* is somewhat similar in the spacing of the adoral cameræ but is less strongly compressed and differs in the shape of the living chamber, having only a faint constriction near the aperture.

Holotype.—Univ. of Cincinnati, No. 24482.

Occurrence.—From the Saluda beds, at Versailles, Indiana. Collected by the writer.

Genus **CYRTORIZOCERAS** Hyatt

Genotype.—*Cyrtoceras minneapolis* Clarke.

Cyrtorizoceras Hyatt, 1900, Cephalopoda in Zittel-Eastmann Textb. Paleont., vol. 1, 1st ed., p. 529 (reprinted with different pagination, later editions); Foerste, 1926, Denison Univ. Bull., Sci. Lab., Jour., vol. 21, pp. 316-7, pl. 35, fig. 3A-E; Foerste, *ibid.*, 1927 vol. 22, p. 52; Foerste, *ibid.*, 1930, vol. 25, pp. 27-8; Foerste, 1933, *ibid.*, vol. 28, p. 87; Foerste, 1936, *ibid.*, vol. 31, p. 50; Flower, 1942, Bull. Amer. Paleont., vol. 27, No. 105, pp. 19-21.

This genus has been used for compressed exogastric cyrtocones which enlarge rather rapidly and constantly toward the aperture. As such it has been employed for a considerable number of Silurian species. The genotype, however, is Ordovician. That species is not very well known, but there is reason to suspect that the Silurian species are homeomorphic and not actually related to true *Cyrtorizoceras* at all. The two groups of species are separated by a stratigraphic interval ranging from certainly the Richmond and possibly the Trenton to the Middle Silurian. The Silurian species are all much larger than those of the Ordovician and have living chambers which tend to become more tubular in vertical outline. The siphuncle is relatively large. The surface lacks the broad costæ of the Ordovician species, and the aperture is not contracted laterally.

The genotype of *Cyrtorizoceras* is a small cyrtocone, expanding vertically to the aperture. The shell is relatively short, the sutures with only faint lateral lobes, the dorsal and ventral saddles not conspicuous. The ventral siphuncle is slender but clearly expanded within the cameræ. Its internal structure has not been studied by sections, as the mode of preservation of the Platteville genotype is not favorable for any such study. There is, however, no reason to suspect but that the siphuncle was free from deposits. The aperture is marked by a deep hyponomic sinus. The shell expands vertically to the aperture but contracts faintly laterally over the adoral end of the living chamber. The surface of the shell bears broad rather widely spaced costæ which may be obscure or may be so strong as to suggest the costate group of species of *Zitteloceras*.

The Ordovician species which have been placed in *Cyrtorizoceras* are for the most part not typical. Aside from the genotype from the Platteville of Wisconsin, the only other Ordovician species which is fairly typical in form is *C. ellisense* Foerste of the Ellis Bay formation of Anticosti. No costæ are known on this species, which is more rapidly expanding than the genotype. One undescribed species is known to the writer from the Lowville limestone, one quite similar to the genotype in ornament and its small size. *Cyrtoceras arcticum* Schuchert which Foerste referred to *Beloitoceras* (see fig. 11 L, M) is clearly typical of *Cyrtorizoceras* rather than *Beloitoceras* in expanding rapidly to the aperture. Teichert (1930) described *C. borni* from the Lychholm beds. Strand (1934) identified this species from the gastropod limestone of Oslo and described *C. ? tenue* from the same horizon. Neither are quite typical.

No species have been found in the Cincinnati region which are typical of the genus.

As noted in the discussion of the Oncoceratidæ, *Cyrtorizoceras* is similar to *Richardsonoceras* and *Beloitoceras* and might have indeed been considered a *Beloitoceras* which failed to attain the usual gibbous living chamber, but which expanded vertically to the aperture and shows maturity only by a very late but well-marked lateral contraction of the shell. The surface markings of typical species are so similar to the ornament of *Zitteloceras* in the group of Z. *billingsi,* that it is suspected that *Zitteloceras* may have been derived from the typical Oncoceratidæ through *Cyrtorizoceras,* the essential changes being the development of a more gradually expanding shell and the increase of the faint costæ of *Cyrtorizoceras* to stronger ones. Some *Zitteloceras* still retain the abrupt lateral contraction of the aperture.

Genus MIAMOCERAS Flower, n. gen.

Genotype.—*Miamoceras shideleri* Flower, n. sp.

Conch compressed in section, venter slightly more narrowly rounded than the dorsum. The phragmocone is fairly rapidly expanding and is curved exogastrically. The living chamber is straight to the aperture on dorsum and venter but appears to contract faintly laterally. The sutures are straight and transverse. The siphuncle lies close to the venter. In transverse section the segments are shaped like those of *Danoceras,* the short recurved necks running apicad within the siphuncle slightly, the connecting rings broadly adnate to the septum adorally, then becoming free and approaching each other adapically so that they meet the next adapical septum with no area of adnation. The siphuncle shows a slight thickening of its wall at the region of the septal necks. This may be due in part to the thickness of the recurved neck, but a slight thickening of the true ring is suspected. The aperture has a moderately developed hyponomic sinus. Surface features are unknown.

Discussion.—This genus, based upon a monotype species, is strikingly different from other cyrtocones in the form of the shell. The straight and essentially tubular living chamber distinguish it from all other genera of the Oncoceratidæ. *Oonoceras,* which is perhaps closest in having a very gradually expanding shell, is cyrtoconic throughout, further the early part is as gradually expanded as the living chamber. *Richardsonoceras* and *Cyrtorizoceras* are likewise curved throughout. *Oncoceras, Beloitoceras,* and *Neumatoceras* are breviconic. The genus most similar in aspect to this one is *Kentlandoceras,* which agrees with *Miamoceras* in the curved rapidly expanding phragmocone followed by a straight tubular living chamber, but the section is circular and the venter clearly lacks a hyponomic sinus. Although the siphuncle is quite close in form to that of *Danoceras* Troedsson, the form of the shell is not. Both are compressed shells with simple transverse sutures. *Danoceras*, however, is an essentially straight shell, but seems to be allied to the endogastric *Diestoceras* rather than to the exogastric Oncoceratidæ.

Miamoceras shideleri Flower, n. sp. Plate 40, figs. 1-3

The phragmocone of this species is a compressed rather rapidly expanding cyrtocone. The living chamber, still compressed, is essentially tubular. The holotype is 75 mm. in length to the aperture, increasing from 10 mm. and 10 mm. near the base to 25 mm. and 22 mm. at the base of the living chamber in a ventral length of 46 mm. and a dorsal length of 37 mm. The living chamber has a maximum length of 30 mm., and the aperture appears to be complete laterally. The dorsum and venter are essentially straight and parallel. The shell contracts laterally over the living chamber, decreasing from 23 mm. to 20 mm. in the basal 24 mm. Laterally a very faint constriction is apparent just before the aperture, 20 to 25 mm. beyond the base. The dorsum of the type is incomplete, but the height remains 25 mm. at a distance 25 mm. beyond the base of the living chamber. The aperture curved apicad on the venter to form a broad deep hyponomic sinus, so that the ventral length of the shell is only 22 mm.

The sutures are straight and transverse. The cameræ, obscure apically, are subequal and 3 mm. in depth in the later part of the shell. The last camera is somewhat shorter, indicating the approach of maturity. The siphuncle is preserved only adorally and has been exposed by a transverse cut on the venter of the phragmocone. A segment 3 mm. long has a width at the septal foramen of 2 mm., and a maximum width near its adoral end of 3 mm. Septal necks are short, strongly recumbent, and appear to project within the siphuncle. Apicad from the neck the ring is expanded and adnate to the septum, then becomes free and the two sides of the siphuncle approach each other gradually, meeting the adapical septal necks with no area of adnation. The connecting ring shows a faint and rather erratic thickening, concentrated near but not altogether confined to the region of the septal foramen. While such a phenomenon is not common in the Oncoceratidæ it is not unknown there and never seems to develop into actinosiphonate structure or to have any relation to the more uniform thickening of the ring found in the Westonoceratidæ. The species may be distinguished from its associates by the generic characters.

Type.—Holotype, collection of Dr. W. H. Shideler.

Occurrence.—From the Saluda beds, in a small tributary of Indian Creek, about 5 miles west of Oxford, Ohio.

Genus RIZOCERAS Hyatt

Genotype.—*Orthoceras indocile* Barrande.

Rizoceras Hyatt, 1884, Boston Soc. Nat. Hist., Proc., vol. 22, p. 276; Hyatt, 1900, Zittel-Eastmann Textbook Pal., vol. 1, 1st ed., p. 529 (reprinted, later editions, with different pagination); Foerste, 1926, Denison Univ. Bull., Sci. Lab., Jour., vol. 21, p. 315, pl. 34, fig. 3A-E; Flower, 1942, Bull. Amer. Paleont., vol. 27, No. 103, p. 60.

Shell slightly compressed, expanding fairly rapidly from apex to aperture. Adoral part of shell straight, apex faintly exogastric. Hyponomic sinus developed throughout life. Sutures are essentially straight and transverse in the genotype but may develop slight lateral lobes, especially in strongly compressed species. Siphuncle close to the venter, segments cyrtochoanitic, heart-shaped, empty in the genotype. Surface with strong faintly rugose transverse markings.

The type species of this genus is from the Silurian of Bohemia. The genus is apparently a long ranging one and is represented by Ordovician and Silurian species in America, which are listed below:

R. (?) *coronatum* Foerste and Savage. Shamattawa limestone, Hudson Bay.

R. (?) *carletonense* Foerste. Black River, Ottawa, Ontario,

R. graciliforme Flower. Cynthiana limestone, Kentucky.

R. conicum Flower. Cynthiana limestone, Kentucky.

R. bellulum Flower, Lower Whitewater, Ohio.

R. (?) *atlanticum* Foerste. Gascons formation, Port Daniel, Quebec.

R. (?) Foerste. Gascons formation, Port Daniel.

R. (?) *infundibuliforme* Foerste. Gascons formation, Port Daniel.

R. (?) *lockportense* Foerste. Medinan, western New York.

R. (?) *pociliforme* Foerste. Gascons formation, Port Daniel.

Nothing is known of the internal structure of any of the species except for the Silurian genotype. It is uncertain whether this genus actually continued from the Ordovician through the Silurian, or whether, as is probably true of *Cyrtorizoceras,* the Ordovician and Silurian species represent convergent and independent lines of descent. Ordovician species are distinctive in having the shell somewhat more clearly exogastric, sometimes with a slight curvature of the apex. However, if *Rizoceras* is a persistent genus, it must have arisen from the *Oncoceras* complex, and it is not surprising that the older species should show traces of the curvature which is an inherent primitive feature in the stock. From Barrande's figures, no trace of apical curvature remains in the Bohemian genotype.

Of the American Silurian species, those from Pt. Daniel are very poorly preserved and little is known of their internal structure. The single Medinan species seems to be atypical, for it has a subcentral siphuncle composed of subspherical segments.

All of the known representatives of the genus in the Ordovician are American. Of these, three occur in the region of the Cincinnati arch, two are Cynthiana species and one is from the Whitewater. The Cynthiana species were recently described and figured by the writer, and only the reference to the descriptions and figures is given, since it contains all of the information available concerning these species.

Rizoceras graciliforme Flower

Rizoceras graciliforme Flower, 1941, Bull. Amer. Paleont., vol. 27, No. 103, p. 21, pl. 2, fig. 7.

Known only from a cephalopod bearing lens found in the Poindexter quarry at Cynthiana, Kentucky.

Rizoceras conicum Flower

Rizoceras conicum Flower, 1941, Bull. Amer. Paleont., vol. 27, No. 103, p. 21-22, pl. 1, figs. 7-8.

Found only in association with the above species.

Rizoceras bellulum Flower, n. sp. Plate 19, figs. 7-9

Conch small, rapidly expanding to the aperture, faintly curved throughout. The section at the base is circular, and adorally the height apparently becomes only very slightly greater than the width if at all, though the venter becomes slightly more narrowly rounded than the dorsum. The holotype consists of a living chamber which has been subjected to compression as the result of flattening. This shell (Pl. 19, fig. 7) expands from 15 mm. and 13 mm. at the base to a height of 23 mm. and an estimated width of 17 mm. The ventral length is 15 mm., the dorsum 14 mm., and ventro-laterally, the greatest length of 17 mm. is attained. The aperture is apparently attained, though incomplete. At the base of the living chamber is a transverse suture. The septum fails to show the position of the siphuncle. A paratype (Univ. of Cincinnati, No. 24330) represents an immature individual in which no distortion appears to have taken place. This shell is circular in section at the base, measuring 6 mm. in diameter. A width of 15 mm. is attained at the aperture in a dorsal length of 16 mm. The dorsum is slightly concave throughout in profile, though slightly less curved adorally than adapically. The adoral half of the venter is missing; 8.4 mm. above the base of the specimen the height of the shell is equal to the width but the venter is becoming slightly more narrowly rounded than the dorsum. Five cameræ and part of a sixth at the base of the specimen occupy 5 mm. on the dorsum and 7 mm. on the venter. The sutures are straight, transverse, and simple. Other features of the phragmocone are not shown. The aperture is straight laterally and dorsally and normal to the slightly curving axis of the shell.

A third specimen (Pl. 19, fig. 9) represents a vertically crushed shell comparable in size to the holotype. It increases from 11 mm. in width and 10 mm. in height to a width of 22 mm. in a length of 22 mm., and has a maximum (lateral) length of 29 mm. The seven cameræ occupy 11 mm. The venter is crushed and its features are not clearly shown.

Discussion.—This small *Rizoceras* occurs in the lower Whitewater beds and in spite of the fragmentary nature of the specimens observed thus far, can be seen to be distinct from its closest relatives of the Cincinnati area, *R. conicum* and *R. graciliforme* of the Cynthiana limestone. *R. graciliforme* is a less curved species which shows only the slightest adapical curvature and is much more slender in its rate of expansion. *R. conicum* is closer to *R. bellulum* in proportions, particularly in rate of expansion. *R. bellulum* becomes definitely compressed, a difference which might conceivably be more apparent than real, as adoral portions of the Whitewater form are known only from flattened fragments. Curvature of the dorsum of the two species differs only slightly, *R. bellulum* being somewhat more curved adapically. Perhaps a better difference is found in the living chambers, for that of *R. conicum* is considerably longer in proportion to its basal diameter than that of *R. bellulum.* Further, *R. bellulum* shows an early narrowing of the curvature of the shell in cross section on the venter which is not developed in the Cynthiana species.

Type.—Holotype and paratype, collection of Dr. W. H. Shideler. Paratype, Univ. of Cincinnati Museum, No. 24330.

Occurrence.—All three of the known specimens are from the lower Whitewater of Dodge's Creek, on the outskirts of Oxford, Ohio.

Genus ZITTELOCERAS Hyatt

Genotype.—*Cyrtoceras hallianum* d'Orbigny.

Zitteloceras Hyatt, 1884, Boston Soc. Nat. Hist., Proc., vol. 22, p. 284.
Zitteloceras Zittel, 1884, Handb. Pal., Abt. 1, Paleozoologie, Bd. 2, p. 374; Hyatt, 1894, Amer. Phil. Soc., Proc., vol. 32, p. 518; Hyatt, 1900, Cephalopoda, in Zittel-Eastmann Textb. Paleont., vol. 1, 1st ed., p. 522 (reprinted with different pagination in later editions); Grabau and Shimer, 1919, North American Index Fossils, Invertebrates, vol. 2, p. 76; Foerste, 1933, Denison Univ. Bull., Sci. Lab., Jour., vol. 28, p. 77.
Laphamoceras Foerste, 1933, Denison Univ. Bull., Sci. Lab., Jour., vol. 28, p. 76.

Description.—*Zitteloceras* consists of cyrtoconic shells, usually rather small, rounded in cross section, usually slightly broader than high with the venter and dorsum about equally rounded. The sutures are straight and transverse normally, but adorally may incline slightly orad from dorsum to venter. The siphuncle is small, close to the venter, and is composed of segments which expand very slightly within the cameræ and which are suborthochoanitic rather than cyrtochoanitic. The siphuncle is not known to contain any organic deposits. The shell surface is characterized by the presence of numerous transverse frills which are typically crenulate. In those species included under *Laphamoceras* crenulation is missing, and in the group of *Zitteloceras billingsi* the frills are replaced by distant noncrenulate annuli.

Historical notes.—The concept of the genus *Zitteloceras* has varied greatly at the hands of various investigators. The original description contains features of the sutures not present on the genotype, but probably based upon Devonian species now placed in other genera: "*Zitteloceras* nobis, includes species of arcuate Silurian and Devonian longicones with whorl in section elliptical and an external frilled layer resembling *Dawsonoceras,* but no costae, and much larger ventral sinus in the aperture, and corresponding deflections of the frilled ridges and lines of growth. Siphon is small, tubular and ventral. Sutures have ventral saddles, lateral lobes, and dorsal saddles. The living chambers are long, and apertures open. Type: Zitt. (Cyrt.) lamellosum, sp. Hall, Nat. Hist. N. Y., Vol. 1, pl. 41. Amer. Mus., N. Y."

In 1894 Hyatt only mentions the genus as a member of the Rutoceratidæ. In 1900 *Zitteloceras* appears as a member of the Halloceratidæ of the Ryticeratida. The diagnosis, though brief, indicates some change of concept: "Cyrtoceras of depressed elliptical section, the venter narrower and more gibbous than the dorsum. The layers finely frilled and closely set in the intervals between more prominent annular bands. Ordovician to Devonian."

Grabau and Shimer (1910) present a brief diagnosis paraphrasing Hyatt's description of 1900, and three species are mentioned in connection with the genus: Z. *hallianum* (d'Orbigny) = Z. *lamellosum* (Hall), Z. *billingsi* (Salter), and Z. *nereus* (Hall). The first two are Ordovician species and still include *Zitteloceras;*

the third is Devonian and is not properly a *Zitteloceras.*

Foerste (1928) described and illustrated several Ordovician species of *Zitteloceras* and later (1933) revised the genus and described and figured other species. At this time he restricted *Zitteloceras* to forms with crenulate bands or distant annular bands, placing species with closely spaced noncrenulate frills in the new genus *Laphamoceras.*

Flower (Middle Devonian cephalopods of New York, in press, New York State Museum) pointed out that *Zitteloceras* is to be restricted to cyrtoconic shells of the Ordovician which are suborthochoanitic to narrowly cyrtochoanitic and that the Devonian species which have been placed here in the past are true orthochoanitic types with tubular siphuncles which are homeomorphic with *Zitteloceras* but not related to it. A new generic name is proposed for the Devonian species formerly placed in *Zitteloceras.*

Hyatt originally proposed this genus under the name *Zittelloceras,* an error which was subsequently corrected. This change is regarded as permissable for not only is it an obvious *lapsus calami,* but a footnote in connection with the original description makes it evident that the genus was named for Zittel.

Species group of Zitteloceras.—Although a small genus, comprising 14 American and one European species. *Zitteloceras* exhibits considerable variation in surface features among the various species. Upon this basis it is possible to recognize four more or less distinct species groups which appear to be genetic units and some of these can be traced from the Middle to the Upper Ordovician.

I. Group of *Zitteloceras billingsi.*—The shell surface is marked by transverse low rounded annuli. No true projecting frills are known, and no trace of crenulation is developed. The group extends from the Black River to the Richmond and is probably more distinct from the remainder of *Zitteloceras* than any other of the groups. It contains four species:

Zitteloceras billingsi (Salter), Middle Ordovician, Paquette Rapids, Ottawa River. (See Foerste, 1932, 1933.) The age of the beds yielding this species is still not satisfactorily settled.

Originally regarded as Leray, they have recently been placed in the Rockland formation of the Trenton by Kay (1937, 1942) though without a clear exposition of the evidence leading to this change. In the opinion of the writer the beds may very easily be post-Chaumont and pre-Rockland, representing local deposition of strata in the time interval between Black River and Trenton when most of North America was probably emergent.

Z. *sinuatum* (Billings), "Leray" limestone, Black River, Ottawa, Ontario.

Z. *brevicurvatum* (Whitfield), (see Foerste, 1932, 1933) Platteville limestone, Wisconsin.

Z. *expansum* Foerste, n. sp., Whitewater beds, Richmond, of Ohio.

II. Group of *Zitteloceras hallianum*.—No annuli are present, but instead there are relatively distant and prominent transverse frills which are distinctly crenulate. No finer markings are known between the primary frills.

Z. *hallianum* (d'Orbigny) (= *Cyrtoceras lamellosum* Hall 1847, not Verneuil, 1842) (see Foerste, 1928), Trenton limestone, Middleville, New York.

Z. *beloitense* Foerste (1928), Platteville limestone, Wisconsin.

Z. *shideleri* Flower, n. sp., lower Whitewater, Ohio.

Z. *hitzi* (Foerste), upper Whitewater, Indiana.

III. Group of Z. *clarkeanum*.—Typically this group has distant rather prominent primary crenulate frills and secondary weaker and more closely spaced frills between. Where differentiation is marked between the two series of frills, the group differs from that of Z. *hallianum* only in the presence of fine transverse frills between the coarse distant ones. This difference may be more apparent than real, as some species of the Z. *hallianum* group are known from material which does not preserve the surface very clearly. In other species differentiation is not marked, and in some forms there is scarcely any differentiation of primary and secondary frills. Such species have low very numerous crowded frills and will not be confused with the Z. *hallianum* group in aspect. However, the frills become more and more numerous, and their crenulations tend to become reduced until a point is reached at which there seems to be no natural boundary between this and the following division.

Z. *clarkeanum* Foerste (1932, 1933, see also McKalvey, 1939), Platteville limestone, Wisconsin. This shows clear differentiation of the two types of frills.

Z. *percurvatum* Foerste (1928) of the Platteville of Wisconsin is intermediate in spacing and crenulation of the frills between Z. *clarkeanum* and Z. *fennemani.*

Z. *russelli* of the Waynesville beds of the Richmond of Ohio approaches *Laphamoceras* in the poor differentiation of primary and secondary frills and the great reduction of crenulation.

Z. *costatum* Teichert (1940) has prominent crenulations, but the frills are closely spaced throughout. Except for the strongly crenulated condition, the species is similar to Z. *lentidilatatum.* It is from the Drummuck group, Girvan district, Scotland.

IV. Group of *Laphamoceras.*—The surface has lost crenulations, and frills are short, simple, and very closely spaced. The type of Foerste's genus *Laphamoceras* is very close to Z. *russelli* but fails to show the faint crenulations of that species with which it agrees in curvature, rapid expansion, and general aspect.

L. tenuistriatum Hall, Platteville limestone, Wisconsin.

L. schofieldi Foerste, Platteville limestone, Wisconsin.

The first species is very similar to Z. *russelli,* not only in aspect, but in the rhythmic thickening of groups of frills over intervals of the shell rather than the thickening of individual widely separated frills. The species, except for the lack of crenulations, is closest to Z. *lentidilatatum* Foerste of the Richmond.

The nomenclatorial expression of these groups is a matter which is capable of more than one solution. If *Laphamoceras* is to be recognized as a distinct genus, clearly it will be necessary to propose a new generic name for the group of *Zitteloceras billingsi,* for that species group is much more sharply set off from *Zitteloceras, sensu stricto,* than is *Laphamoceras* itself. As tendencies in taxonomy are toward the recognition of finer divisions, this step may eventually be taken. However, at the present time it seems that the number of species is sufficiently small, that the genus is far from unwieldy, and the relationships throughout them are so evident, that subdivision of *Zitteloceras* will not bring about the nomenclatorial recognition of any important distinctions of morphological, genetic, or stratigraphic significance.

Zitteloceras has formerly been placed in the Ryticeratida, properly Rutoceratida, with orthochoanitic or supposedly orthochoanitic frilled gyroceracones of the Devonian. Instead it is a member of the complex radicle or secondarily cyrtochoanitic cephalopods which were derived from suborthochoanitic types in pre-Chazyan time. Within such cephalopods three groups were differentiated from the Chazyan onward, the Tripteroceratidæ, the Valcouroceratidæ, and the Oncoceratidæ. The Oncoceratidæ are compressed brevicones with empty more or less cyrtochoanitic siphuncles. It is from this group that several longiconic cyrtoconic types appear to have arisen. One such development is that leading through *Richardsonoceras* to *Oonoceras*, in which the segments of the siphuncle are rather broadly expanded, though variation appears in latest Ordovician and Silurian derivatives of this stock. Presumably a parallel development of a cyrtoconic type with an open aperture, but with a simpler siphuncle outline, is found in *Cyrtorizoceras*. Typical Ordovician *Cyrtorizoceras* develops costæ on the shell surface and differs from the group of *Zitteloceras billingsi* mainly in that the ridges of the surface are not quite so strong, and the cross section of the shell is compressed rather than depressed or, as sometimes is the case in this particular group of species, circular.

KEY TO CINCINNATIAN SPECIES OF ZITTELOCERAS

A. Surface without true frills but with transverse annuli
  B. Frills relatively distant, less than 15 in a length equal to the shell diameter.
    C. Crenulations prominent, shell small, very gently curved throughout, hyponomic sinus narrow and deep .... *williamsæ*

CC. Crenulations obscure or wanting.
D. Shell rapidly expanding, frills distant, 4-5 in 5 mm., crenulations wanting .... *shideleri*
DD. Shell slender, gently expanding, frills more closely spaced, about 10 in 15 mm., crenulations slight but present .... *hitzi*
BB. Frills very closely spaced, more than 15 in a length equal to shell diameter, usually 20 or more.
E. Shell very slender, essentially gyroconic, section circular, frills very short, crowded, and irregularly crenulate .... *lentidilatatum*
EE. Shell rapidly expanding, cyrtoconic, section depressed adorally with slight ventral keel. Frills separated by spaces greater than their own length, thickened in groups over shell in rhythmic intervals producing an annulated aspect, but with only vestigial crenulations .... *russelli*

Zitteloceras russelli Flower, n. sp. Plate 27, figs. 1-3

This species is known only from the type. The shell is cyrtoconic, strongly curved adapically, straighter adorally. The type expands in a ventral length of 76 mm. from 8 mm. to 25 mm. and 16 mm. The adoral part of the shell is vertically flattened by pressure. In the undistorted basal portion the shell increases from a circular section 8 mm. in diameter to a slightly depressed section 18.5 mm. wide and 16 mm. high in a ventral length of 30 mm. Here venter and dorsum are equally rounded. Adorally the venter becomes faintly keeled, and the dorsum is flattened, producing a subtriangular section. The radius of curvature of the venter is 22 mm. in the basal 30 mm. of the type, but increases adorally to about 65 mm.

The suture at the base of the specimen is apparently straight and transverse. Other sutures are not shown, and it is even uncertain how much of the type represents the phragmocone, save that the adoral 33 mm. at least pertain to the living chamber, The siphuncle lies close to the venter, but its structure has not been observed.

The type preserves the shell over almost its entire length, though in some regions the surface features are obscured by encrusting Bryozoa. Frills are developed, which are closely spaced and are thickened rhythmically giving the shell an obscurely annular appearance. Such thickenings, best shown in the middle part of the type, involve the accentuation of frills over an interval 4 mm. long, separated by a region of weaker frills about 3 mm. long. Adorally this is still continued but is less pronounced. The frills are spaced about 10 in 5 mm. near the middle of the specimen and five or six in 5 mm. adorally. Evidently the frills are very closely spaced at the base of the specimen but are so obscured by Bryozoa that their spacing cannot be measured. The frills show only the faintest trace of crenulation and are of such a nature that they appear to be intermediate between those of *Laphamoceras* and typical *Zitteloceras*. The frills are transverse dorsally, slope sharply apicad toward the apex on the ventral half, the slope being sharply accentuated to a hyponomic sinus 4 mm. wide basally and 5 mm. wide adorally.

Discussion.—This striking species may at once be recognized on the basis of the character of the surface features. Further, it is evidently larger than any other *Zitteloceras* thus far known in the Cincinnatian. The strong apical curvature of the shell and the adoral reduction of curvature are also distinctive. The species on the basis of ornament is intermediate between the group of Z. *clarkeanum* and *Laphamoceras*. From described species of both groups it may be distinguished by the faintly subtriangular section of the mature part of the shell which, though exaggerated in the type by distortion, was apparently normally slightly developed. No species of the group of Z. *clarkeanum* are known which possess annular exteriors due to rhythmic thickening of the frills in rather widely spaced groups. This appears, on the other hand to be a feature hitherto known only in *Laphamoceras tenuistriatum*, genotype of *Laphamoceras*, which, according to Foerste's excellent photographs, shows no trace of crenulations whatsoever.

Z. russelli supplies the essential evidence of the intergradation of *Zitteloceras* and *Laphamoceras.*

One other species is associated with *Z. russelli* in the Waynesville, *Z. williamsæ,* a small more gently curved species with distant crenulate frills, belonging clearly to the group of *Z. hallianum.* The species may be readily distinguished by the very different surface features.

Type.—Holotype, Univ. of Cincinnati Museum, No. 24272.

Occurrence.—From the trilobite shales of the lower Waynesville, from Stony Run, south of Fort Ancient, Ohio. The type and only known specimen was collected by Mr. Robert T. Russell.

Zitteloceras williamsæ Flower, n. sp. Plate 26, figs. 7-9, 12

This is a small gently curved species of the group of *Z. hallianum.* The type and only known specimen is a small shell 23 mm. in length, expanding in 20 mm. from 4 mm. and 3 mm. at the base in a length of 10 mm. and 6 mm. at the adoral end. The extreme basal part of the shell is covered by Bryozoa but appears to terminate in a natural rather blunt apex. The type is compressed by pressure in its present condition. Curvature is slight, the radius of curvature of the venter being about 50 mm. Nothing is known of the features of the phragmocone. The exterior of the specimen is marked by strongly crenulate frills with only the faintest lines of growth between. The frills are transverse over most of the circumference of the conch but form a narrow and rather deep and conspicuous hyponomic sinus on the venter. Adorally this is 1.5 mm. wide and 1 mm. deep. The frills are spaced nine or ten in a length of 10 mm. and do not appear to be more widely spaced adorally than adapically.

Discussion.—This species may be readily distinguished from *Z. russelli* with which it is associated by the very gentle curvature of the shell as well as by the more widely spaced and more strongly crenulate frills. In a portion of *Z. russelli* of equal proportions the frills would lack all crenulations and would be nearly twice as closely spaced. The species is allied to the group of *Z. hallianum.* *Z. hallianum* itself is somewhat more curved, has slightly more distant frills, and a broader more rounded hyponomic sinus. *Z. beloitense* has stronger but less crenulate frills and was in addition probably a much more slender shell. *Z. hitzi* has much more closely spaced frills with less strongly developed crenulations.

Type.—Holotype, Univ. of Cincinnati Museum, No. 24274.

Occurence.—From the trilobite beds of the lower Waynesville, from Clarkesville, Ohio. Collected and donated by Miss Carrie Williams of Clarkesville, Ohio.

Zitteloceras lentidilatatum Foerste, n. sp. Plate 26, figs. 13, 14

Revised description.—Shell strongly curved, very gradually expanding. The species is known only from specimens comprising parts of the last half whorl, but when complete was probably gyroceraconic rather than cyrtoconic. The type has an actual length of 98 mm., and a radius of curvature of the venter of from 40 mm. to 55 mm. The section in all specimens is somewhat distorted but was probably originally either circular or very slightly broader than high. The type increases vertically from 18 mm. at the base to 22 mm. at the adoral end.

The sutures are closely spaced, unlobed, and oblique, sloping orad from dorsum to venter. About eight cameræ occur in a length equal to an adoral shell height of 20 mm., and this relationship appears to be fairly uniform. The siphuncle has not been observed. The septa are very flat.

The surface bears numerous closely spaced transverse frills. These are spaced about 1 mm. apart though rather irregular in occurrence. They are narrow elevated frills, very short, and finely, irregularly and sometimes obscurely crenulate. There is an obscure trace of rhythmic thickening of the frills at intervals of about 6 mm. On the venter the frills slope slightly apicad to form a broad and shallow hyponomic sinus which is never a very conspicuous feature of the shell surface.

The living chamber is rather long, and probably is complete on the paratype, where it is 60 mm. in length, and increases in height from 19 mm. to 21 mm. This specimen, however, is immature, and it is possible that the length of the living chamber may be due to the destruction of some adoral cameræ of the phragmocone.

Discussion.—The very slender form, strong curvature, and fine low irregularly crenulate frills which are very close together serve to distinguish this species from all others. It is most closely related to the group of *Z. clarkeanum*. *Z. percurvatum* is close to this species in general proportions but is more rapidly expanding and has more distant frills and stronger differentiation between primary and secondary frills. *Z. russelli* of the Waynesville is a much more rapidly expanding species with crenulations which are almost vestigial.

Types.—Holotype and paratype, collection of Dr. W. H. Shideler.

Occurrence.—From the upper Whitewater beds. All of the known specimens are from Dodge's Creek, near Oxford, Ohio.

Zitteloceras shideleri Flower, n. sp. Plate 26, figs. 15, 16

This species is known only from two fragmentary specimens from the lower Whitewater. The shell is gently curved, with a radius for the ventral profile of about 60 mm., and expands in 10 mm. from 8 mm. to 12 mm., the section being circular. The septum at the base of the living chamber which is the holotype is straight and transverse. The frills of the surface are rather widely spaced, seven occurring in the length of 10 mm., and show no finer markings between. The frills are not crenulate on the dorsum, and only vestigial crenulations can be seen on the ventral side. The hyponomic sinus is relatively narrow, deep, but distintly rounded at the center and U-shaped rather than V-shaped.

Apparently the living chamber described here is not from a mature shell, as a phragmocone 17 mm. long expanding from 6 mm. to 13 mm. appears to belong to this species. In this form the cameræ occur six in a length of 10 mm.

Types.—Holotype and paratype, collection of Dr. W. H. Shideler, Miami University.

Occurrence.—Both of the known specimens are from the *Tetradium* zone of the Saluda, the holotype is from Dodge's

Creek, near Oxford, Ohio, the paratype from Hannah's Creek, near Liberty, Indiana.

Zitteloceras perexpansum Foerste, n. sp. Plate 26, figs. 10, 11

The single representative of this species known is a portion of a rapidly expanding exogastric cyrtoceracone, slightly broader in section than high. The holotype is 26 mm. in length on the venter, the adoral 10 mm. representing a nearly complete living chamber. The ventral profile has a radius of curvature of 40 mm. The shell enlarges from 9.5 mm. at the base to 18 mm. in a basal ventral length of 22 mm., the cross section being circular at both points.

The sutures are straight and without any lobation. Near the base of the type they are transverse to the shell axis, but farther orad they slope forward from dorsum to venter, making an angle of 15 degrees with a plane transverse to the shell axis. At a shell diameter of 17.5 mm. four cameræ occupy a length of 8.5 mm. on the venter. The siphuncle is not shown.

The surface of the shell bears transverse narrow low annular raised lines. Basally five occur in a length of 4.5 mm.; adorally five occur in 5 mm., and at the extreme adoral end the lines become obscure after the appearance of a single very prominent band. This is believed to be gerontic. As seen from the venter, the lines curve apicad toward the venter so that they are convex adorally and form a subangular V-shaped hyponomic sinus. The curvature of the annuli occupies the entire ventral surface of the shell, and the depth of the sinus is 2 mm.

Discussion.—This species belongs to the group of *Zitteloceras billingsi* and may be distinguished from species of other groups by the annular character of the surface markings. The three other members of this group are all more gradually curved, more gently expanded, or both. Z. *billingsi* is smaller, more slender, and is faintly compressed in the later part of the shell. Z. *sinuatum* is more slender, more curved, and has more distant and more prominent annuli. Z. *brevicurvatum* is a much more slender and a much more strongly curved species.

Type.—Holotype, collection of Dr. W. H. Shideler.

Occurrence.—From the lower Whitewater beds. Thus far the species is known only from Little Four Mile Creek, near Oxford, Ohio.

Zitteloceras hitzi (Foerste) Plate 26, figs. 1-6

Cyrtoceras hallianum Cornett, 1874, Indiana Geol. Surv., Rep. 6, p. 183; Kindle, 1898, Indiana Dep. Geol. Nat. Res., Ann. Rep. 22, p. 476; Cumings, 1907, Indiana Dep. Geol. Nat. Res., Ann. Rep. 32, p. 1028.

Cyrtoceras hitzi Foerste, 1910, Denison Univ. Bull. Sci. Lab., Jour., vol. 16, p. 78, pl. 1, figs. 7A-B; pl. 2, fig. 23A-C.

This is a small gently curved species, the largest known shell attaining a length of 33 mm. and a shell diameter of 10 mm. The section is circular. The shell expands gently. One hypotype represents an apical portion. The tip is blunt, the shell assuming a diameter of 2 mm., 1 mm. from the apex. In a ventral length of 14 mm. the shell attains a height of 7 mm. and a width of 4 mm. but is compressed by pressure. The radius of curvature of the ventral profile is about 40 mm. Evidently the conch became more slender and less curved farther orad as a hypotype representing a living chamber increases from 4 mm. to 8 mm. in a length of 12 mm. and has a radius of curvature of at least 60 mm. The features of the phragmocone are poorly known. The septum is straight and transverse at a shell diameter of 4 mm. and is shallow, nearly flat. The siphuncle is minute and close to the venter.

Transverse frills mark the surface. From 12 to 15 occur in a length of 5 mm. at a diameter of 4 mm. Adorally they are more widely spaced, seven occuring in 5 mm. at the adoral end of the first hypotype, while on the second seven also occur in a length of 5 mm. at a shell diameter of 8 mm. The frills are short, sharply elevated, and very faintly crenulate. The hyponomic sinus is narrow, less than one-third as wide as the entire shell, and is faintly rounded.

Discussion.—This species is confined to the Hitz layer of the Saluda at Madison, Indiana, and is evidently very rare there. The species is one which is small and which becomes very gently curved in the later part of the shell. It may be distinguished from the somewhat similar *Z. williamsæ* by the shorter and more closely spaced frills; further these frills are not so strongly crenulated as in the Waynesville species. Of the three hypotypes available, one is much larger and more complete than the holotype. Unfortunately, this shell is so encrusted with *Dystacospongia* that it was hardly worth figuring, and indeed its ornament was only obscurely preserved. The two additional hypotypes show vestigial crenulation much better than did the holotype.

Types.—Holotype, U. S. National Museum, No. 78816. Hypotypes, Univ. of Cincinnati Museum, No. 24273 and collection of Dr. W. H. Shideler, one specimen.

Occurrence.—Known only from the Hitz bed in the uppermost layers of the Saluda at Madison, Indiana.

FAMILY VALCOUROCERATIDÆ Flower, n. fam.

The Valcouroceratidæ are comprised of exogastric cyrtoceracones with ventral cyrtochoanitic siphuncles. In section they are primitively compressed and subtriangular, and even when the compressed condition is modified, the section is subtriangular, with a flattened dorsum and a venter which is narrowly rounded and sometimes acute. The family is differentiated from the Oncoceratidæ by the presence of actinosiphonate deposits within the siphuncle. It comprises one of the three groups of secondarily cyrtochoanitic cephalopods which were presumably developed from suborthochoanitic stenosiphonate cephalopods not long before Chazyan time. It is closely allied to Oncoceratidæ, being distinguished from it first by the development of actinosiphonate deposits, and secondarily, by the marked tendency in the family toward the broadening of the section of the shell. The Allumettoceratidæ consist of primitively depressed nearly straight cephalopods and are less closely allied. Superficially the anomalous genus *Diestoceras* might be considered as similar to the Valcouroceratidæ in the development of actinosiphonate deposits in a marginal ventral cyrtochoanitic siphuncle. However, as noted elsewhere, (Flower, 1943, pp. 64-66) actinosiphonate structure is too broad a generalization and may have no genetic implications within itself. The deposits of *Diestoceras* are discrete, irregular, and quite unlike those of the Valcouroceratidæ. Similarity of early stages of *Diestoceras* with *Valcouroceras* suggest a relationship. Yet *Diestoceras* and *Danoceras,* being essentially endogastric shells, are properly placed in a distinct though probably allied family, the Diestoceratidæ. The early stages of the Valcouroceratidæ, Oncoceroidea, and Allumettoceratidæ all agree in showing suborthochoanitic siphuncular segments, as observed in largely undescribed Chazyan material. The Discosoroidea are apparently quite distinct as an Ordovician group which shows no trace of suborthochoanitic early stages, and therefore must represent either as independent and possibly much older development of cyrtochoanitic structure, or else a case in which ancestral stages have not been retained in the ontogeny. That group is further differentiated by the thickening of the connecting ring and the nature of the deposits which develop within the siphuncle.

Although simple actinosiphonate deposits occur throughout the Valcouroceratidæ, the genera which constitute the family show so much divergence in almost all other features that it is impossible to present a succinct description which will be at the same time sufficiently detailed to be useful and also reliable. The same difficulty is encountered in the definition of the major divisions of the Brachiopoda and is one which is to be expected in any major genetic unit within which form deviation is rife. Relationship within the family is based mainly on the intergradation of genera, rather than on strict morphological uniformity. For this reason, the relationships within the family are best explained by tracing its evolution.

Development of the Valcouroceratidæ.—The essential features of the six genera here placed in the Valcouroceratidæ are illustrated in text figure 14. The family makes its appearance nearly contemporaneously in the Chazyan of the Champlain Valley and that of the Mingan Islands, where it is represented by several species of *Valcouroceras* Flower.

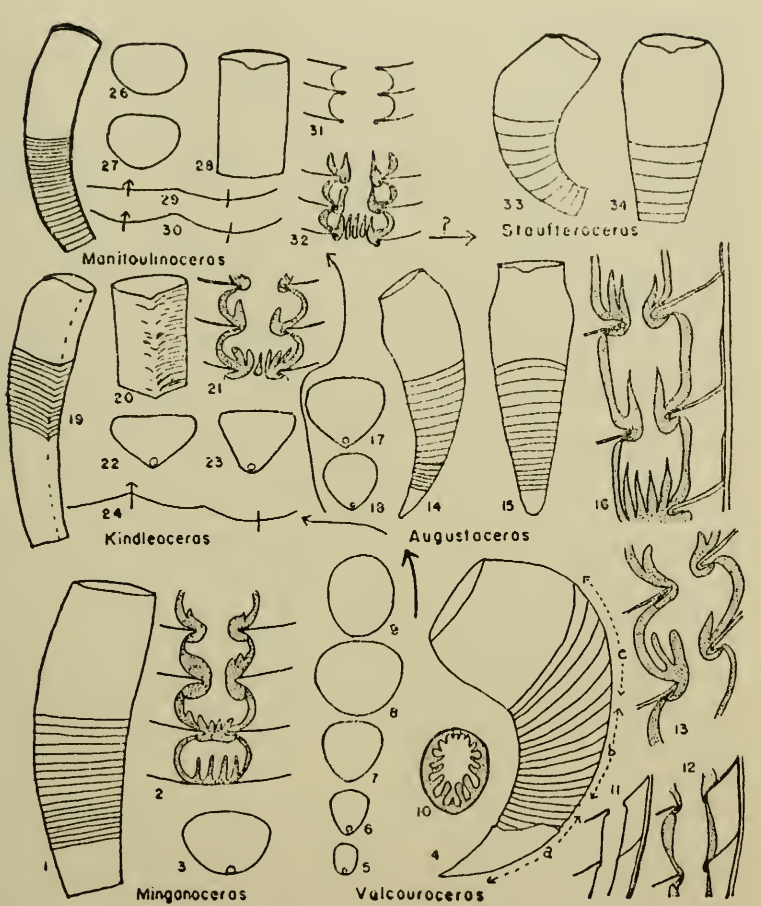

Figure 14. The principal genera of the Valcouroceratidæ and their relationship. 1-3. *Minganoceras.* 1, lateral view; 2, section from venter of siphuncle cutting to different levels in different segments; 3, diagrammatic cross section. Based upon *Minganoceras subturbinatum* (Billings) of the Mingan formation. 4-12. *Valcouroceras.* 4, lateral view of a typical species; 5-7, three successive sections showing the modification of the section in the phragmocone of a large mature specimen; 8, section shortly beyond the base of the living chamber of the genotype; 9, cross section near the aperture of genotype; 10, cross section of siphuncle showing symmetry of actinosiphonate lobes; 11, suborthochoanitic stage of siphuncle, found in early stages (a on fig. 4); 12, second stage of siphuncle, found approximately in region b on fig. 4. 13. Mature segments of a typical large species, found in region c as indicated on fig. 4., the only stage with well-developed rays within the siphuncle. 14-18. *Augustoceras.* 14, lateral and 15, ventral views of the internal mold of a typical form; 16, vertical

section through siphuncle; 17, mature cross section; 18, compressed cross section, found only in *A. minor*. 19-24. *Kindleoceras*. 19, lateral aspect of *K. equilaterale*, the only species known to show a contracted aperture; 20, ventral view of a typical living chamber, from *K. cumingsi;* 21, section through siphuncle, showing actinosiphonate deposits; 22, cross section of *K. cumingsi;* 23, cross section of *K. equilaterale*. Obliquity is probably due to slight distortion; 24, projection of suture, from *K. equilaterale*. 25-32. *Manitoulinoceras*. 25, lateral aspect of a typical form, showing relative rapid expansion and deep cameræ of early portion, and slender later portion with shallow cameræ; 26-27, cross sections showing range of variation from subtriangular to a simple depressed section; 28, ventral view of living chamber, showing hyponomic sinus; 29-30, projections of sutures, showing variation in development of a lobe on the venter; 31, typical siphuncle as seen in section; 32, section of a siphuncle retaining actinosiphonate deposits. 33-34. *Staufferoceras*. 33, lateral view; 34, ventral view. Differs from *Manitoulinoceras* in gibbosity and contracted aperture. The deep cameræ and the fairly rapid expansion of immature *Manitoulinoceras* is retained throughout the early normal growth stage.

Minganoceras (text fig. 14: 1-3) is known only from *M. subturbinatum* (Billings) which insofar as the writer is aware, is known only from a single specimen. The shell is a slender cyrtocone, broader than high, and with the venter more narrowly rounded than the dorsum. The sutures are simple and transverse. The siphuncle is broadly cyrtochoanitic and contains simple actinosiphonate deposits. The section shown in fig. 14: 2, passes nearly through the center of the siphuncle at its dorsal end, but passes obliquely closer to the margin adapically, thereby showing more clearly than would otherwise be possible the rays of the deposit.

Valcouroceras (fig. 14: 4-12) seems more complex, probably because it is better known. The shell is more curved, and the living chamber more gibbous. The sutures are usually oblique, sloping strongly orad from dorsum to venter. The section varies in the growth stages, being first a simple compressed section (5), later becoming flattened on the dorsum (6), and then widened (7). At or slightly orad of the base of the living chamber, the subtriangular aspect of the cross section may be lost (8), though the shell in such cases is generally compressed at the extreme aperture (9).

Valcouroceras shows in the earliest growth stages compressed cyrtoconic shells with suborthochoanitic ventral siphuncles (fig. 14: 4, 5, 11). In the very earliest growth stages observed, it is not always possible to identify the genus or even the family with absolute certainty, as the condition is practically identical with that found in commensurate portions of the associated *Beloitoceras, Oncoceras,* and *Richardsonoceras.* This strong similarity of stages presents convincing evidence for a common origin of the Oncoceratidæ and the Valcouroceratidæ from suborthochoanitic exogastric cyrtoceracones which were probably a pre-Chazyan but apparently a post-Beekmantown development[12]

Later segments of *Valcouroceras* show a gradual increase in the degree to which the siphuncle is expanded within the cameræ. Further, as might be expected, there is a direct connection within any species between the growth stage of the siphuncle to be found at any point with the shell diameters at the point where a section is taken for observation. This is the condition to be expected within a species where ontogeny follows a normal tachygenetic course. However, *Valcouroceras* shows this correlation not only within specimens of a species, but also among the known species which vary considerably in size. Thus species which are small and in which shell growth stopped relatively early have only narrow segments as in fig. 14: 12, and fail to attain the broader segments which are found only in the latter part of the phragmocone of the larger species which underwent a longer ontogenetic development. Further, there is in these Chazyan species no fixed interval of the shell which may be called ephebic, and in which the structure of the siphuncle is uniform in outline through any appreciable series of cameræ, except possibly in the latest growth stages of some of the largest species.

Precisely the same relationship holds for the development of

[12] The suborthochoanitic stages indicate a common origin of the families not very much earlier than Chazyan. Indirect stratigraphic evidence in support of this is found in our failure to recognize any such cephalopods in the Canadian as yet. While this supporting evidence is purely negative, it is at least convincing in view of the well-defined retention of early suborthochoanitic stages in both the Oncoceratidæ and Valcouroceratidæ in the Chazyan. Further, such stages are less well developed in Middle and Upper Ordovician representatives of both groups and are in these periods suppressed, partially or completely by tachygenesis.

actinosiphonate deposits with reference to the shell regions, which applies to the form of segments of the siphuncle. Early segments in the suborthochoanitic stage lack all trace of organic deposits (fig. 14: 11). The connecting ring becomes thicker, as it is traced orad through increasingly expanding segments, and at length a stage is reached in which the thickened ring sends out lobes or rays which bring them into the form category of actinosiphonate structures (fig. 14: 10, 13). The form and significance of these deposits have been discussed elsewhere for *Valcouroceras* with proper illustrations (Flower, 1943, pp. 40-43) and need not be duplicated here.

Although *Valcouroceras* appears from the above discussion to be much more complex than *Minganoceras*, this may be in part because the genus is much better known. I regard it as the more primitive of the two for two reasons. First, the broad cross section of *Minganoceras* is duplicated in the mature living chamber of *Valcouroceras*, while in the early stages *Valcouroceras* has the compressed section and simple siphuncle of the simpler and almost certainly more primitive Oncoceratidæ. This, of course, implies the assumption of tachygenesis, but aside from the fact that tachygenesis fits these morphological features and offers a clear interpretation of them, there is stratigraphic evidence. Secondly, *Valcouroceras* is known from strata slightly older than those containing *Minganoceras*. Although mainly known from the *Glaphurus pustulatus* fauna of the Valcour limestone, which is the equivalent of the beds carrying *Minganoceras*, it is also developed in the middle Chazyan and possibly in the lower Chazyan.[13]

The plasticity of the form of the segments of the siphuncle and also of the development of actinosiphonate deposits is essentially a primitive feature. Inasmuch as there is already some specializa-

[13] One undescribed form is listed as lower Chazyan. This specimen is labeled as the Chazyan of Valcour Island and is in the collections of the New York State Museum. I regard the horizon as open to some question in view of Raymond's demonstration that the Valcour Dock section of Ruedemann (1906) originally regarded as lower Chazyan, is middle Chazyan in age, a conclusion subsequently accepted by Ruedemann. This alteration in correlation may also affect supposedly lower Chazyan beds in the nearby Valcour Island section.

tion in *Valcouroceras* itself, it is not surprising that the correlation between the ontogenetic stage and actual size, as measured in terms of the height of the whorl, is not quite perfect, but departures from this correlation are always slight, and there is a significant absence of a long series of essentially uniform ephebic cameræ preceded by cameræ in which there is a rapid ontogenetic progression.

The next genus of the *Valcouroceratidae*, *Augustoceras*, is more normal in its ontogenetic progression. The ontogenetic progression in the siphuncle, both in relation to the form of segments and the development of the deposits, is confined to such very early stages, and such small ones, that ontogeny of the outline of the segment has not been fully observed, and only rarely is there evidence of an adapical simplification of the actinosiphonate deposits. Instead, throughout most of the phragmocone the actinosiphonate deposits are found in a series of uniform more or less barrel-shaped segments, which are relatively much narrower than any of the segments of *Valcouroceras* which have ever yielded well-developed deposits. However, segments not unlike those of *Augustoceras* are found in *Valcouroceras* between the stages represented by subfigures 12 and 13 of text figure 14, but they never have well-developed rays. In form *Augustoceras* looks quite unlike *Valcouroceras*. The shell is gently curved, but is fusiform rather than gibbous anteriorly. The living chamber is less strongly inflated near its base and much less strongly contracted orad. Indeed, some living chambers in this genus may be almost tubular. A further specialization is seen in the development of a small hyponomic sinus, a feature absent in both *Valcouroceras* and *Minganoceras*. The cross section is subtriangular (figs. 14: 17-18) the first figure showing the condition in the genotype, in which the whorl is as broad as high, while the second shows the compressed section in the smallest of the known species, *A. minor*. Tendencies toward compression of the section are found in the earliest stages of *A. shideleri* and *A. medium*. The deposits of the siphuncle are discussed more fully below in the description of the genus. *Augustoceras* is as yet known only from the Covington, being best developed in the Leipers but also occurs in the equivalent Fairview. It is doubtfully developed in the Eden, and rather strangely, has not been recognized in the Cynthiana or Cathys, which contains so many close relatives of Leipers cephalopods of other genera.

Kindleoceras and *Manitoulinoceras* show a further progression toward the development of shells which tend to be slender and essentially tubular adorally instead of gibbous, and further agree in that the ephebic segments of the siphuncle are short, and so very broad at the septal foramen that the convex connecting rings cause much less relative expansion of the segment within the camera than was the case in any of the earlier genera.

Kindleoceras, which can be traced from the Cynthiana to the Richmond, is a curved, or sometimes essentially straight shell of strongly triangular section. Figure 14: 19 is a lateral view of *K. equilaterale,* the only species known to show any contraction of the mature aperture. The cross section of this same species is shown in figure 14:23 in contrast to the broader section of *K. cumingsi* of figure 14:22. Figure 14:21 shows the form of the segments of the siphuncle and the actinosiphonate deposits as noted in *K. cumingsi.* The rays are shorter and more numerous than in *Augustoceras.*

Manitoulinoceras agrees with *Kindleoceras* closely in the form of the segments of the siphuncle, but in other respects is clearly the result of an independent development. The shell in general tends to remain more strongly curved. The aperture is open, the section tends to become a depressed oval, and while the dorsum is always somewhat more flattened than the venter, the shell is never strongly triangular. (Figure 14:25-30.) A peculiar feature is the tendency toward suppression of actinosiphonate structure, in that actinosiphonate deposits have been observed only in two specimens of the genus, indicating that it is not only delayed until the approach of gerontism, a not uncommon feature in itself, but that it is apparently confined to relatively early portions of the phragmocone, and is never the universal structure that it is in *Augustoceras. Kindleoceras equilaterale* shows somewhat similar though less strongly marked tendencies.

Staufferoceras (figure 14:33, 34) is like *Manitoulinoceras* in cross section but is gibbous adorally. It has the deep cameræ and rapid expansion noted in the early stages of typical *Manitoulinoceras,* but lost adorally in typical species, though retained in some others. Its internal structure is not known, and its position in the Valcouroceratidæ is therefore not definitely established. I place it here tentatively on the basis of its strong affinities with *Manitoulinoceras.*

The actinosiphonate deposits of the family consist first of all in a thickening of the connecting ring. From this arise processes in each segment extending toward the center of the siphuncle. These processes arise from a pronounced thickening of the adapical end of the ring within the septal foramen, thin orad, and also become shorter orad in each segment. Further details are discussed under the genus *Augustoceras,* as they have been observed there more fully than anywhere else in the family. Indeed, the genus has provided material for a more complete examination of its siphuncle than any other actinosiphonate nautiloid up to the present time.

Genus **AUGUSTOCERAS** Flower, n. gen.

Genotype.—*Augustoceras shideleri* Flower, n. sp.

Conch a slender exogastric cyrtoceracone somewhat fusiform in vertical outline, subtriangular in cross section. Expansion is rapid in the initial portion, gradual over the greater part of the phragmocone. The shell then becomes faintly gibbous and may contract gradually to the aperture, or the adoral end of the living chamber may be produced and essentially tubular. In section the shell is strongly flattened dorsally and the venter is subangular so that the section is subtriangular. The shell is as wide as high and may be slightly depressed ephebically. Only in the early stages of one species, *A. minor,* is the primitively compressed condition of *Valcouroceras* retained. The sutures are rather closely spaced, and they tend to slope orad from dorsum to venter, without, however, the development of clear lateral lobes. The siphuncle is close to the venter. Owing to the obliquity of the septa close to the venter, the septal foramen is very slightly compressed. The septal necks are short, recurved with free short brims. The connecting ring expands abruptly from the brims, soon attaining the maximum width of the siphuncle. Thereafter the sides of the siphuncle may be subparallel, straight or forming segments slightly concave in the middle, or faintly convex and approach each other very gradually apicad. Near the adapical end of the segment the siphuncle contracts rapidly so that the rings meet the adapical septa with no real area of adnation. Deposits are simple actinosiphonate outgrowths of the connecting rings, and their morphology is discussed in detail below.

The living chamber is slender, elongate, contracting slightly or tubular to the aperture which is more strongly inclined orad from dorsum to venter than is the plane of the last septum. Ventrally the course of the aperture is modified by a slight hyponomic sinus. The surface of the shell bears only fine transverse sometimes faintly rugose lines of growth which reflect the hyponomic sinus throughout.

Discussion.—*Augustoceras* is closely related to *Valcouroceras*, from which it differs mainly in the relatively slender siphuncular segments which are combined with actinosiphonate deposits. Both features are nearly uniform throughout the greater part of the phragmocone. Externally and also in gross internal features, there are no very fundamental differences between the two genera, although they are not strikingly similar in aspect, owing to the fusiform rather than breviconic shape of *Augustoceras*, the development of a slight hyponomic sinus, and the broadening of the cross section.

Wetherbyoceras Foerste, as noted under the discussion of that genus, was described on the basis of a species which cannot be recognized in the absence of the missing holotype, and which might even prove to be unrecognizable if the holotype is found. Nevertheless it is clear that the material which Foerste had in mind in describing *Wetherbyoceras* has all of the essential features of *Augustoceras*, except that the living chamber was not known, and is clearly to be considered congeneric with the species included under this new name. *W. conoidale* is essentially an unknown species, and, therefore, no other species can be placed with certainty in the genus of which it is the type. From the point of view of clarification of the species, this is not so unfortunate as it might at first appear. *W. conoidale* and also *Augustoceras* (?) *vallandighami,* both of which Foerste included in his genus, are based upon such small fragments of phragmocones, that specific identification is extremely difficult, and it would be uncertain which of the four Leipers species, known from relatively complete undistorted specimens, should properly be included under those names.

At the present time *Augustoceras* is definitely known only from the Leipers formation of southern Kentucky and Tennessee and from the equivalent Fairview of Cincinnati. One small species from the Southgate shales of the Eden is doubtfully placed in *Augustoceras,* but is so poorly preserved internally that its generic position cannot be demonstrated, and I have included this form only as *Augustoceras* (?), sp. The genus attains a prolific development in the Leipers formation as exposed on the Cumberland River of Rowena, Kentucky. Here are found *A. shideleri, A. medium, A. commune,* and *A. minor.* In the Fairmount of Cincinnati, *Cyrtoceras vallandighami* is reported. I have reproduced the original figure and description of this species, which cannot be recognized with certainty. Such material as is available for *Augustoceras* in the Fairmount is so fragmentary and so poorly preserved internally, that specific identification is usually impossible, and in only a very few specimens are the essential features of *Augustoceras* demonstrable. The species *vallandighami* is very poorly known, and the name has obviously served as a receptacle for any small fragmentary cyrtoceracones from the lower part of the Covington. It is uncertain whether the Cincinnati specimens represent a species distinct from those of the Leipers, or whether any, or possibly all of the contemporaneous Leipers species may have drifted occasionally into the Cincinnati region proper. The fragments do, however, suggest that more than one species is present in the Fairmount of the Cincinnati region.

Augustoceras is known at the present time only from these species of the Cincinnati-Nashville region. The boreal faunas have yielded no material as yet showing the essential features of the genus. *Wetherbyoceras? contractum* Miller (1932, p. 287, pl. 28, figure 3) may or may not be an *Augustoceras,* a point which can be determined only by an examination of the interior of the siphuncle. Unfortunately the Bighorn formation which yielded this specimen is a very poor medium for the preservation of such morphological details. Miller reports that the segments of the siphuncle are globular, a feature which is at variance with *Augustoceras* and which suggests that the species in question may belong elsewhere.

Morphology of actinosiphonate deposits.—(Text figs. 15-17) Pl. 19, fig. 10; Pl. 20, figs. 1-7. The deposits within the siphuncle of *Augustoceras* consist first of all of a much thickened connecting ring, from which there develops in each segment a series of vertical tabulæ which in cross section are more or less clavate, tending to be rounded and stightly inflated at their tips. These converge toward the center but always terminate without meeting. Although in many sections the rays may appear to pass from segment to segment, they are actually discrete segmental structures, as are the connecting rings from which they arise. In general the rays are poorly differentiated from the thickening of the connecting ring at the adapical end of the segment, essentially within the septal foramen, and gradually become more distinct orad, being rather well separated from the main mass of the thickened ring in outline. As they are traced farther orad in the segment, they tend to become shortened and terminate where the adoral end of the ring is reached, at the tip of the septal neck. Orad from this region will be found the massive adapical end of the next adoral deposit, for it springs from the connecting ring which extends within the septal neck to or nearly to its tip. This relationship is shown clearly in the adoral end of the section on Plate 20, figure 7, in the upper two of the complete segments shown there and is better developed on the left than on the right side of the siphuncle. Plate 18, figure 10 shows the only section so far observed which cuts the planes of rays on both sides of the siphuncle.

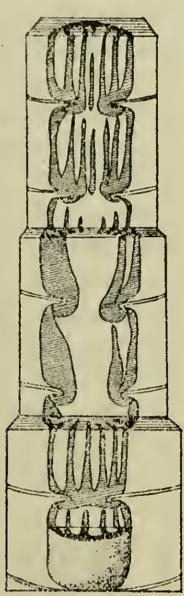

Figure 15. Block diagram of a siphuncle of *Augustoceras*. At the base, part of the wall of the siphuncle is shown. This is followed by a region which has been cut to a plane deep enough to pass through the septal foramen, but not deep enough to pass through the actual cavity of the siphuncle, passing instead through a portion of the greatly inflated connecting ring. Note the secondary fusion at this level of the originally discrete segment deposits. The middle section is taken approximately at the middle of the siphuncle. On the left the plane of the section coincides with the plane which is the axis of one of the rays, and here as in the upper portion of Plate 20, figure 7, the discrete nature of the deposits is apparent. On the right the section fails to coincide with plane of a ray and instead intersects one radial ray which meets it at an angle of about 20 degrees. The upper longitudinal section is slightly oblique, but nearer the center than the first section shown at the base of the diagram. The ray at the center of the cross section at the top becomes longer adapically and so intersects the plane of the section at the adapical end of the segment. No attempt is made to take into account additional complexities of the section due to the slightly clavate character of the rays.

Because the rays of the deposits are radial, only one section, that passing through the planes which are axes of the rays on both sides of the siphuncle, will show the simplest possible condition of the rays in section. This rarely occurs unless a section is ground deliberately for such a purpose, and even then the plane will not usually cut the axes of the rays on both sides of the siphuncle.

Casually made sections, whether natural or artificial, will usually cut through a number of the radially converging rays. This phenomena is well shown and also partially explained by the accompanying text figure. Complications arise from the slight inflation of the tips of the rays. This increases the area of the tips, and therefore, increases the probability that a section will intersect them. Further, in any given section of a ray, the part of the section which intersects the tip of a ray will show a broader area of organic material than that which cuts the narrower stem of the ray. Because the intersection of a plane along which the specimen is ground with the radially converging rays, will vary in pattern much from one level to another, the aspect of sections or even of casual serial sections may produce the impression of a disorderly array of converging elements. Such irregularities are shown in the three sketches of text figure 16.

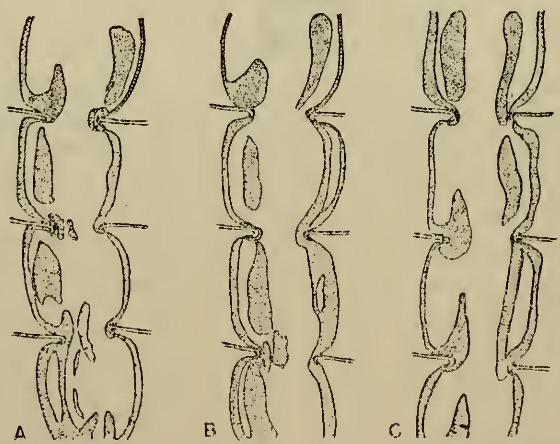

Figure 16. Sketches of serial sections of *Augustoceras shideleri*. The three figures, A, B, and C, pass progressively closer to the center of the siphuncle.

The appearance of the cross section varies with its position in the segment. At the adapical end of the deposit, within the septal foramen, the organic deposit is massive and individual rays are not well developed. Figure 16B shows such a section in which a median ventral ray flanked by two smaller pair occupies the venter. Two more irregular rays are seen on the dorsum. Figure 16A is a section of the same specimen taken slightly farther orad in the siphuncle, showing the better and more equal development of the rays. Farther orad in the expanded part of the siphuncle, sections are more regular radially. Such sections are illustrated in Plate 20, figures 1, 2, and 4. Figure 3 is one taken close to the septal foramen but actually at the point at which the segment expands rapidly. This section is somewhat oblique, the lower part, as oriented in our figure, passing through the more expanded region, the upper part being in the constricted region at the septal foramen.

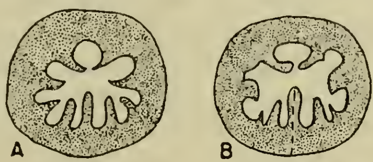

Figure 17. Cross sections of *Augustoceras shideleri.* A. Slightly orad of center of septal foramen. B. Section at septal foramen. Note massive deposit, in which the rays are poorly differentiated but clearer ventrally than dorsally.

No clear ontogenetic progression of the deposits has been found analogous to that noted in the development of annulosiphonate deposits in the Michelinoceratidæ, Pseudorthoceratidæ, and Actinoceroidea. In those groups owing to the serial repetition of alterable parts, the youngest adoral deposit shows the earliest growth stage in the adoral part of the phragmocone, and as successive deposits are traced apicad, older units are encountered which show later growth stages. As noted in other actinosiphonate deposits (Flower, 1943, also 1939) the absence of such an adoral region of growing deposits indicates that the actinosiphonate structures must have been formed rapidly throughout the siphuncle, and in most instances, this development seems to have occurred relatively late in life and might even be considered an early gerontic feature. Whether this is so in *Augustoceras* it is impossible to say, for while abundant material was available consisting of isolated phragmocones, specimens complete enough to show whether they were immature were very limited. The almost universal occurrence of deposits throughout the series of some 60 specimens suggests that maturity here may not be an essential factor, for certainly some of these fragmentary specimens must have represented immature individuals. In no case was there any clear adoral ontogenetic progression. A few sections showed a faint trace of a thinning of the rays in the last two or three cameræ. but apparently no significant morphological variations occur there.

Adapically the deposits have been observed as thinning rapidly when traced to the extreme apical portion of our specimens, and at length a point is reached in which the rays are reduced, and also the lining of the siphuncle, a thickening of the connecting ring, is also reduced. This is shown in Plate 20, figure 5. Evidently, as in *Valcouroceras,* the earliest segments never develop deposits. Later segments develop only a thickening of the primary ring, and in the following three or four cameræ there can be traced a gradual development of rays, after which the deposit is uniform over the remaining part of the phragmocone, which is the greater portion of it and the portion which is most commonly observed.

Augustoceras shideleri Flower, n. sp.
Plate 18, figs. 1-10; Plate 19, fig. 14; Plate 20, figs. 1-7

This is a relatively large species which when complete was a cyrtocone about 90 mm. in length. Curvature is slight, the radius of the ventral profile being about 50 mm. up to a point near the base of the mature living chamber where the shell height is 23 mm., becoming less curved and then resuming its normal curvature to the aperture. The shell is slender. the section is flattened on the dorsum at the earliest stage assigned to the species with certainty. The shell expands from 11 mm. to 19 mm. and 19 mm. in a ventral length of 35 mm. and a dorsal length of 24 mm. Farther orad the shell becomes more triangular in section, the venter becoming faintly angular, and the section becomes slightly broader than high. The holotype increases from 22 mm. and 19 mm. to 25 mm. and 23 mm. in a ventral length of 36 mm. and a dorsal length of 28 mm. in the length of the phragmocone, and the living chamber in a ventral length of 35 mm. and a dorsal length of 22 mm. attains a height of 25 mm. and a width of 25 mm. at the aperture.

The sutures are essentially straight though sloping increasingly orad from dorsum to venter as the aperture is approached. The cameræ occur nine in a length equal to a shell width of 16 mm., decreasing to seven in a length equal to the width, a condition which obtains throughout the ephebic portion of the phragmocone from a shell width of 18 mm. to the base of the living chamber where shorter cameræ may develop gerontically. The septa are nearly flat throughout the greater part of the phragmocone but become more curved in the later 5 mm.

The siphuncle lies close to the venter throughout the phragmocone. The segments arise as septal necks which are very short and are recurved. Apicad, the segment enlarges rapidly attaining its maximum diameter in its adoral fourth. Apicad from this the ring may be faintly convex over the middle two-thirds of the segment, or it may bear a faint concavity in the middle of the segment. The segment contracts at the adapical end somewhat more gradually than at the adoral end.

The siphuncle is occupied by actinosiphonate deposits which arise from the connecting ring, from which they cannot be distinguished, and of which they are clearly a part. In cross section the rays of the actinosiphonate deposit show some variation in number and arrangement. A cross section taken at or just orad of the foramen shows characteristically a group of three to five long slender rays springing from the ventral side, some or all of which may display clear axes. Laterally the rays, two or three on a side, are more irregularly lobed, and on the dorsum the deposit is nearly solid, and only two short very irregular rays are developed. At the middle of the segment, however, the rays are all long and slender, and spring from a relatively slightly thickened connecting ring.

In longitudinal sections, the aspect of the rays may vary depending upon the direction and the depth of the section. A section through the very middle of the siphuncle may pass through rays or both the dorsum and on the venter, so that they appear as a thick siphonal lining, the actinosiphonate nature of which is not evident from such a section alone. They are thin at the septal foramen, and in some sections are not continuous from segment to segment at this point. In other sections, not attaining the center, several rays are cut. In such cases it can be seen that some, particularly the lateral ones, are the longest and thickest near the adapical end of the segment and become thinner and shorter near the adoral end. Only rarely are the rays bifurcated or lobed, and such variations of the simple structure are always irregular both in form and spacing. The organization of the actinosiphonate deposits is very similar to that of *Valcouroceras*.

The surface of the shell bears transverse lines of growth. These swing apicad on the venter marking the position of a rather small and shallow hyponomic sinus.

Discussion.—This is the largest of the three species of *Augustoceras* developed in the Leipers formation of southern Kentucky. Fragments of the early part of the shell, except for possibly the very earliest growth stages, may be distinguished from *A. medium* by the somewhat deeper cameræ and the much more rapid rate of expansion of the shell.

Types.—Holotype and paratypes, Univ. of Cincinnati Museum, Nos. 24290, 24291, 24292; Shideler Collection, paratypes.

Occurrence.—In the Leipers formation of the Cumberland River, at Rowena and near Belk Island. The species is found throughout the *Tetradium* reef layers and in the overlying pelecypod limestone but has not been noted in higher beds.

Augustoceras medium Flower, n. sp. **Plate 19, figs. 11-13**

Conch intermediate in size between *A. commune* and *A. shideleri*, very gently and uniformly curved, the radius of curvature of the venter being 85 mm. throughout the shell. The holotype increases in the basal 37 mm. of the phragmocone from 15 mm. in height and 16 mm. in width to 24 mm. and 22 mm., and contracts slowly toward the base of the living chamber to 21 mm. and 22 mm., 47 mm. beyond the base as measured on the venter, and 40 mm. on the dorsum. The living chamber is incomplete but has a lateral length of 23 mm. and contracts only very slightly toward the aperture. The septa are flat, the sutures inclined orad from dorsum to venter but without lateral lobes. The cameræ are relatively deep, seven occurring in the adoral 22 mm. equal to the adoral shell height there. The siphuncle is close to the venter and typical of the genus.

The surface bears the usual lines of growth and in addition is faintly undulate.

Discussion.—This species approaches *A. shideleri* in size but is more gibbous over the adoral part of the phragmocone. The cameræ resemble those of *A. shideleri* in depth, but the phragmocone does not expand rapidly, and the dorsum is not so conspicuously flattened.

The species is much larger than *A. commune* but resembles that species rather than *A. shideleri* in general shape.

Type.—Holotype, Univ. of Cincinnati Museum, No. 24284.

Occurrence.—From the *Tetradium* layers and overlying pelecypod bed of the Leipers at Rowena, Kentucky.

Augustoceras commune Flower, n. sp. Plate 8, figs. 11-13; Plate 19, figs. 1-4

Conch slender, moderate in size, faintly gibbous over the lower part of the living chamber and the upper part of the phragmocone. The radius of curvature of the venter is about 75 mm. adapically, decreasing to 40 mm. over the gibbous region, and increasing toward the aperture. The section is faintly subtriangular, the dorsum being slightly flattened, and the venter very obscurely subangular. The holotype, a remarkedly well-preserved specimen, increases from 13 mm. and 13 mm. to 19 mm. in height and 20 mm. in width in a ventral length of 33 mm. and a dorsal length of 25 mm. and then decreases in a ventral length of 23 mm. and a dorsal length of 23 mm. to a height of 19 mm. and a width of 19 mm. at the incomplete aperture. A complete living chamber 24 mm. long on the venter and 19 mm. long on the dorsum has a basal width of 21 mm. and a height of 20 mm. and decreases adorally to 20 mm. and 18 mm. This specimen is probably very slightly flattened vertically by pressure.

The rate of expansion of the phragmocone is 5 or 6 mm. in a length of 20 mm. The cameræ are spaced nine in a length equal to a shell height of 15 mm., though this seems to vary somewhat among individuals, there being only seven in such a length on the holotype, and other specimens showing intermediate conditions.

The septum is relatively flat. The siphuncle lies close to the venter and is typical of the genus in form and in internal structure. No differences have been found within the siphuncle which will serve to distinguish this from associated species of *Augustoceras*.

The surface bears fine lines of growth and may be obscurely undulate. On the venter a slight hyponomic sinus is developed, but this is never strong or conspicuous.

Discussion.—This is the most abundant *Augustoceras*, and indeed, the most abundant cephalopod in the Leipers at Rowena, Kentucky. Most of the specimens consist of small portions of the phragmocone and living chambers are relatively rare. The form is a slightly variable one but may be distinguished from its associates by the size attained by the mature shell. The early portion of the phragmocone may be distinguished from that of *A. minor* by its slightly more rapid expansion and broader section. *A. shideleri* is more rapidly expanding in the early stages and has deeper cameræ, becomes much larger and is nearly tubular over the middle portion instead of gibbous.

Types.—Holotype, collection of Dr. W. H. Shideler. Paratypes, Univ. of Cincinnati Museum, Nos. 24283-5.

Occurrence.—From the Cumberland River at Rowena, Kentucky, and at Belk Island. The species is abundant in the *Tetradium* reef layers and occurs more sparingly in the overlying pelecypod limestone.

Augustoceras minor Flower, n. sp. Plate 19, figs. 5, 6

This is the smallest and most slender of the species of *Augustoceras* so far noted in the Leipers formation. The holotype, the most complete specimen, has a length of 65 mm. in which the radius of curvature of the venter decreases from 95 mm. in the basal two-thirds, to about 55 mm. over the living chamber. The section is slightly higher than wide in the basal portion and rounded, the dorsum not being more flattened than the venter. It is 9.2 mm. high and 8.7 mm. wide. In the length of the phragmocone, 36 mm. on the venter and 28 mm. on the dorsum, the height and width are equal, being 27 mm. and the dorsum has become slightly flattened, though the venter never attains the subangular condition of other species of the genus. The living chamber, much weathered on the venter, appears to have a dorsal length of 17 mm. Laterally the aperture can be seen 20 mm. from the base of the living chamber on one side and the ventral length was probably 28 or 30 mm.

The sutures are straight, nearly normal to the axis of the shell near the base but strongly inclined orad from dorsum to venter at the base of the living chamber. The cameræ are well preserved only at the base of the specimen where the sutures are straight, nine cameræ occur in a length equal to an adoral shell width of 13 mm., and the siphuncle is exposed by weathering and is typical of the genus in the form of the segments and in the development of the actinosiphonate deposits.

Discussion.—Although this species is represented by scant and rather poorly preserved material, it is unquestionably distinctive in its very slender form, the small size of the mature living chamber, as well as in the more generalized condition of the mature cross section and the faintly compressed condition of the early cross section. In association with the other three species, which together dominate the lower part of the Leipers in southern Kentucky to such an extent that two days collecting yielded over a hundred specimens, only four representatives of this form can be recognized definitely. The shell was apparently exceedingly fragile, as most specimens are either crushed or, as in the case of the type, have lost parts of the shell by breakage or solution.

Types.—Univ. of Cincinnati Museum, holotype, No. 24287. Paratypes, Nos. 24288-24289.

Occurrence.—From the Leipers formation of the Cumberland River of southern Kentucky at Rowena, and from the Painted Cliffs at the south side of the river near the head of Belk Island, near Horseshoe Bottom.

Augustoceras (?) vallandighami (Miller) Plate 28, fig. 9

Cyrtoceras vallandighami S. A. Miller, 1874, Cincinnati Soc. Nat. Sci., vol. 1, p. 232, fig. 23; James, 1886, (*pars*), Cincinnati Soc. Nat. Hist., Jour., vol. 8, p. 245; Ulrich, 1880, Cat. Foss. Cincinnati Group, Cincinnati, p. 22; Harper and Bassler, 1896, Cat. Foss. of the Trenton and Cincinnati Periods, Cincinnati, p. 27; Nickles, 1902, Cincinnati Soc. Nat. Hist., Jour., vol. 20, p. 81; Bassler, 1915, U. S. Nat. Mus., Bull. 92, vol. 1, p. 357; Miller, 1889, North American Geol., Pal., p. 435, fig. 730.

Wetherbyoceras vallandighami Foerste, 1932, Denison Univ. Bull., Sci. Lab., Jour., vol. 27, pl. 31, fig. 5A-B; Foerste, 1933, *ibid.*, vol. 28, p. 86.

This species, like *Wetherbyoceras conoidale,* is valid, but the original description and illustration are inadequate for its recognition. The species cannot be recognized and its generic position cannot be made certain without a restudy of the holotype, which cannot be located.

Original description.—Shell rather strongly curved. Section nearly circular, the dorso-ventral diameter a little longer than the lateral, occasioned by an oval prolongation for the siphuncle on the dorsal margin.

Surface smooth as far as observed. Siphuncle small and in contact with the shell on the dorsal side.

The specimen figured has 19 septa; length in a direct line on the dorsal side, 55/60 inch; ventral side 32 /60 inch; diameter, large end, from ventral to dorsal side 31/60 inch; small end, 10 /60 inch; length of septa on the dorsal side, at large end, 4/60 inch; small end 2 /60 inch.

The chamber of habitation has been broken from the large end, and has not been observed in other specimens.

The specific name is given in honor of Mr. George Vallandigham, of Cincinnati, an active collector, who found the specimen near the top of the hills at Cincinnati. Other collectors have found fragments and inferior specimens, but it may be regarded as an extremely rare species.

The precise horizon of this species is very uncertain, although it is customarily included in the list of species characteristic of the Fairmount beds. Fragmentary shells of the general aspect of this species in the collection of the University of Cincinnati Museum are largely without accurate horizon data and usually without good locality data. All of the fragments which have been available for the present study have been exceedingly small. In most instances the morphological features for the recognition of the genus *Augustoceras* have been lacking. As it is not even certain that these all represent one species, they are described below as *Augustoceras* (?), sp.

Type.—Location of holotype unknown.

Occurrence.—The holotype is from "the top of the hills at Cincinnati" which has been interpreted as Fairmount.

Augustoceras (?), sp. (1) Plate 25, figs. 4-7, 10

Specimens formerly identified as *Cyrtoceras vallandighami,* which were available for the present study, are too fragmentary and often too distorted to be identified with certainty. Five of the more characteristic and best preserved specimens are illustrated here, but all are too poor for specific and often generic determination. The original of figures 4, 5, Univ. of Cincinnati, No. 17164, from the Ayres Collection of the University of Cincinnati, is the least distorted of these specimens but as can be seen has slightly deeper cameræ than indicated in the original figure of *vallandighami.* The shell is scarcely curved and increases from 8 mm. and 8 mm. to a height of 15 mm. and a width of 17 mm. in a length of 17 mm. The eight cameræ have sutures which are essentially straight, sloping slightly orad from dorsum to venter. The specimen is an internal mold showing clearly the molds of cameral deposits. No trace of the siphuncle remains, and the generic position is therefore uncertain. In aspect the species suggests only *Augustoceras.*

The originals of Plate 25, figures 6, 7 are two of four specimens from the collection of S. A. Miller determined in the author's hand writing as his species *C. vallandighami.* Both specimens, here illustrated natural size, are crushed laterally and show no trace of the siphuncle. The third specimen from the same suite, which was less crushed, was sectioned, and it yielded traces of a badly distorted siphuncle. No actinosiphonate deposits were found, but the shape of the segments is not inconsistent with the genus *Augustoceras.* These specimens are No. 10376 in the University of Cincinnati Museum. They are labeled "Cincinnati, Ohio," with no statement as to horizon. One additional specmen, not illustrated, is a tiny fragment of a shell somewhat compressed, increasing from 4 mm. and 4 mm. to 10 mm. and 11 mm. in 11 mm. and containing eight cameræ. The sutures are simple and curvature is barely apparent. The section shows the subtriangular form of *Augustoceras* at the adoral end of the specimen, and the siphuncle, which is close to the margin, yields simple actinosiphonate deposits. The specimen, Univ. of Cincinnati, No. 24296, is labeled "Lorraine group, Cincinnati, Ohio." It is of interest as the only one of these specimens which definitely shows the actinosiphonate structure which is the only sure means of recognizing such small fragments of phragmocones as *Augustoceras.*

Augustoceras (?), sp. (2) Plate 25, figs. 1-3

Shell slightly curved, section subtriangular, slightly compressed, evidently by pressure, but with the venter more narrowly rounded than the dorsum. The shell increases from 4 mm. and 4 mm. at the base to 10.5 mm. and 9.8 mm. at the adoral end. The 13 cameræ are subequal in length. The sutures slope slightly orad from the dorsum to venter. Upon being sectioned, however, it was found that the interior of the shell was destroyed by pressure, and all that remained of the siphuncle was a few obscure traces of slightly recurved septal necks.

Discussion.—This form is clearly more slender, less curved than those discussed above, and also has deeper cameræ. While clearly representing another species in the Cincinnati area, quite distinct from the one or ones formerly included under *vallandighami,* this fragment is inadequate to serve as a type. It fails to show any very close resemblance to the original figures of *Wetherbyoceras conoidale.*

Figured specimen.—University of Cincinnati Museum, No. 17163, from the S. A. Miller collection, in which the specimen was determined as *"Cyrtoceras conoidale."*

Occurrence.—"Maysville, Cincinnati, Ohio." Precise horizon and locality unknown.

Augustoceras (?), sp. (3) Plate 5, figs. 12, 13

In the collections of the University of Cincinnati Museum there are four specimens of poorly preserved small cyrtocones of the general aspect of phragmocones of *Augustoceras,* but which are so poorly preserved that their taxonomic position cannot be ascertained with certainty. Two of these specimens are figured. One consists of a laterally flattened shell increasing in height from 9 mm. to 17 mm. in a ventral length of 23 mm. and a dorsal length of 19 mm. consisting of 11 cameræ. The siphuncle is not preserved. A second shell is flattened along the axis of the conch and may retain the cross section only slightly distorted. The shell is 14 mm. wide and 13 mm. high, the dorsum flattened, the venter narrowly rounded. Five cameræ occupy 11 mm. on the venter. Again the siphuncle is not preserved. The section is so broad that the species is evidently either *Augustoceras*, which it resembles very closely, or some genus as yet not recognized by other material in the Covington. Two additional specimens are even smaller and more poorly preserved fragments and are not figured.

Discussion.—While it is not possible to prove that this form is even an *Augustoceras* on one hand, it is impossible on the other to distinguish it from fragments of *Augustoceras* under somewhat similar conditions of preservation in the Leipers. Therefore, I refer the form to this genus. The specimens fail to give any clear conception of the characters of the species, or indeed, of whether this species is distinct from those of the Leipers, though judging from the restricted range, particularly of cyrtoceraconic cephalopods, this will probably prove to be the case should this rare form be made known from better material.

Figured specimens.—University of Cincinnati, No. 17167. Four specimens are included under this number, only two of which are figured.

Occurrence.—Southgate formation, Eden. Hillside Flats, Cincinnati, Ohio. From the collection of Charles L. Faber.

Genus **WETHERBYOCERAS** Foerste

Genotype.—**Cyrtoceras conoidale** Wetherby.

Wetherbyoceras Foerste, 1926, Denison Univ. Bull., Sci. Lab., Jour., vol. 21, pp. 323-325, pl. 43, fig. 4; Foerste, 1933, Denison Univ. Bull., Sci. Lab., Jour., vol. 28, p. 85.

Although Foerste made it clear in his description that he based it upon certain specimens in the U. S. National Museum which he considered to be *Cyrtoceras conoidale*, he designated that species as the genotype. Under the rules of zoological nomenclature that designation must stand, and knowledge of *Wetherbyoceras*, therefore, depends upon knowledge of *Wetherbyoceras conoidale*. Unfortunately there is such a wide discrepancy between Foerste's photographs and the original figures of *W. conoidale* as to raise grave doubts as to whether the specimen which Foerste figured under that name can be properly included in that species. The matter can be determined only by an examination of the original types of the species, and these cannot be located and indeed, are believed to be permanently lost. (Foerste, *fide litt.*).

Until the type of *Wetherbyoceras conoidale* has been restudied, *Wetherbyoceras* cannot be regarded as possessing the characters which were attributed to it by Foreste. All that is known of the genotype at present is that it is a small cyrtocone, only the phragmocone of which is known, with very shallow cameræ and a ventral siphuncle of unknown structure. From all that is known to the contrary, the species might be based upon a phragmocone belonging to none of several previously described genera, *Oncoceras, Beloitoceras,* and *Loganoceras,* to cite only a few of the more obvious possibilities.

Further, the genotype cannot be recognized with certainty until its holotype can be located and studied, and consequently it is not possible to compare this inadequately known species with those which are possibly related and which are described in this work. There is little doubt but that, were the holotype available and properly preserved, *Wetherbyoceras* would be found to have essentially the scope of *Augustoceras,* and *W. conoidale* would quite probably be found to be identical with one of the species described within that genus.

Since the genotype is so poorly known that it cannot be compared with other species properly, and indeed, so poorly known that the essential structural features of the genus are uncertain, no other species than the genotype can be assigned to *Wetherbyoceras* with certainty, and it is not even certain whether the genus is valid.

Wetherbyoceras conoidale (Wetherby) Plate 27, figs. 8, 11

Cyrtoceras conoidale Wetherby, 1881, Cincinnati Soc. Nat. Hist., Jour., vol. 4, pp. 78-79, pl. 2, fig. 6, 6a.

Cyrtoceras vallandighami James, 1886, Cincinnati Soc. Nat. Hist., vol. 8, p. 245.

C. conoidale Harper and Bassler, 1896. Cat. Fossils of the Trenton and Cincinnati Periods, Cincinnati, p. 27; Nickles, 1902, Cincinnati Soc. Nat. Hist., Jour., vol. 20, p. 81; Bassler, 1915, U. S. Nat. Mus., Bull. 92, vol. 1, p. 350.

Wetherbyoceras conoidale Foerste, 1926, Denison Univ. Bull., Sci. Lab., Jour., vol. 21, pp. 323-325.

Original description.—Shell very rapidly tapering, consisting of numerous short septa, of equal length. The specimens which I regard as typical, fig. 6a, Pl. 11., have a comparatively slight curvature. There are seventeen septa in a length of one inch. The siphuncle is small and dorsal. The shell seems to have been exceptionally fragile as all specimens which I have seen, except one from the Tennessee locality, are very much distorted by pressure.

Remarks.—I collected this fossil on August, 1877, at "Mt. Parnassus," Columbia, Maury County, Tennessee; in 1879, at McKinney's station on the S. S. R. R., Boyle county, Kentucky; and have since received it from my friend, Mr. W. M. Linney, of Harrodsburg, Kentucky who collected it in Garrard county. At Columbia it was associated with *Stellipora antheloidea*, *O. lynx*, and *Crania scabiosa*, on the old redoubt excavation of "Mt. Parnassus;" at McKinney's, I collected it with *Streptorhynchus filitextus*, *Ptilodictya hilli*, *Murchisonia bellicincta*, and undetermined corals, evidently belonging to the Cincinnati group. At the Garrard county locality, it occurs with *P. hilli*, and a *Rhynchonella*, probably a variety of *R. capax*. It has been confounded with the *C. vallandighami*, S. A. Miller, from which it is entirely distinct. The body chamber being wanting in all the specimens, the diameter cannot be determined. I regard the specimen, fig. 6, Pl. II., as a different species, and nearly allied to *C. vallandighami*, S. A. Miller.

Discussion.—Unfortunately the types of this species cannot be located, and it is greatly to be feared that they have been irretrievably lost. Without recourse to them it is not possible to recognize this species with certainty. The description, quoted above, is couched in terms too general to be of much practical importance in present day usage of specific distinction based upon shell proportions, and from the original illustrations it is probable that both of the specimens figured in connection with the original description were somewhat crushed. The shell is a cyrtoceracone with shallow cameræ, a rather rapid rate of expansion, and the two figured specimens vary so much in curvature that Wetherby was probably correct in regarding them as representatives of two different species. The "dorsal" siphuncle was clearly ventral. Nothing is known of the structure of the siphuncle and it is not certain that *C. conoidale* possesses the actinosiphonate structure Foerste considered an essential feature of the genus *Wetherbyoceras* upon which he based this species.

James (1886) considered this species a synonym of the earlier recognized species, *Cyrtoceras vallandighami*. The original illustration of *C. vallandighami* shows a shell which is more rapidly curved and possibly more rapidly expanded than Wetherby's figure 6a, the holotype, to the exclusion of the original of his figure 6, which he considered as more closely allied to *C. val-*

landighami. The species are almost certainly distinct, but the types cannot be located, and it has been found to be impossible to determine what the features of the species are on the basis of the original descriptions and figures.

W. conoidale is from the Leipers of Tennessee and Kentucky, but no authentic records exist of the species in the Cincinnati area. Bassler (1915) listed the species as Leipers. Nickles (1902) listed it as Fairmount, but it is uncertain that any specimens have ever been identified as this form from the true Fairmount of the Cincinnati region. Such specimens which resemble *conoidale* superficially in the collections of the University of Cincinnati Museum, are labeled "Cincinnati, Hudson River Group," for the most part. The horizon is not precise, and the term Cincinnati has a most elastic meaning, particularly when found on labels from old collections.

Wetherby's list of associated species requires some explanation, and there is some room for doubt as to the correct interpretation of some of his faunal data. The Columbia County locality could represent a fauna of either Cathys or Leipers age. One of the species *Stellipora anthaloidea* is listed by Bassler as Middle Ordovician but is probably a misidentification and may have been based upon another species and genus.

Platystrophia ponderosa (=*O. lynx* of authors) appears in the upper Leipers but is present though rare in the lower part, and an allied species from the Cathys might have served as the basis for Wetherby's determination. The presence of *Escharopora hilli* (*Ptilodictya hilli* of Wetherby) is indicative of the Leipers age of the strata at the Boyle County locality. The *Murchisonia* is a *Cyclonema.* The *Escharopora* determines the Leipers age of the Garrard County locality. Unfortunately it is not even certain from which localities the original of Wetherby's figure 6a was derived.

The species is a valid one but one which cannot be recognized without recourse to the type. It is to be feared that the type is too incomplete to serve as a good basis for a species. Among cyrtoceracones which would probably be found to embrace *C. conoidale* and *C. vallandighami,* there are several closely allied species which can be distinguished only with difficulty on the basis of such fragmentary material as is represented by Wetherby's type of *conoidale* and Miller's type of *vallandighami*. Somewhat similar specimens in the collection of the University of Cincinnati Museum I have preferred to identify in terms of *Augustoceras*, sp. The section and rate of expansion are the most diagnostic special features of these cyrtoconic cephalopods, and distorted specimens cannot therefore be identified with certainty.

Genus KINDLEOCERAS Foerste

Genotype.—**Kindleoceras reversatum** Foerste.

Kindleoceras Foerste, 1924, Canada Geol. Surv., Mem. 138, pp. 226, 227.

Shell strongly triangular in section, the venter angled, the dorsum strongly flattened, and with the sides forming fairly well-defined angles. The shell is slender, gradually expanding to the aperture, though often tubular or nearly so in the later stages of growth. The sutures are inclined orad from dorsum to venter. On the dorsal face a broad lobe is interrupted in the center by a low but well-defined median saddle in some species. The lateral faces are without distinct lobes, but the sutures rise obliquely from the lateral angles to the ventral angle. The siphuncle lies close to the venter and is composed of expanded segments containing actinosiphonate deposits. The aperture and lines of growth show a well-developed hyponomic sinus on the venter and form a broad low sinus over the dorsal face. The living chamber is short, nearly tubular basally, but in at least *K. equilaterale*, contracts sharply at the mature aperture.

Discussion.—In form this genus is best described as the inversion of such a type as *Tripteroceras*, in which the venter is flat and the dorsum angled. In actual genetic relationship this genus is a development from *Augustoceras*, which is cyrtoconic and still somewhat breviconic, and through that genus from *Valcouroceras*, a more gibbous breviconic cyrtoceracone the section of which is less obviously triangular. The development of a more slender form and a more triangular section, seen in the transition from *Valcouroceras* to *Augustoceras*, is carried much farther in *Kindleoceras*, so much so, that only the structure of the siphuncle remains to show its relationship. Some species fail to show curvature of the shell and appear to be essentially straight. All of the

Richmond species described below are clearly cyrtoconic, although the single Cynthiana species is straight, judging from the adoral portion of the shell, the only part observed.

Outside of the Cincinnati region *Kindleoceras* is known from *K. reversatum* and *K. triangulare* (Foerste, 1924) both from the Meaford of southern Ontario. This horizon has been correlated with the Waynesville. Curiously, all Richmond *Kindleoceras* of the Cincinnati area occur in considerably higher strata, in the Whitewater and Saluda. The Cincinnati species may be recognized by the following key.

KEY TO CINCINNATIAN SPECIES OF KINDLEOCERAS

1. Section with the faces rounded, obscurely subtriangular 2
   Section strongly triangular, faces scarcely convex and strongly rounded at the ventral keel and dorso-lateral angles 3
2. Shell orthoconic, section slightly higher than wide; sutures strongly oblique; living chamber straight and tubular .... *K. kentuckiense*
   Shell cyrtoconic, sutures only slightly oblique; living chamber faintly cyrtoconic, slightly contracted toward the aperture .... *K. rotundum*
3. Section as high as wide; living chamber short, contracted. *K. equilaterale*
   Section broader than high; living chamber parallel-sided to aperture .... *K. cumingsi*

Kindleoceras kentuckiense Flower, n. sp. Plate 14, figs. 6-8

The holotype consists of a living chamber, dorsally incomplete and two attached cameræ. The shell is straight, subtriangular in section, the dorsum flattened, the venter subangulate, and the greatest shell width dorsad of the center of the conch. The height is 16 mm. at the base, the width 17 mm., normal to the axis of the shell. The sutures are strongly oblique, sloping orad on the venter. The first camera is 1.8 mm., the second 1.5 mm., showing contraction indicative of maturity. The septum is relatively flat transversely, but slopes strongly orad on the ventral side producing considerable vertical curvature. The siphuncle is close to the venter, probably in contact with the ventral wall or nearly so when expanded within the cameræ. Weathering indicates that the segments are cyrtochoanitic, but no indication of the precise outline, or of the presence of any possible internal organic deposits can be seen. The living chamber has a ventral length of 28 mm. It is cylindrical or nearly so to the aperture. The ventral profile shows a faint trace of convexity, which may or may not be original. A trace of the aperture is preserved on the venter, indicating the presence of a low shallow hyponomic sinus. Shell surface unknown.

Discussion.—This species appears to be typical of *Kindleoceras* but differs from previously known Richmond species of Ontario in that it is less strongly depressed. *Garryoceras* Foerste (1928, p. 42) is rather similar in form but is orthochoanitic. Its phyletic relationship is unknown.

Type.—Holotype, Univ. of Cincinnati, No. 24077.

Occurrence.—From the Greendale member of the Cynthiana limestone, Poindexter quarry, Cynthiana, Ky.

Kindleoceras rotundum Flower, n. sp. Plate 24, figs. 10, 11

Shell slender, the dorsal and ventro-lateral faces more rounded than in most members of the genus, expanding very slowly to a point shortly above the base of the living chamber, and then contracting faintly, though nearly tubular, to the aperture. The holotype increases in the basal 20 mm. from 15 mm. and 18 mm. to 16 mm. and 20 mm., the width being greater than the height. In the remaining portion, 28 mm. long ventrally, the shell attains an adoral width of 19 mm. and a height of 18 mm. The living chamber has a ventral length of 24 mm.

The sutures are slightly inclined orad from dorsum to venter and are essentially straight. The cameræ are uniform in depth, four occuring in 9 mm. The septa are very flat. The siphuncle lies close to the venter and is exposed by weathering on the type. The segments are broad, short in proportion to their diameter at the septal foramen, slightly expanded in the cameræ. The weathering of the siphuncle has brought out very clearly the simple actinosiphonate deposits of the siphuncle. The surface features and aperture are unknown.

Discussion.—In contrast to other species of *Kindleoceras* the section is less strongly triangular and the sutures are less curved than in the associated Richmond species. *K. kentuckiense* has a section which is higher, and the sutures are more oblique.

In the faint contraction of the living chamber this species recalls also the more slender forms of *Augustoceras*, and the rounded section is not inconsistent with placing the species in that genus. However, the contraction of the living chamber is found in *Kindleoceras equilaterale* also, where the strongly triangular section of *Kindleoceras* is developed, and the broad short segments of the siphuncle suggest a closer relationship to *Kindleoceras* than to *Augustoceras*.

Holotype.—Collection of Dr. W. H. Shideler, Miami University.

Occurrence.—From the Saluda beds above the *Tetradium* reef, Big Sains Creek, 2 1/2 miles southwest of Laurel, Indiana.

Kindleoceras cumingsi Flower, n. sp. Plate 24, figs. 1-4

This is a rare species of the Saluda which is known only from adoral portions of the conch which are very slightly exogastric though nearly orthoconic. The holotype has a maximum length of 54 mm. The section is triangular, the lateral angles rounded, the ventral angle subacute. The adoral part of the shell is nearly tubular, increasing from a height of 22 mm. and a width of 26 mm. to a height of 23 mm. and a width of 27 mm. in a length of 40 mm. In this length the dorsum is very faintly concave and the venter is very slightly convex in profile.

The holotype retains seven cameræ in a length of 13 mm. These are subequal in length, The sutures describe a mid-dorsal saddle flanked by a pair of lobes on the dorsal surface, and from there swing orad over the lateral faces to a saddle on the ventral angle of the shell. The septum is asymmetric in vertical curvature, and at least adorally, is rather strongly convex, as in the adoral segments of *Augustoceras*. Material does not permit a detailed study of the siphuncle, but it lies close to the venter, is relatively large, having a diameter of 4 mm. at the base of the holotype, and contains a thick organic lining. From this spring about 17 vertical actinosiphonate rays which are, however, relatively short and blunt. The segments of the siphuncle are more tubular than those of *Augustoceras*. The septal neck cannot be clearly determined, but the segments are broad, short, and are better described as suborthochoanitic than cyrtochoanitic. At the base of the type the siphuncle is 3.7 mm. wide and 3 mm. high.

The surface features of the shell are not clearly shown but evidently consist of rugose lines of growth, which are impressed faintly upon the internal mold of the living chamber where they are accompanied by faint constrictions of the shell. The paratype, consisting only of a portion of a living chamber, shows clearly that the lines of growth describe a broad rounded sinus on the dorsum and curve apicad again upon approaching the venter where a hyponomic sinus is developed.

Discussion.—In general aspect this form is quite similar to the genotype *Kindleoceras reversatum* of the Meaford of Ontario. It differs from that species in some features of shell proportions, in particular, in the greater height of the shell in proportion to its width, and in exhibiting slight exogastric curvature. Both of these differences might conceivably be more apparent than real if they are lost in *K. reversatum* owing to slight shell distortion. They are, however, regarded as real by the writer as the type of *K. reversatum* does not seem to be flattened vertically by pressure. Another and more important difference is found in the conspicuous saddles on the mid-dorsal region of the sutures of *K. cumingsi*, a feature which is probably developed only in the later stages of growth judging from similar phenomena found in the late stages of Cincinnatian species of *Manitoulinoceras*.

Types.—Holotype and paratype, collection of Dr. W. H. Shideler, Miami University.

Occurrence.—From the Saluda formation. Both specimens are from Cooper's Falls, 5 miles south of Versailles, Indiana, from the upper part of the Saluda regarded as carrying the Hitz fauna, where the fine-grained Saluda lithology has replaced the upper Whitewater bryozoan and coral facies as developed farther north and east.

Kindleoceras equilaterale Foerste, n. sp. Plate 24, figs. 8, 9

Shell slender, very gently curved, strongly triangular in section. The holotype is 106 mm. long adorally. The radius of curvature of the dorsum is 250 mm., that of the venter about 35 mm. on the living chamber the ventral profile becomes much more strongly curved, a condition which appears to be natural, the radius of curvature being reduced there to 30 mm. over a short interval, so that the living chamber becomes abruptly contracted in a manner suggesting a *Neumatoceras*. The shell has a width at the base of the type of 27 mm. and a height of 21 mm. In a ventral length of 85 mm., at the base of the living chamber, the height is 28 mm. and the width is not known as one side is lost but is assumed to be nearly the same as in the early portion. The extant part of the living chamber is 20 mm. long. Contraction of the venter begins about 8 mm. beyond the base and is rapid so that at the apertural end the shell has a height of 20 mm. The aperture is not preserved.

The sutures are obscure dorsally but appear to form shallow lobes over the whole dorsal face. No indication of a mid-dorsal saddle is present. The sutures rise orad on the lateral surfaces to a ventral saddle. The cameræ are fairly closely spaced, five in 10 mm. adapically, four in 10 mm. adorally, and near the base of the living chamber four and a half in an equal length. The siphuncle can be seen at the base of the specimen to be circular in section, very close to the venter, and 3 mm. in diameter. In cross section the wall of the siphuncle is thickened greatly, so much so that the internal cavity is less than 1 mm. across, but at this point no actinosiphonate rays are clearly apparent.

The surface of the shell, shown only on the dorsum, bears rugose lines of growth which describe a broad low sinus over the dorsal face of the shell.

Discussion.—This species is distinctive in the curvature of the shell, the relatively high cross section, and the contraction of the living chamber. The associated *K. cumingsi* is broader in section, less curved, and has the adoral part of the shell essentially tubular. The lateral angles of that species are more broadly rounded, the sutures bear a mid-dorsal saddle, and the siphuncle is somewhat larger in proportion to the cross section of the shell.

Type.—Holotype, collection of Dr. W. H. Shideler, Miami University.

Occurrence.—Saluda beds, 3/4 mile north of Mixerville, Franklin County, Indiana.

Genus MANITOULINOCERAS Foerste

Genotype.—Cyrtoceras lysander Billings.

Manitoulinoceras Foerste, 1924, Canada Geol. Surv., Mem. 138, p. 230; Foerste, 1933, Denison Univ. Bull., Sci. Lab., Jour., vol. 28, p. 126.

Conch exogastric, cyrtoconic, depressed in section, with the dorsum somewhat more flattened than the venter. The venter in cross section may be rounded or may be more or less subangular, but the ventral keel is not ordinarily strongly developed. The shell is moderately expanding in the early stages but is very slender, in fact almost tubular, throughout the greater part of its length. The mature living chamber is nearly tubular but is not contracted at the aperture.

The sutures are straight and transverse in the early stages but soon slope orad from dorsum to venter. The dorsal face often bears a low lobe, but in the late stages of *M. tenuiseptum* this may be interrupted by a small but conspicuous saddle.

The siphuncle is located close to the venter. The segments are broad at the septal foramen in proportion to their length and expand within, the cameræ being subspherical to obscurely heart-shaped in form. The septal necks are short and gradually recurved, while the adapical end of the connecting ring meets the next adapical septum at a fairly sharp angle. Deposits are not ordinarily found in the siphuncle in the late stages of growth close to the living chamber. Such deposits as are found there consist of a thickening of the connecting ring which may be produced toward the center of the chamber. Such deposits as are found in this part of the shell are very often irregular and seemingly erratic in their distribution through any considerable series of cameræ and consist only of a thickening of the connecting ring inflated slightly at the septal foramen so as to suggest incipient annulosiphonate deposits. Such thickenings, however, are not similar to those of annulosiphonate cephalopods proper but suggest rather an incipient phase in the development of actinosiphonate deposits. Fragments of earlier portions of the conch, farther from the living chamber, have shown simple actinosiphonate deposits, essentially similar to those found in the Valcouroceratidæ, particularly as known from *Augustoceras.* Deposits are not known within the cameræ. The surface of the shell is relatively smooth bearing only fine lines of growth. The aperture is generally inclined orad from dorsum to venter but develops a clear hyponomic sinus.

Discussion.—This genus may be readily recognized in the Cincinnatian by its very slender curved form, the depressed rounded section, the marginal siphuncle, and usually by the very shallow cameræ. *Augustoceras* which is similar in the deposits of the siphuncle has more slender siphuncular segments. The shell expands more rapidly in the early part, and the living chamber is at least faintly contracted at the aperture. *Kindleoceras* is more closely allied but is less curved, and the cross section is always conspicuously triangular with not only dorso-laterally angled but a well-defined ventral keel. Not only are the segments of the siphuncle of these genera similar, but *Kindleoceras* also shows the deposits close to the living chamber of a mature shell to consist of a thick lining derived from the connecting ring in which the rays are obscured though not to the extent shown in *Manitoulinoceras*. *Staufferoceras,* discussed below, is possibly allied to *Manitoulinoceras*. It is a shorter, more strongly curved, shell with a slightly contracted living chamber. The cross section may be rounded or faintly subtriangular. The segments of the siphuncle are known to be rather broad and cyrtochoanitic, suggesting those of *Kindleoceras* and *Manitoulinoceras,* but material demonstrating the presence of actinosiphonate deposits has not yet been found.

The demonstration of actinosiphonate structure in *Manitoulinoceras* serves to show that its external similarities with *Kindleoceras,* and to a lesser degree with *Augustoceras,* represent a real relationship. Without this evidence it would not be possible to show that *Manitoulinoceras* is not instead a depressed cyrtocone derived through cyrtocones of circular section, as *Loganoceras,* from compressed cyrtocones such as *Oonoceras* and *Richardsonoceras* which in turn can be traced to the true Oncoceratidæ, compressed brevicones, apparently the primitive radicle of one large and important group of cyrtoconic Cephalopoda characterized by the absence of deposits within the siphuncle. (Flower, 1942, pp. 26-31.)

Foerste (1933) has suspected that all of the species placed in *Manitoulinoceras* may not be closely related. The above remarks apply to a group of species which are closely similar to the genotype in this section, in the close spacing of the cameræ, and in fact, all known structures. It is not impossible that other species, the structure of which has not as yet been subjected to a thorough investigation, might prove to have other relationships. The form pattern of *Manitoulinoceras* is a simple one, theoretically one which might be attained several times in cephalopod development.

As at present understood, *Manitoulinoceras* ranges from the Black River to the top of the Richmond and is a genus which by its distribution is boreal in its paleogeographic affinities. Foerste erected the genus first for the reception of two species from the Meaford (middle Richmond and presumably the Waynesville equivalent) of southern Ontario, *M. lysander* (Billings) and *M. postumius* (Billings). Additional species are *M. middlevillense* Foerste (1928) from the Trenton limestone of New York, *M* (?) *canadense* Foerste (1933) of the Black River limestone of La Petite Chaudiére, at Ottawa, *M.* (?) *warsawense* Foerste (1933) of the Decorah shales of Minnesota, and *M.* (?) *wykoffense* Foerste (1933) of the Prosser of Minnesota. These, together with the species described below from the Cincinnati region, constitute the known representatives of the genus.

All of these species are not, as Foerste (1933) noted, typical. *M. middlevillense* is a form which is unusually narrow in section and has unusually deep cameræ. It is known only from small fragments. *M* (?) *warsawense* is atypical but is not well known morphologically. It is a small cyrtocone of generalized aspect, more rapidly expanding than typical *Manitoulinoceras*, and difficult to place anywhere satisfactorily on the basis of the present evidence. *M.* (?) *canadense* is rather too narrow in section and shows the suture curving with the concavity orad as in *Richardsonoceras*. *M. wykoffense* appears to be quite typical in the slender form of the shell and also in the form of the segments of the siphuncle. *M. postumius* (Billings) is poorly known externally. Foerste considered it too rapidly expanding for typical *Manitoulinoceras*, but it is fairly typical in the outline of the segments of the siphuncle. Further, it is possible that the type may represent the early portion of the shell. Commensurate specimens of the species of *Manitoulinoceras* which in later stages are slender and tubular, in short, typical of *Manitoulinoceras* agreeing with the genotype in form, may be quite rapidly expanding. This is true of *M. moderatum*, *M. williamsæ*, and *M. tenuiseptum*.

The nucleus of the genus is made up of a group of species in which the late part of the shell is very slender and has very shallow cameræ. This includes the genotype, *M. lysander,* which seems to be known exclusively from fragments representing this portion of the conch. Closely similar in late growth stages are four species of the Cincinnati area, *M. williamsæ, M. tenuiseptum, M. moderatum,* and *M. gyroforme.* While the part of the phragmocone which is commonly found shows these features, there is an earlier stage in which the cameræ are markedly deeper and the rate of expansion of the shell is considerably greater. This has been observed in *M. tenuiseptum* and is strongly suggested in *M. gyroforme,* and is also developed in *M. moderatum,* though confined to a considerably smaller apical interval in that species. In contrast, there are species in which whatever the form of the shell, the cameræ remain relatively deep until late in life. *M. wykoffense* apparently belongs to this group, as does the Cincinnatian species *M. erraticum,* while in *M. ultimum* the deeply camerated stage is succeeded by a broad gerontic interval in which the cameræ are very shallow as in the better known specimens of other species of the genus.

Cincinnatian species.—Manitoulinoceras is not common anywhere in the Cincinnatian and is found only from the lower Waynesville to the Elkhorn. The first occurrence of the genus is found in the soft trilobite shales of the Fort Ancient, lower Waynesville. Here occur two closely related forms, *M. williamsæ* and *M. tenuiseptum.* Early stages of these species cannot be distinguished. Typical fragments of the phragmocone can be recognized readily by the different course of the sutures. In *M. tenuiseptum* the suture is transverse over the dorsum and finally develops a mid-dorsal saddle. In *M. williamsæ* a broad shallow lobe is present on the dorsum up to the mature and even gerontic living chamber.

The middle Waynesville has yielded only one small unidentifiable fragment which lacks the obliquity of the sutures of both of the lower Waynesville species.

In the lower Whitewater two species occur. One is the anomalous *M.* (?) *trigonale,* which may not even be a *Manitoulinoceras.* It may be distinguished by the triangular cross section, which is not so pronounced as that of *Kindleoceras,* but suggests that of *Staufferoceras subtriangulare*. Due to the slender form of the shell it is tentatively included in *Manitoulinoceras*. At the same horizon there appears a typical slender species, gently curved, which differs from *M. williamsæ* and *M. tenuiseptum* in that the sutures are scarcely inclined orad from dorsum to venter. This is *M. moderatum*, better represented in the Saluda and upper Whitewater and known from one fragment in the Elkhorn. Also in the upper Whitewater and Saluda there is found a relatively large species with deep cameræ and nearly transverse sutures, *M. erraticum*. The Elkhorn has yielded one very characteristic form, *M. ultimum*, the early stages of which agree with *M. erraticum* in the distant septa but which develops later a considerable series of closely spaced cameræ.

One problematical member of this genus remains to be mentioned. It is quite possible that *Cyrtoceras irregulare* Wetherby might prove to belong to *Manitoulinoceras*. If so, it is probably identical with either *M. williamsæ* or *M. tenuiseptum*. However, judging from the extant information, even if the type is found, it is feared that it is too poorly preserved to be identified in terms of either of these species with certainty.

KEY TO CINCINNATIAN MANITOULINOCERAS

1. Shell with deep cameræ and a moderate rate of expansion confined to extremely early stages, the greater part of the shell (usually the only part found) being nearly tubular and having very shallow cameræ 2
   Shell with relatively deep cameræ except possibly for a short interval near the living chamber of gerontic forms 3
2. Shallow cameræ and a marked tubular form appear at a shell width of 20 mm. ......*M. ultimum*
   Shell slender beyond 15 mm. width, but with shallow cameræ not developed in known portion (up to 30 mm. width)......*M. erraticum*
3. Shell strongly keeled on the venter; section triangular. *M.* (?) *trigonale*
   Shell rounded, keel vestigial or absent 4
4. Shell very strongly curved, approaching the gyroceraconic form ...... *M. gyroforme*
   Shell cyrtoconic, gently curved 5
5. Sutures scarcely inclined orad from dorsum to venter...... *M. moderatum*
   Sutures strongly inclined orad on venter 6
6. Sutures describe a broad lobe over the entire dorsum throughout life ...... *M. williamsæ*
   Sutures at first becoming transverse dorsally, so that there is a definite bend where they swing orad laterally toward the venter, and finally with a slight saddle on the mid-dorsal region ...... *M. tenuiseptum*

Manitoulinoceras williamsæ Flower, n. sp. Plate 23, figs. 1-6

(?) *Manitoulinoceras lysander* Foerste, 1924, Canada Geol. Surv., Mem. 138, pp. 231-2 (*pars*).

Shell gently curved, slender, depressed in section, the dorsum slightly more flattened than the venter, attaining a large size without the development of any saddles on the dorsum. The holotype is a slightly crushed mature living chamber showing the maximum size of the species, but in which the original section has been compressed, and its subtriangular aspect strongly exaggerated. The normal shell is depressed in section, and in the early stages is probably indistinguishable from *M. tenuiseptum* which is associated with it, and probably comparable stages of *M. lysander* would be indistinguishable. The dorsum and venter there are about equally evenly rounded, but soon the dorsum becomes flatter than the venter, though at comparable growth stages the dorsum is more flattened in *M. tenuiseptum* which is a smaller species and consequently attains ephebic characters at lesser shell diameters.

The curvature of the shell and the rate of expansion are essentially similar to those of *M. tenuiseptum;* for practical purposes of distinction they are of little value because shells of both species are frequently more or less distorted. The paratype, representing a slightly compressed portion of the earlier stages of the shell, increases in height from 14 mm. to 21 mm. in a length along the venter of 85 mm. and has a radius of curvature of 110 mm. The holotype has a ventral length of 65 mm. and increases in height from 24 mm. to 27 mm. In its present condition the corresponding widths are 24 mm. at the base and 15 mm. at the aperture. In undistorted specimens the width is slightly greater than the height, and the dorsum is slightly more flattened than the venter. This condition apparently increases adorally, for at one portion of the paratype which is undistorted the width is 20 mm. and the height 16 mm., the greatest width being attained about halfway between the center and the dorsum. At the base of the holotype, however, the maximum width is attained farther dorsad indicating a flatter dorsum and a section which is more subtriangular.

The sutures in this species differ from those of *M. tenuiseptum* in being more uniformly oblique and not flattened on the dorsum. Instead, as the result of the obliquity, the slightly convex dorsal face appears to bear a broad lobe which is continued orad toward a saddle on the venter. This condition continues up to the latest sutures noted. The cameræ are shallow. Five occupy a length of 11 mm. at the base of the paratype where the shell height is 14 mm. Five occur in the same length at a height of 20 mm. at the dorsal end of the paratype. The same relation holds at the base of the holotype, but at the adoral end of the phragmocone next to the base of the living chamber, six or seven cameræ may occur in a length of 10 mm., plainly a gerontic feature, though the gerontic contraction of the cameræ is never so strongly developed as in most other cyrtoconic genera. The siphuncle lies close to the venter. Although several specimens have been sectioned, none have been found preserving the segments of the siphuncle very clearly. The segments are rounded as in *M. moderatum*. No trace of internal deposits has been observed in the siphuncle of *M. williamsæ*.

The living chamber, as observed on the compressed holotype, has a ventral length of 38 mm. and a dorsal length of 29 mm. and may not be quite complete, as the hyponomic sinus cannot be seen. The holotype is compressed gradually as it approaches the aperture, a condition, which although exaggerated by lateral compression of the shell after death, was almost certainly original, as displacement of the shell parts is not greater adorally than adapically.

The surface features of the shell are not displayed well in this species, although the shell fragments are preserved as a black carbonaceous film. The hyponomic sinus is not demonstrated in this species, but there is no real evidence that it was not developed here as it is in closely related species. The aperture, aside from the probable sinus, was evidently strongly oblique, sloping orad from dorsum to venter.

Discussion.—This species is closely allied to *M. lysander* (Billings) of the Meaford shales of Ontario and also to *M. tenuiseptum* with which it is associated. I regard the form as distinct from *M. lysander* on the basis of the greater curvature of the ventral profile, the somewhat more rapid expansion, and the very slightly deeper cameræ. It agrees with *M. lysander* and differs from *M. tenuiseptum* in that the sutures are uniformly oblique, are not flattened conspicuously on the dorsal surface in the early stages, and lack saddles on the dorsum in the late stages. Probably the early stages of all three species would be indistinguishable, a condition not confined to these species or this genus in nautiloids. This species is slightly more abundant in the trilobite beds of the Waynesville than is *M. tenuiseptum.* There both species show the crenulate sutures which cause them to show such a strong resemblance to *M. lysander* and seem to set these three species apart from all others of the genus. This feature may be more apparent than real and due to the nature of the preserving medium which brings out sutural details as well as details of the surface of the internal mold very clearly not only in the *Manitoulinoceras* but also in associated genera. Rather strangely, no trace of conchial or septal furrows can be seen in this species.

Types.—Holotype and paratype, University of Cincinnati, Nos. 24293, 24294. Shideler Collection, two specimens.

Occurrence.—From the shales of the lower Waynesville, regarded as the uppermost part of the Fort Ancient division. The species is not commonly encountered anywhere but is occasionally found in the vicinity of Clarkesville, Ohio. The holotype is the gift of Miss Carrie B. Williams, for whom I have named the species as some slight expression of gratitude for this and many other fine paleontological gifts to the University of Cincinnati Museum.

Manitoulinoceras tenuiseptum (Faber)

Plate 22, figs. 1, 2, 9-11; Plate 23, fig. 10

Cyrtoceras tenuiseptum Faber, 1886, Cincinnati Soc. Nat. Hist., Jour., vol. 9, p. 18, pl. 1, fig. 3a-c; Cumings, 1908, Indiana Dep. Geol. Nat. Res., Ann. Rep., 32, p. 1928, pl. 49, figs. 16-17; Bassler, 1910, U. S. Nat. Mus., Bull., 92, vol. 1, p. 357.

Manitoulinoceras lysander Foerste, 1924, Canada Geol. Surv., Mem. 138, p. 232. (*Pars.*)

This is a slender species of depressed section, characterized by a rather pronounced flattening of the dorsum where the sutures are relatively transverse in the early stages and in the later stages develop a slight median saddle. The two syntypes represent undistorted individuals, one a small part of a phragmocone which supplied the original figure of the section, the other a nearly complete but immature living chamber with several cameræ attached. These are supplemented in the following description by a third specimen consisting of a somewhat larger phragmocone.

The shell is cyrtoconic, though variable in curvature, the radius for the ventral profile varying from 85 mm. in the longer syntype to 50 mm. in the hypotype. The section is broader than high, the venter rounded, and the dorsum more flattened. In early growth stages the greatest width of the shell lies about midway between the dorsum and venter, but adorally it comes to lie well dorsad of the center of the shell as the flattening of the dorsum becomes more pronounced. The shell is very slender. The hypotype increases in its undistorted portion from 17 mm. and 20 mm. to 19 mm. and 22 mm. in a ventral length of 35 mm. The one syntype, representing a living chamber and four attached cameræ, increases from 19 mm. and 22 mm. to 24 mm. and 22 mm. in a ventral length of 24 mm. The immature living chamber increases from 20 mm. and 22 mm. to a height of 24 mm. and an estimated width of 26 mm. in a mid-ventral length of 27 mm. Because of the hyponomic sinus the maximum length of the living chamber is 30 mm. and is ventro-lateral. From the ventro-lateral region the aperture slopes apicad toward the dorsum, where it has a length of 27 mm.

The cameræ are shallow, the closely spaced septa show in the internal molds curious finely crenulated sutures which are present in the associated *M. williamsæ* and also in the genotype, and which are unknown in all other species. The early sutures are nearly straight and transverse, but from the earliest stage they can be seen to slope slightly apicad from the lateral to the mid-ventral region while remaining straight on the dorsum. The obliquity of the sutures on the ventral side increases as the sutures are traced orad until a fairly conspicuous saddle is developed on the venter as the result of obliquity. At a shell width of 21 mm. there begins to appear a slight mid-dorsal saddle which is prominent at a width of 22 mm.

The septa are very flat in this species. The cameræ orad of a shell width of 18 mm. occur six in a length of 10 mm. The four cameræ at the base of the larger syntype occupy a ventral length of 7.5 mm. In the 10 mm. orad of a shell width of 23 mm. five cameræ occur, the latest stage observed. The siphuncle lies close to the venter. Its structure in this species has not been observed.

The surface of the shell bears subrugose lines of growth which follow the contours of the aperture.

Discussion.—This species is a relatively rare one found only in the trilobite shales in the lower Waynesville, where it is associated with the simpler *Manitoulinoceras williamsæ*. It may be distinguished readily from that species, however, by the more transverse dorsal sutures in the early stage, as well as by the dorsal saddles of the later growth stages. The species was formerly regarded as a synonym of *Manitoulinoceras lysander* by Foerste, as noted in the synonymy of the species, but the conclusion was reached without a study of types. *M. lysander* has the sutures more uniformly sloping and is not known to develop dorsal saddles. It shows the same corrugation of the sutures which is exhibited by *M. tenuiseptum* but is more tubular and slightly less curved than either *M. tenuiseptum* or *M. williamsæ*. Probably extremely early stages of *M. williamsæ* or *M. tenuiseptum* would be very difficult to differentiate. I have not had opportunity to compare these stages, for curiously the earlier portion of all of the shells of this genus in the Waynesville are very badly crushed.

The syntypes by their lithology come from the shales of the lower Waynesville, where additional material of this species has been found. The species is not recognized from higher or lower levels. Probably the original record of this species from Versailles, Indiana, is false, though the specimen on which it was based cannot be located. Quite probably that represented a different species from higher in the section, possibly *M. medium* of the Whitewater and Saluda.

Types.—Syntypes, Univ. of Cincinnati Museum, Nos. 103-104, the originals of Faber's figures accompanying the original description of this genus. One additional specimen, figured here, is from the collection of Dr. W. H. Shideler.

Occurrence.—From the "*Orthoceras duseri*" bed of the Fort Ancient member of the Waynesville, from the vicinity of Waynesville and Clarkesville, Ohio.

Manitoulinoceras (?) trigonale Flower, n. sp. Plate 22, figs. 6-8

This is a relatively large species, readily differentiated from other species of *Manitoulinoceras* by the relatively rapid rate of expansion and the subtriangular section. The holotype increases in the length of the phragmocone, a ventral length of 37 mm. and a dorsal length of 30 mm., from 17 mm. and 21 mm. to 19 mm. and 23 mm. The living chamber shows the same rate of expansion, and expands to 22 mm. and 27 mm. at the adoral end which is incomplete on the venter, though the aperture can be seen dorsally and laterally where it lies 22 mm. beyond the last septum. The shell has a nearly uniform radius of curvature of 85 mm.

The sutures are nearly straight and transverse, showing only a very slight obliquity, moving slightly orad from dorsum to venter, at the adoral end and very faint lobes on the flattened dorsal face. The dorsum is flattened, the venter broadly rounded but with the faintest suggestion of a median keel. The cameræ are shallow, averaging 3 mm. in depth throughout most of the phragmocone, but slightly shorter near the base of the living chamber. The internal structures are not preserved on any of the specimens. Lines of growth are preserved very faintly on the dorsum. There is good reason to believe that the aperture was strongly inclined orad from dorsum to venter, where it was interrupted by a hyponomic sinus.

Discussion.—This species is atypical of *Manitoulinoceras* in the strongly triangular section, a feature which gives it a strong similarity to the associated *Staufferoceras subtriangular.* It may be distinguished from *Staufferoceras* by the more slender phragmocone, the more gradual curvature, and the failure of the mature living chamber to show any gibbosity. The section and large size together will differentiate this species from associated *Manitoulinoceras.* The subtriangular *Kindleoceras* is also comparable, but the section of *M. trigonale* is not so strongly keeled ventrally as is *Kindleoceras,* and the mature part of the shell has not developed the tubular condition which is characteristic of all known species of that genus.

The exact affinities of this species remain obscure. Possibly it will eventually be set aside from *Manitoulinoceras* in a distinct genus; certainly in section and the rather rapid rate of expansion it is not typical of the genus. Foerste (1933) has discussed Middle Ordovician species as well as *C. postumius* of the Richmond of Ontario which appear to be atypical of *Manitoulinoceras,* but none appear to agree closely with this species which instead seems to be intermediate between *Staufferoceras* and *Manitoulinoceras* in form.

Holotype.—Collection of Dr. W. H. Shideler.

Occurrence.—From the cephalopod bed of the lower Whitewater, Little Four Mile Creek, near Oxford, Ohio.

Manitoulinoceras moderatum Flower, n. sp.

Plate 21, figs. 1-3, 9, 15; Plate 22, figs. 12, 13

Shell gently curved throughout and broadly depressed in section, dorsum and venter being about equally rounded. The radius of curvature varies owing largely to flattening of the shells, but in the best preserved specimens, including the holotype, ranges from 70 mm. to 90 mm. in the mature portion. The holotype increases from 16 mm. and 22 mm. to 18 mm. and 23 mm. in the ventral 40 mm. of the phragmocone, and in the 26 mm. of the living chamber increases to 20 mm. and 25 mm.

The sutures are straight and transverse failing to slope orad on the venter adorally as in most other species of the genus. The septum, shown at the base of the holotype, is relatively deep, but other specimens show the same relatively flat septum found in most members of the genus. The explanation for this discrepancy probably lies in the development of relatively strongly curved septa in the late stage of *Manitoulinoceras,* such as have been observed in the late growth stages of *Augustoceras.*

The siphuncle lies close to the venter. A segment 2 mm. long expands from 1.6 mm. at the septal foramen to 2.5 mm. within the camera. The septal neck is gradually recurved, the segment circular for the most part in its expansion within the camera. The adapical end of the connecting ring swings centrad meeting the next adapical septum at a considerable angle. The holotype, upon being sectioned, showed in addition to the outline of the siphuncle a curious thickening of the connecting ring such as is observed in the incipient stage of development of actinosiphonate deposits in *Valcouroceras.* Occasionally this shows also slight thickenings of the deposit at the septal foramen, a condition shown in a more advanced state in another specimen. In neither section, however, was there any apparent correlation between these deposits and growth stages, as the deposit was not uniformly thicker adapically than adorally, but seemed rather erratic in its distribution throughout a series of cameræ.

The septa are relatively closely spaced, as is common and, in fact, characteristic of *Manitoulinoceras.* Five occupy a length of 10 mm. throughout the phragmocone of the type, though they are, not unnaturally, somewhat closer in other specimens representing fragments of earlier stages of growth attributed to this same species.

The length of the complete living chamber is not known nor is the aperture.

Discussion.—This appears to be the common species of *Manitoulinoceras* from the lower Whitewater through the Saluda and upper Whitewater, although many of the fragments from these horizons are really too poor to merit specific identification. However, this form may be distinguished from the older species of the Waynesville by the more transverse condition of the sutures in the late stages of growth. Even this feature, which is easy to use in comparing undistorted material, fails when an attempt is made to apply it to badly crushed specimens. From *M. gyroforme* of the Saluda, this form differs on the basis of the much more gradual curvature of the shell.

I attribute to this species one fragment representing the early growth stage of a *Manitoulinoceras.* This specimen increases in 30 mm. from 6 mm. and 7 mm. to 11 mm. and 14 mm., showing that in the early stages the section enlarges quite rapidly before assuming the ephebic subtubular condition, and that the breadth of the section increases more rapidly than does the height. This septate fragment cannot, if real caution is employed, be assigned to any species with certainty until specimens are found which show definitely the continuity from the early rapidly expanding portion to the later subtubular portion of the shell. However, there can be little doubt but that such early stages belong to most *Manitoulinoceras.* Allowing for such an early stage, the shell would be expected to attain when complete a length of about 150 mm. Without such stages it would necessarily be much longer. A rapidly expanding apical portion would explain the puzzling absence in all beds containing *Manitoulinoceras* of slender adapical fragments.

Types.—Holotype and three paratypes, collection of Dr. W. H. Shideler; also a suite of additional specimens referred to this species.

Occurrence.—From the lower Whitewater through the upper Whitewater and apparently in all stages of the Saluda. This species is recorded from many localities largely from the area of outcrop extending from the vicinity of Oxford to Madison, Indiana, though it is far more abundant in the northern half of this range, being known in the southern half only from three fragmentary shells. Probably also one specimen which Foerste described but did not figure, as *Manitoulinoceras lysander,* from the Hitz layer of Madison, Indiana, belongs to this species. At present, owing to the storage of types due to the present war, this specimen is not available for examination.

The holotype is from the middle Whitewater beds, though approaching the Saluda in lithology, from the eastern slope of Four Mile valley, opposite the mouth of Lil Brook, near Oxford, Ohio. Two distorted specimens from the cephalopod zone of the lower Whitewater, which show, however, the tranverse condition of the septa clearly, are from the cephalopod zone of the lower Whitewater of Little Four Mile Creek. The paratype illustrating the early stages is from the Saluda of Dodge's Creek near Oxford. Other specimens are from Big Sains Creek, near Laurel, Indiana, and Laughery Creek, Batesville, Indiana.

Manitoulinoceras gyroforme Flower, n. sp. Plate 21, figs. 12-14

This species can be readily distinguished from all others of this genus by the combination of shallow cameræ and a relatively strongly curved shell. The cross section is broadly rounded, depressed, and with the dorsum scarcely more flattened than the venter. The holotype increases from 15 mm. and 21 mm. near the base to 18 mm. and 25 mm. in the length of the phragmocone, 35 mm. ventrally and 22 mm. dorsally, and to 21 mm. and 27 mm. in the incomplete living chamber, measuring 27 mm. on the venter and 11 mm. on the dorsum. The radius of curvature of the shell is uniform throughout the type and is 45 mm. Expansion of the shell is constant in the type except where it appears to be greater at the very base of the specimen, an effect which is partly at least due to weathering. The sutures are straight and transverse to the curving axis of the shell, but are slightly inclined orad from dorsum to venter over the adoral portion. The cameræ are uniformly shallow, and the 16 present on the type average 2 mm. in depth on the venter.

The living chamber has a maximum ventral length of 31 mm. and fails to retain the aperture. The surface features and the siphuncle are not preserved.

Dicussion.—In all known features this is a typical *Manitoulinoceras* though more strongly curved than most other species. It can be most readily distinguished by the great curvature from the associated *M. moderatum,* as well as from the slightly curved Waynesville species. The curvature will also distinguish this from *M. lysander,* and indeed from all described species, *M. lysander* also has much more oblique sutures.

Types.—Holotype, collection of Dr. W. H. Shideler, Miami University.

Occurrence.—Saluda beds, from a tributary of Indian Creek near Oxford, Ohio.

Manitoulinoceras erraticum Plate 21, figs. 4, 5, 10; Plate 22, figs. 3-5

Two fragments of *Manitoulinoceras* from the upper part of the Richmond appear to represent an otherwise unknown species characterized by relatively deep cameræ, large size, and a rapidly expanding slightly curved initial portion followed by a tubular straight mature portion. The early part of the shell expands from 11 mm. and 14 mm. to 13 mm. and 19 mm. in a ventral length of 28 mm. The dorsum is straight in profile, the venter slightly convex, and in section the dorsum is broadly flattened and the venter more rounded. In this part of the shell the sutures are uniformly and very slightly inclined orad from dorsum to venter and are spaced four in a length of 10 mm. The mature part of the shell is shown on another specimen which consists of five cameræ and a portion of a living chamber. In the length of the five cameræ the shell increases from 20 mm and 26 mm. to 22 mm. and 29 mm., and the ventral length of this interval is 13 mm. The living chamber extends 29 mm. beyond the last septum, and adorally has a width of 28 mm., but a height, owing to slight flattening and perhaps also to weathering, of 18 mm. Three cameræ occupy a length of 9 mm.

The siphuncle lies close to the venter and is seen only on the smaller specimen.

Discussion.—This species is clearly recognized on the basis of the relatively deep cameræ, the large size, and the very slight curvature of the shell. The rapidly expanding portion of the conch persists to much greater diameters than in any other observed species, and the shell is considerably less curved. The marked flattening of the dorsum in cross section noted in the early stages is probably due to pressure rather than to an original condition, but distortion is relatively slight.

Types.—Holotype and paratype, collection of Dr. W. H. Shideler, Miami University.

Occurence.—From the upper Whitewater beds. The holotype is from Dodge's Creek and the paratype from McDill's Mills, near Oxford, Ohio.

Manitoulinoceras, sp. **Plate 23, figs. 7-9**

Two specimens of *Manitoulinoceras* in the upper Whitewater show well-preserved actinosiphonate deposits but are so flattened that it is uncertain whether they belong to *M. moderatum* or to an otherwise unknown species. Indeed, one fragment is so distorted that its position in *Manitoulinoceras* is not clearly demonstrable, and it is placed here because no other genus in the Richmond is known to exhibit such a slender shell in combination with such uniformly shallow cameræ. This fragment, 26 mm. in length, shows no curvature and is so flattened that the siphuncle appears near one edge of one of the two broader surfaces. In its present condition the shell increases from 8 mm. and 12 mm. to 9 mm. and 16 mm. The cameræ are very shallow, three occurring in a length of 5 mm. The sutures are apparently straight. The marginal siphuncle is well exposed by weathering and shows broad short rounded segments typical of *Manitoulinoceras* and in no way different from those of *M. moderatum* except that they contain well-defined actinosiphonate deposits consisting of a small number of simple rays similar to those of *Augustoceras*.

The second specimen is somewhat better preserved. It has a maximum length of 32 mm. and is incomplete basally. In the adoral 25 mm. it expands from 9 mm. and 14 mm. to 10 mm. and 14 mm. The shell has been flattened somewhat vertically but still shows a faint trace of curvature. The sutures are straight and transverse. At the middle of the specimen seven cameræ occur in a length of 10 mm. The siphuncle is exposed by weathering on the venter, showing broad segments, rounded and expanded within the cameræ, typical of *Manitoulinoceras* in form, but containing very clearly preserved actinosiphonate rays.

Discussion.—These poorly preserved specimens, and also a third which shows a lining of the siphuncle in a later growth stage but no rays, may be flattened individuals of *M. moderatum*, from which they cannot be distinguished on the basis of the present material. However, I refrain from identifying them in terms of any species largely because of the much distorted condition of the shells. They suggest that actinosiphonate deposits with well-defined rays and a very slight thickening of the connecting ring may have been developed adapically while adorally the rays were not developed gerontically, but instead the connecting ring became more thickened, especially at the region of the septal necks. Of these two specimens, the generic position of the first might be questioned because of the peculiar distortion. The second, however, which shows identical structure, clearly has all of the essential features of the phragmocone of *Manitoulinoceras*. *Kindleoceras* has such a strongly triangular section that flattened specimens would be expected to show some trace of it at least in the configuration of the sutures. Further, in the known *Kindleoceras* of the Richmond the sutures slope orad from dorsum to venter.

Figured specimens.—Collection of Dr. W. H. Shideler.

Occurrence.—From the upper Whitewater beds, from Dodge's

Creek and McDill's Mills, near Oxford, Ohio.

Manitoulinoceras ultimum Flower, n. sp. Plate 21, figs. 6-8

Conch only very slightly curved, depressed in section, and the dorsum slightly more flattened than the venter. The holotype has a ventral profile with a radius of curvature of at least 120 degrees ephebically, becoming perfectly straight in the gerontic portion as marked by the series of contracted cameræ. The holotype is 52 mm. in length. In the basal 32 mm. the shell increases from 12 mm. and 15 mm. to 18 mm. and 21 mm., and in the adoral 20 mm. the rate of expansion has decreased so that at the end of this interval the shell attains 20 mm. and 22 mm.

The cameræ are usually deep adapically but are replaced at a shell width of 21 mm. by a series of gerontic cameræ which are almost twice as closely spaced. Adapically five cameræ occur in a length equal to an adoral shell width of 19 mm.; adorally 11 or 12 cameræ occupy a length equal to a width of 22 mm. The septum is very flat basally and more curved gerontically. The sutures describe a broad lobe on the dorsal face and adapically a similar but broader lobe appears on the venter. Adorally the sutures are straight and transverse ventrally.

The siphuncle has been lost by weathering over the adapical part of the type, but the cavity remaining suggests that the segments were broad at the septal foramen, short, and expanded only slightly within the cameræ. Adorally the segments are somewhat better preserved where they appear very slightly narrower, much shorter, and as a consequence appear to be more broadly expanded within the cameræ. The filling of the adoral segments of the siphuncle shows that the connecting rings were somewhat thickened, particularly at the septal foramina, suggesting annulosiphonate deposits, and also reminiscent of the structures seen in a much less advanced condition of growth in *Manitoulinoceras medium*. Possibly farther apicad true actinosiphonate rays were developed. Nothing is known of the surface of the living chamber.

Discussion.—This species, the youngest known member of the genus *Manitoulinoceras,* shows marked gerontic phenomena; first, in the shortening of the adoral cameræ, and second, in the development of deposits within the siphuncle close to the living chamber. Other species of *Manitoulinoceras* in the Richmond fail to show any adoral shortening of the gerontic cameræ. Instead, such slight shortening as does occur is to be found in a much earlier part of the shell, and in one which is, unfortunately, not often found. In comparing this species with *M. medium*, it is apparent that the deposits of the siphuncle occur much farther orad in the shell and are much more strongly developed, a condition which is to be expected if actinosiphonate deposits are, as the writer has suggested, one of several methods of removing excess calcareous material in the gerontic stage.

The remarkable shortening of the adoral cameræ will distinguish this from all other *Manitoulinoceras*. Fragments of this species showing only one stage or the other might, however, be confused with other forms. The early part of the phragmocone is superficially similar to commensurate portions of *M. erraticum* but in that species comparable stages show a greater rate of expansion, slightly shallower cameræ, sutures which are straight ventrally instead of faintly lobed, and a siphuncle which is somewhat narrower.

Adoral parts of the shell would show about the same sort of shallow cameræ developed over wider regions of the shell in *M. williamsæ*, *M. tenuiseptum*, *M. medium*, *M. moderatum*, and *M. gyroforme*. Commensurate portions of *M. tenuiseptum* have dorsal saddles. *M. moderatum* has the sutures more transverse on the dorsum, *M. gyroforme* is more strongly curved, but *M. williamsæ* could probably not be distinguished with certainty on the basis of such fragments alone. The species are, however, quite distinct in range, and may be distinguished at a glance on the basis of reasonably complete specimens, for the cameræ are never deep adapically in *M. williamsæ*. The two have not been found in association and to all practical purposes stratigraphy is apparently a helpful guide here, for *M. williamsæ* is known only in the lower Waynesville while *M. ultimum* is upper Elkhorn.

Holotype.—Collection of Dr. W. H. Shideler, Miami University.

Occurrence.—From the upper Elkhorn, 2 miles west of Hamburg, Indiana.

Manitoulinoceras (?) irregulare (Wetherby)

Cyrtoceras irregulare Wetherby, 1881, Cincinnati Soc. Nat. Hist., Jour., vol. 4, p. 79, pl. 2, fig. 3; James, 1886, Cincinnati Soc. Nat. Hist., Jour., vol. 8, p. 246; Nickles, 1902, Cincinnati Soc. Nat. Hist., Jour., vol. 20, p. 93; Bassler, 1915, U. S. Nat. Museum, Bull. 92, vol. 1, p. 353.

This little known species is based upon a much crumpled specimen which it has not been possible to locate. Wetherby's original description is quoted:

Shell composed of short segments, nearly equal in length and size in the anterior third, gradually becoming shorter and smaller in the posterior two-thirds. It is moderately curved, the curvature not being well shown in the figure, which is a dorsal view. The specimen is slightly distorted by pressure, but evidences remain that it was somewhat elliptical in section from the shortening of the dorso-ventral diameter.

The irregularities in form, which are well shown in the figure, characterized, likewise, a specimen once shown to me at the University by the veteran paleontologist, C. B. Dyer, Esq., and which I instantly recognized as being this species. The two specimens are the only ones that have fallen under my observation. The siphuncle is dorsal and comparativly large.

The specimen figured, which has a small portion of the body chamber, consists of twenty-four septa, and measures 55 mm. in length. The body chamber measures 24 mm. in its greatest and 11 mm. in its least diameter. The opposite extremity measures 8 mm. and 5 mm. in the same diameters respectively. I collected this species in May, 1877, at Freeport, Warren County, Ohio, in the upper part of the Cincinnati group. It appears to be rare.

Discussion.—From the shallow condition of the cameræ and the evidently slight curvature, as well as the presumably depressed section, this is probably a species of *Manitoulinoceras.* It has been reported as Waynesville in range by Nickles and by Bassler. It is quite possible that it may be conspecific with one of the two species of *Manitoulinoceras* subsequently described, *M. tenuiseptum* (Faber) or *M. williamsæ* Flower, n. sp. However, it is greatly to be feared that even were the type available, it would prove too poorly preserved to be regarded as definitely conspecific with either of these species which are associated in the Waynesville. Further, it is not certain that the specimens upon which Nickles and Bassler based their determination of the horizon of this species included the type which cannot be located. *Manitoulinoceras* has been found in the trilobite beds of the Waynesville crushed in a manner suggesting Wetherby's figure but may be distorted similarly in other horizons.

Type.—Location unknown.

Occurrence.—"Upper part of the Cincinnati group, at Freeport, Warren County, Ohio, in the upper part of the Cincinnati group."

Genus STAUFFEROCERAS Foerste

Genotype.—*Cyrtoceras featherstonehaughi* Clarke.

Staufferoceras Foerste, 1933, Denison Univ. Bull., Sci. Lab., Jour., vol. 28, pp. 130-131.

Conch cyrtoconic, exogastric. Section depressed, the dorsum strongly flattened and the venter more broadly rounded or subangular. The living chamber is slightly contracted at the aperture and may be slightly inflated near its base. The sutures are slightly oblique being inclined orad from dorsum to venter. The siphuncle is made up of expanded segments and is located close to the venter. The shell is strongly curved but shows much variation in rate of expansion and the condition of the mature living chamber, as well as in cross section.

Discussion.—Not much information is available to serve as the basis of differentiating this genus clearly from *Manitoulinoceras* which agrees with it in being exogastric, sometimes subtriangular in section, but which differs mainly in that the shell is always very slender and the sutures are always very closely spaced. Probably additional differences may be found in the siphuncles, but the Cincinnatian species concerned has not yielded siphuncles well enough preserved to study by means of sections.

The relationship of this genus is obscure. It might belong to the Valcouroceratidæ, but definite evidence of actinosiphonate structure is lacking in the genus, and this conclusion is reached solely upon the basis of the form of the shell, which in some respects seems to be transitional between *Augustoceras* and *Kindleoceras*. However, it might also belong to the large group of cyrtoconic genera of which the Oncoceratidæ form the nucleus, in which the siphuncle was free from organic deposits, and in which the section departed sometimes from the supposedly primitive compressed condition to a circular or depressed one. However, so little is known of the internal structure of many such genera, including *Loganoceras, Staufferoceras, Romingeroceras, Schofieldoceras, Ehlersoceras,* and *Fayettoceras,* that their relationship to other cephalopod genera is uncertain. At the present time the available information suggests that these forms had relatively small empty cyrtochoanitic siphuncles, but in some cases the siphuncle is not known at all, and in others it has apparently been examined only from weathered internal molds, not always satisfactory for preservation of the organic deposits which have such great taxonomic significance.

The genus is thus far known only from the genotype, which occurs in the Platteville limestone at Minnesota, and the Richmond species described below.

Staufferoceras subtriangulare Foerste, n. sp. Plate 24, figs. 5-7

This is known only from a single specimen. The shell is small and rather strongly curved. The section is subtriangular, being flattened dorsally, and having a rounded ventral keel. The shell increases from 11 mm. and 17 mm. to 16 mm. and 19 mm. in the 38 mm. of the phragmocone as measured ventrally, and to 18 mm. and 21 mm. at the adoral end of the living chamber which is complete laterally where the length is 13 mm. The ventral length, incomplete, is 16 mm. The radius of curvature of the ventral profile in this length is 35 mm. over the phragmocone but 33 mm. over the living chamber, which is faintly gibbous just above its base and then less curved to the aperture.

The sutures describe broad shallow lobes on the flattened dorsal surface and slope orad from the rounded lateral angles to the venter. The nine preserved cameræ are relatively deep and range from 2.5 mm. to 4 mm. in length on the venter. The septa are not exposed. The siphuncle, seen only at the base of the specimen, is small and close to the venter.

Discussion.—This species can be distinguished from other Cincinnatian cephalopods by the characters of the genus.

Holotype.—Collection of Dr. W. H. Shideler, Miami University.

Occurrence.—From the lower Whitewater beds, of Little Four Mile Creek, near Oxford, Ohio.

Family DIESTOCERATIDÆ Teichert (emend.)

The family Diestoceratidæ is employed here for the reception of compressed brevicones with cyrtochoanitic siphuncles, typically with discrete rather irregular actinosiphonate deposits. The shells are more or less contracted to the aperture where a hyponomic sinus is developed. The conchs often appear straight but usually show some trace of endogastric curvature. Sometimes this is shown in the curvature of the early stages of the phragmocone, again it may be indicated only by the sutures which are typically somewhat more closely spaced on the venter than on the dorsum.

At the present time only two genera are included in this family, *Diestoceras* and *Danoceras*. *Diestoceras* was originally used for gibbous straight to faintly endogastric shells, and as such has been stretched to include a large number of Ordovician species which vary considerably in aspect and internal structure. *Hyperoceras* Foerste is a synonym of *Danoceras,* which is more slender and is characterized by having more slender segments of a characteristic form. However, on the basis of shell form *Diestoceras* and *Danoceras* are so closely allied that it is questionable to which some species should be referred. Possibly a clearer distinction can be found on the basis of the form of the segments of the siphuncle, but in the present state of our knowledge this is impractical, because the siphuncles are not known for a number of the borderline species.

Early stages of both genera have not been available for study. However, since the segments of the siphuncle do become simpler adapically and are simpler in small species than in large ones, it is suspected that the same relationship holds here which was found in *Valcouroceras,* and that the Diestoceratidæ represents another family of the secondarily cyrtochoanitic cephalopods. As such, it may be readily differentiated from the Allumettoceratidæ which are depressed and not at all breviconic. The Oncoceratidæ and Valcouroceratidæ are compressed but both are exogastric groups. The Valcouroceratidæ have actinosiphonate deposits but of a type more regular than those of the Diestoceratidæ. No deposits are found in the siphuncles of the Oncoceratidæ.

Teichert (1939, p. 107) proposed the Diestoceratidæ as a family of the Actinosiphonata defining it as containing "either straight or slightly curved brevicones," and including in it *Diestoceras, Wetherbyoceras, Herkimeroceras,* and *Pachtoceras.* The writer (Flower, 1943) has presented evidence which leads him to believe that the Actinosiphonata are polyphyletic, and that actinosiphonate structure appeared at various times in a number of distinct lines of descent in the cephalopods. Further, it does not appear that the genera which Teichert placed in the Diestoceratidæ are demonstrably related. *Diestoceras* has endogastric tendencies and highly distinctive actinosiphonate deposits. Different types of deposits are found in the exogastric *Augustoceras,* which has essentially the features attributed to *Wetherbyoceras* by Foerste, and belongs in the Valcouroceratidæ. *Wetherbyoceras,* as noted in connection with the Valcouroceratidæ, is abandoned for nomenclatorial reasons. The affinities of the Devonian genera, *Herkimeroceras* and *Pachtoceras,* are admittedly certain but there does not seem to be clear evidence connecting them with *Diestoceras*. *Herkimeroceras* Foerste occurs in the Upper Silurian and Lower Devonian. It is a depressed exogastric cyrtoceracone with a slender living chamber. The ventral siphuncle is broadly expanded within the cameræ and possesses well-developed actinosiphonate deposits. If it is to be traced to any Ordovician genus, *Manitoulinoceras* of the Valcouroceratidæ is probably the best candidate for its ancestor. *Pachtoceras* Foerste of the Upper Devonian is a straight depressed brevicone, peculiar in that the actinosiphonate siphuncle is relatively far from the wall of the shell. Its affinities are uncertain, but while the genus resembles *Diestoceras* in form, except in being depressed instead of compressed and is not known to have a hyponomic sinus, its affinities are admittedly uncertain.

Unfortunately, while a considerable series of species and a good supply of specimens represent this family in the Cincinnatian, many of the specimens are so poorly preserved that the internal structure is lost. As a consequence, much more remains to be learned concerning the structures of the siphuncle in this family. The extant material suggests that *Diestoceras* possesses deposits which are irregular, but essentially similar to those found in the earlier and simpler of the Valcouroceratidæ. Indeed, the internal structure found in *Diestoceras cyrtocerinoides* is so similar to that exhibited by *Valcouroceras seeleyi* (Ruedemann) and allied species of the Chazyan, that I at first believed the species to belong to that genus, but later removed it to *Diesoceras* on the basis of its evident endogastric tendencies. It supplies the only evidence, however, serving to connect the Diestoceratidæ with any other family. Inasmuch as these shells are compressed cyrtoceracones with cyrtochoanitic siphuncles which are marginal and show some slight simplification of outline when traced from the later to the younger stages, it appears that they might join the Oncoceratidæ and Valcouroceratidæ. *D. cyrtocerinoides* by its internal structure, lends some support to this view. In *Danoceras* the segments of the siphuncle are relatively slender and simple and possess only vestiges of annulosiphonate deposits. Only in the larger species of *Diestoceras* is the actinosiphonate structure well developed. The same relationship which is found in the various species of the Chazyan *Valcouroceras* but which is lost tachygenetically in the higher Valcouroceratidæ appears to persist into the Richmondian and youngest of the species of the Diestoceratidæ.

On the basis of the gross features of the shell no clear distinction exists between *Diestoceras and Danoceras.* Typical *Diestoceras* expands rapidly and contracts strongly toward the aperture. Typical *Danoceras* presents a very different aspect, because the initial part of the shell expands very gradually, and the contraction near the aperture is relatively slight. However, the described species supply a series of forms showing such gradation of form from one extreme to the other that no clear distinction can be drawn on this basis. A clear distinction seems to exist on the basis of the form of the segments of the siphuncle, but the siphuncles are not known for those species which intergrade on the basis of form.

Genus DIESTOCERAS Foerste

Genotype.—*Gomphoceras indianense* Miller and Faber.

Diestoceras Foerste, 1924, Denison Univ. Bull., Sci. Lab., Jour., vol. 20, p. 262; Foerste, 1926, *ibid*, vol. 21, p, 326; Troedsson, 1926, Meddeleser om Grønland, vol. 71, p. 99; Foerste and Savage, 1927, Denison Univ. Bull., Sci. Lab., Journ., vol. 22, p. 86; Foerste, 1929, *ibid.*, vol. 24, p. 225: Foerste, 1933, *ibid.*, vol. 28, p. 142; Foerste, 1935, *ibid.*, vol. 30, p. 61; Roy, 1941, Field Mus. Nat. Hist., Geol. Mem., vol. 2, p. 151.

This large genus is characterized mainly by the form of the shell, which is compressed and which may be faintly endogastric or straight adapically but is strongly gibbous adorally, the shell usually attaining its greatest height and width close to the base of the living chamber and then contracting toward the aperture which has a hyponomic sinus but is otherwise straight and transverse.

The sutures are typically transverse, the cameræ slightly deeper on the dorsum than on the venter, but lateral lobes are poorly developed if at all discernible. The siphuncle lies close to the ventral side. The segments are broadly expanded, subquadrate in section, and usually more or less scalariform in outline. The necks are short and abruptly recurved. The connecting ring is broadly adnate beyond the tip of the neck on the dorsum but is free on the venter. The ring then swings apicad, sometimes being curved, as in *D. cos,* and again being nearly straight as in *D. indianense* and *D. scalare* of Anticosti, in both of which the segments of the siphuncle appear strongly scalariform and subquadrate in section. At the adapical end of the segment the ring joins the septum at the edge of the foramen on the dorsum, but well outside of it ventrally, so that a broad area of adnation is developed on that side of the shell. Deposits within the siphuncle begin as small annulosiphonate rings derived from the adapical end of the connecting ring which extends inside the neck of the adapical septum nearly to the tip. These deposits then give rise to irregular linear processes which extend apicad and orad of the original annulosiphonate mass. The structure is essentially actinosiphonate but irregular and quite characteristic. The deposits never form a series of rays which may appear to continue from segment to segment as in some other actinosiphonate types. Faint cameral deposits in the gerontic stage may produce shallow linear impressions on the internal molds of the phragmocones.

The aperture is commonly bent inward in this genus and is commonly preserved as a band of black carbonaceous material. This is suggestive of the black deposit of the hood of *Nautilus* but probably has no such significance in *Diestoceras,* as many pelecypods are preserved completely by a similar carbonaceous substance. Apparently it represents an excess of conchiolinous matter in the shell at this region.

Discussion.—Diestoceras is a very large genus, about 40 species having been placed in it from the American Ordovician alone. These species range from the Chazyan through the Richmond and include small as well as large forms. The internal structure of the siphuncle is known for probably not more than a half dozen of these species. The typical broadly expanded scalariform segments and actinosiphonate deposits occur in the larger species but have not been observed in the smaller ones. The small and medium-sized species agree in being compressed straight or faintly endogastric brevicones, but differ in the extent of gibbosity, the position of gibbosity in relation to the base of the living chamber, and in the pattern of the sutures. Also, among these species there is apparently considerable variation in the form of the segments of the siphuncle, some segments being elongate and relatively slender while others are more broadly expanded.

Among these smaller species there are a number which approach very close to *Danoceras* Troedsson in form. A number of the smaller species of the Cynthiana and Leipers have been placed in *Danoceras,* particularly since one of them shows a siphuncle which is typical of that genus in the form of its segments. Some of these are related to species from other regions which have been placed in *Diestoceras.* The siphuncles of these species are not known, but it is highly probable that such species might better be placed in *Danoceras.* From the few siphuncles which are known in the species of the two genera, the form of the segments of *Danoceras* and *Diestoceras* appear to be very distinct. However, gradation may be found with the study of the internal structure of more species. Further, a few forms show simple elongate ovoid segments which are properly typical of neither genus. These species are tentatively retained in *Diestoceras.*

Diestoceras is not, in its present state, a very satisfactory genus. Possibly it can be subdivided with further study, but data for such procedure are lacking at the present time. Typical forms are the large essentially straight brevicones represented in the Cincinnatian by *D. waynesvillense, D. indianense, D. eos, D. shideleri,* and *D. attenuatum. D. scalare* of Anticosti is typical and is quite similar in form of its siphuncle to *D. indianense,* though Foerste (1926, p. 326) at one time suspected that this form might be atypical. At that time the segments of *D. indianense* were not known. *D. strangulatum* Foerste of the Vaureal formation and *D. arenicolum* Foerste of the Ellis Bay formation are typical *Diestoceras.* Other Anticosti species are smaller and not really typical in form. *D. anticostiense,* on the basis of the strong lateral lobes and strong saddles, appears to be a *Danoceras.* *D. vagum* and *D. carletonense* of the English Head formation are smaller more generalized species, which remain in *Diestoceras* on the basis of the form of the shell, but apparently belong to a group of small slender forms quite distinct from the large species which comprise the nucleus of the genus. *D. obesum* Foerste, also of the English Head formation, is small but more typical of the genus in its strong gibbosity.

The Whitehead formation of Gaspé has yielded *D. gaspense,* *D. brevidomum,* and *D. subglobosum,* large strongly gibbous species, but the slender and smaller *D. cooperi* is atypical and may be as easily placed in *Danoceras.*

In the boreal faunas of Red River affinities the largest species are found. The Cape Calhoun formation has yielded *Diestoceras pyriforme,* an almost globose form, which has markedly developed actinosiphonate deposits and subquadrate siphuncular segments.

The "Richmond" of Frobisher Bay has yielded a bulbous *D. schucherti* Foerste and the larger *D. milleri* Roy. The Ordovician of Hudson Bay has yielded *D. tyrrelli* Foerste and Savage, a form faintly reminiscent of our *D. attenuatum,* from the Shamattawa limestone, and an unnamed form, known from a distorted phragmocone in the Nelson limestone, which appears to be one of the typical northern globose forms.

The Red River formation of Lake Winnipeg has yielded the giants of the genus, *D. nobile* (Whiteaves) being perhaps the largest known brevicone. The other species are typical of the group including the genotype. These are *D. whiteavesi* Foerste, a small form but one quite typical in shape, and one characterized by broad segments of the siphuncle and an incurved aperture, *D.*

(?), sp., also with a typical aperture, the subglobose *D. gibbosum* and *D. apertum*, which is more similar to *D. shideleri* and *D. indianense* than most of the Red River species.

The Bighorn formation has yielded the large *D. magister*, a form with a relatively slender phragmocone and a domelike living chamber, *D. landerense*, a moderate-sized form, and *D. flexuisutile* Miller, a species which is atypical in the large siphuncle and may be a *Landeroceras*. Smaller species are *D. fremontense* Foerste, *D. kirki* Foerste, *D. occidentale*, and a very slender form which is atypical of any known genus, *D. walcotti* Foerste, described from the Fremont limestone of Colorado.

The Middle Ordovician species of North America are inadequately known, indeed a considerable series of species, largely from the Trenton of Quebec, now await description. The two Chazyan species described by Foerste (1938) from the Mingan Islands of Quebec, one as *Diestoceras*, sp., the other as *D. maccoyi* (Billings), are small slender shells known only from exteriors. They are far from being typical members of the genus in form but fit there better than in any other genus described at the present time. I have not encountered *Diestoceras* in the Chazyan of the Champlain Valley. The Black River and Trenton beds have yielded a few species, all small and atypical. *D. alceum* (*Hall*) occurs in the Platteville beds (Foerste, 1928, p. 209, pl. 44, fig. 3A-B). This is a small slender form which might as easily be placed in *Danoceras*, although its weathered siphuncle shows segments which are too large and too broad for that genus. *D. clarkei* Foerste (1929, p. 314, pl. 47, fig. 5) of the Galena of Minnesota is smaller and more slender than typical species of *Diestoceras* but closer to them in form. *D. romingeri* Foerste (1933, pl. 34, 1933, p. 145) is a species which is scarcely contracted adorally and appears to be closer to *Danoceras* than to *Diestoceras* on the basis of the form. *D. cornellense* Foerste (1932, pl. 35; 1933, p. 145) of the Cornell member of the Trenton of Michigan is a small species but a gibbous one, differing in form from typical species mainly in the production of the aperture.

The single Maquoketa species *D. staufferi* Foerste belongs to the globose group of arctic species but is atypically small. The absence of species in the Maquoketa similar to those of the Whitewater of Cincinnati is surprising.

The genus is present in Europe, though it is less well known. The only typical form is *Diestoceras stensioi* (Troedsson, 1926) of the Lykholm formation of Esthonia. This form, which is quite similar to *D. eos* and *D. indianense* in general aspect, was originally described as a *Cyrtogomphoceras,* probably because of the markedly endogastric condition of the apical part of the phragmocone. Strand (1934) has described three species of the Oslo region in terms of the genus *Diestoceras,* all of which are relatively small and only faintly gibbous forms. Of these, *D. stormeri* is probably the most typical, having a well-rounded living chamber. *D. isotelorum* expands fairly rapidly but the aperture is only slightly contracted. *D. acuminatum* has a more slender phragmocone but the living chamber becomes rounded and contracts adorally as in *Diestoceras.* However, all these three are among the group of species which border upon *Danoceras.* Strand also notes other European species belonging to *Diestoceras* or *Danoceras.* He doubtfully assigns *Poterioceras intortum* Blake of the English Bala group to *Diestoceras* and notes that in Bohemia *Gomphoceras primum* Barrande of horizon D5 is either a *Danoceras* or a *Diestoceras.* This is a moderately gibbous species. The siphuncle on Barrande's specimen is lost by weathering and shows as an imperfect external mold. Its segments seem to be quite slender and more consistent with placing this species in *Danoceras* than in *Diestoceras.*

The Cincinnatian species likewise form a heterogeneous group. Closely allied are the large Whitewater forms which may be briefly diagnosed as follows:

D. indianense.—A shell with a nearly straight rather short living chamber, little contracted adorally. The phragmocone is concave adapically on the venter, strongly convex dorsally. Sutures moderately close. Lower Whitewater, Saluda, and probably upper Whitewater.

D. eos.—A larger form, living chamber nearly symmetrical, gibbous, contracting more strongly toward the aperture. Early stages slender, then rapidly expanding, becoming concave, and then convex in profile. Gibbosity best developed shortly orad of the base of the living chamber. Lower Whitewater and Saluda.

D. shideleri.—A large form, living chamber comparable in length with *D. eos*, but less gibbous, only slightly contracted toward the aperture. Phragmocone with exceptionally deep cameræ; early part curved as in *D. indianense.* Lower Whitewater, Saluda, upper Whitewater. A form similar to this is found in the Elkhorn.

D. attenuatum.—A smaller species, nearly straight, with a long living chamber and a rather slender phragmocone with deep cameræ. Not markedly curved.

D. waynesvillense.—Phragmocone nearly symmetrical as in *D. eos*, but the living chamber is slender, as in *D. shideleri*, only much smaller.

D. cyrtocerinoides.—A small rapidly expanding phragmocone in outline similar to *D. eos*, but differing in cross section and in the spacing of the cameræ. This occurs in the Hitz bed at Madison, Indiana.

The remaining species are small, atypical and remain in *Diestoceras* largely because no better resting place has been provided for them, and they are insufficiently known to serve as genotypes.

D. sp. (Flower, 1941).—Cynthiana limestone, Cynthiana.

D. edenense.—A tiny top-shaped shell of the Eden, typical in form, but a miniature edition of the genus. Its siphuncle is not known.

D. bettinæ.—A Fairmount species peculiar in the low position of gibbosity and the conical contraction of the entire living chamber.

D. vasiforme Flower.—A slender form, apparently from the Saluda, close to *Danoceras* in form, but placed in *Diestoceras* largely on the strength of the low gibbosity and the absence of any decisive characters or strong resemblances to described species.

D. pupa.—A tiny species of the Hitz fauna, inadequately known, but typical of the genus in being a straight compressed brevicone.

D. reversum.—A Saluda form peculiar in that the cameræ are deeper on the ventral than on the dorsal side. This is another atypical form without close relatives.

Diestoceras indianense (Miller and Faber)

Plate 36, figs. 1-3; Plate 41, figs. 10, 11

Gomphoceras indianense Miller and Faber, 1894, Cincinnati Soc. Nat. Hist., Jour., vol. 17, p. 137, pl. 7, fig. 3-5; Harper and Bassler, 1896, Cat. Foss. Trenton and Cincinnati Periods occurring in the Vicinity of Cincinnati, Ohio, Cincinnati, p. 27; Nickles, 1902. Cincinnati Soc. Nat. Hist., Jour., vol. 20, p. 93; Cumings, 1908, Indiana Dep. Geol. Nat. Res., Ann. Rep. 32, p. 1030, pl. 19, fig. 4, 4b; Bassler, 1915, U. S. Nat. Mus., Bull. 92, vol. 1, p. 560.

Diestoceras indianense Foerste, 1924, Denison Univ. Bull., Sci. Lab., Jour., vol. 20, p. 263 (*pars*), pl. 25, fig. 1A-B; pl. 26, fig. 2A-B. (Not pl. 26, fig. 1A-B.)

The holotype of this species is missing, and not one of the specimens of *Diestoceras* available for the present study agrees with the original figure in combining the shell size indicated with the depth of the cameræ shown. However, a series of specimens which constitute a species agree quite closely with the original description in the proportions of the living chamber, and *D. indianense* is recognized here, though of necessity tentatively, pending the rediscovery of the type specimen. These forms differ from the original illustration mainly in possessing deeper cameræ. It may be that the cameræ have been represented as too closely spaced on the original drawing. Their spacing is not emphasized in the original description. Nevertheless, inasmuch as *indianense* is the genotype of the widely known genus, *Diestoceras,* it seems best to retain the name particularly in view of the fact that the characters of *Diestoceras* will not be altered at all on the basis of the question as to which of the large *Diestoceras* species of the upper Richmond is properly the genotype.

Description.—The shell is compressed in section, the venter slightly more narrowly rounded than the dorsum. In profile the venter is slightly concave adapically, becoming straight and then faintly convex as the base of the mature living chamber is approached. Over the living chamber the venter is convex and approaches the dorsum gradually at the aperture. The dorsal profile is convex adapically and more uniformly curved, though becoming slightly less curved in the adoral half of the living chamber. The sides are slightly convex in profile, more curved adapically than adorally. The greatest shell width is attained at or slightly apicad of the base of the living chamber; the greatest height occurs just orad of the base of the living chamber.

The early part of the shell is displayed in a specimen, essentially a topotype, shown on Plate 41, figs. 10-11. Eight cameræ are preserved, the phragmocone being 52 mm. long dorsally and 43 mm. ventrally. Except for the last camera, which is shortened gerontically, these increase gradually in depth orad. The phragmocone in this length increases in height from 25 mm. to 53 mm. The dorsal wall of the shell continues for 35 mm., but the aperture is evidently not attained. The siphuncle, clearly shown here, is composed of broadly quadrangular segments, which are scalariform very much as in *Diestoceras scalare* of the Richmond (Vaureal) of Anticosti. The necks are strongly recurved on the dorsum, much more so than on the venter. At the adapical end of the siphuncular segment the connecting ring is broadly adnate ventrally but not dorsally. This specimen shows annuli at the septal foramen which give rise to irregular actinosiphonate processes, though these processes have not been observed to be as complexly developed as in *D. scalare*.

Another specimen (Univ. of Cincinnati, No. 24480, pl. 36, fig. 3), though flattened on one lateral surface, displays the same profile and retains a complete living chamber. The phragmocone retains seven ephebic cameræ and one gerontic. In the adoral six cameræ, which occupy dorsal and ventral lengths of 38 mm. and 30 mm. respectively, the height of the shell increases from 34 mm. to 51 mm. The living chamber has a length of 42 mm., increasing to a maximum height of 53 mm., and contracting toward the aperture. At the aperture the shell is retained as a carbonaceous film and bends strongly inward, a feature characteristic of most *Diestoceras*. The height of the aperture is estimated at 45 mm., but it is not quite complete ventrally.

A third specimen retains the original propositions more closely (Univ. of Cincinnati, No. 24479, Pl. 36, figs. 1,2) but has been flattened very slightly obliquely. The phragmocone of six cameræ has a ventral length of 34 mm., a dorsal length of 36 mm. The living chamber increases from 51 mm. and 56 mm. to 52 mm. and 57 mm. shortly above its base and contracts to a slightly distorted aperture estimated at 40 mm. and 32 mm. The length is between 38 mm. and 40 mm. The phragmocone increases from 44 mm. and 40 mm. to 56 mm. and 51 mm. This specimen appears less curved and shows an angular bend separating the expanding part of the shell from the contracting living chamber. These are regarded as the results of slight distortion. In section, this form shows the ventral siphuncle but its outline is poorly preserved, represented only by faintly darker material, and while the structure is not particularly clear there is indication of segments similar to those shown in the first of the specimens discussed above and also of faint actinosiphonate deposits. The septa, as can readily be seen, are broken and displaced slightly internally.

Discussion.—Diestoceras indianense was originally separated from *Diestoceras eos* largely upon features which are unnatural and are largely due to the distortion of the holotype of *D. eos*. However, Miller and Faber present measurements of the living chambers of a specimen which they recognized, probably correctly as *D. eos* and also measurements of their type. It is evident from these that *D. indianense* has a mature living chamber which is considerably shorter than that of *D. eos* and also somewhat smaller in both height and width. Further, in *D. indianense* the ventral side of the phragmocone is evidently either straight or slightly concave, while in typical *D. eos* it is only slightly less curved and less convex than is the dorsum. The original figure of *D. indianense* represents the species as possessing extremely shallow cameræ. Since the type cannot be located the accuracy of the drawing could not be checked. However, the presence of a number of specimens which agree in other features with *D. indianense*, but possess slightly deeper cameræ, suggest very strongly that the drawing was inaccurate in this matter. Two of the three specimens studied by the writer are from the Faber Collection in the University of Cincinnati Museum. These are apparently not, on historical evidence, any of the specimens upon which the original description was based. Such specimens were a part of Faber's first collection, sold to the University of Chicago, which has one unfigured specimen of this species indicated as a "cotype." The Faber specimens in the University of Cincinnati collections were obtained at a later date from Little Four Mile Creek, a locality not mentioned in connection with the original description of *D. indianense.* The one topotype was collected by the writer in the Saluda at Versailles in 1938.

D. shideleri is a somewhat more slender form with a less gibbous living chamber and in which the cameræ are somewhat deeper and the living chamber considerably longer. *D. eos* is a larger and more gibbous species with a much longer and more gibbous living chamber. One of the specimens which Foerste (1924) figured as *D. indianense* (Foerste, 1924, pl. 26, fig. 1A-B) is atypical and is here referred to *D. eos,* as it has the longer and more inflated living chamber which characterizes that species.

Types.—Holotype, location unknown. Paratype, Univ. of Chicago (unfigured), No. 8818. Hypotypes, Univ. of Cincinnati Nos. 24479, 24480.

Occurrence.—The holotype is from Versailles, Indiana, from an unspecified horizon probably either lower Whitewater or Saluda. Hypotypes are from the lower Whitewater of Little Four Mile Creek, near Oxford, Ohio, and from the Saluda of Versailles, Indiana. I have not been able to recognize the species from any specimens of the upper Whitewater or Elkhorn beds.

Diestoceras eos (Hall and Whitfield)

Plate 34, figs. 1, 6; Plate 35, fig. 9; Plate 37, fig. 10; Plate 38, fig. 7; Plate 39, fig. 10

Gomphoceras eos Hall and Whitfield, 1875, Ohio Geol. Surv., Paleontology, vol. 2, p. 100, pl. 3, fig. 5; Ulrich, 1880, Cat. Foss. occurring in the Cincinnati Group of Ohio, Indiana and Kentucky, Cincinnati. p. 21; James, 1886, Cincinnati Soc. Nat. Hist., Jour., vol. 8, p. 244; Harper and Bassler, 1896, Cat. Foss. Trenton and Cincinnati Periods occurring in the Vicinity of Cincinnati, Ohio, Cincinnati, p. 27; Nickles, 1902, Cincinnati Soc. Nat. Hist., Jour., vol. 20, p. 95; Bassler, 1915, U. S. Nat. Mus., Bull. 92, vol. 1, p. 560.

Diestoceras eos Foerste, 1924, Denison Univ. Bull., Sci. Lab., Jour., vol. 20, p. 265, pl. 28, fig. 1A-B.

Diestoceras indianense (*pars*) Foerste, 1924, *ibid.*, p. 263, pl. 26, figs. 1-2.

Diestoceras cf. indianense Foerste, 1924, *ibid.*, p. 265, pl. 27, fig. 2.

The holotype of *Diestoceras eos* is a shell which has been widened greatly by flattening. The specimen is 117 mm. long. Of this length the basal 11 mm. represents a septal surface the curvature of which has been greatly exaggerated by flattening. The phragmocone has a basal width of 41 mm. Its length is 45 mm.

on the supposed dorsum and 40 mm. on the supposed venter. Orientation is assumed here by the fact that in undistorted specimens of *Diestoceras* the septa are characteristically shorter on the venter. The phragmocone contains seven cameræ which vary slightly and irregularly in length. At the base of the living chamber the shell is 70 mm. across. About 25 mm. above the base the maximum width of the shell, 75 mm., is attained. The aperture is obscure, but at the adoral end of the living chamber the width is 58 mm.

The original shape of the shell is probably most closely approximated in the specimen which Foerste (1924, p. 26, fig. 1A-B) figured as *D. indianense* (Pl. 34, fig. 6). The dorsum is slightly and uniformly convex, the venter is faintly concave adapically owing to the rapid development of the gibbous area, and more strongly convex than the dorsum over most of the specimen. The greatest height and width are attained slightly orad of the base of the living chamber. The phragmocone, consisting of eight normal and one gerontic cameræ, occupies a ventral length of 48 mm. and a dorsal length of 51 mm. In this interval the shell increases from a height of 33 mm. and a width of 29 mm. to a height of 60 mm. and a width of 52 mm. The living chamber has a ventral length of 39 mm., owing to the deep hyponomic sinus, and a length elsewhere of about 43 mm. The aperture, measured just prior to its abrupt rounding inward, has a length of 50 mm. and a width of 37 mm., but is slightly compressed by pressure. The hyponomic sinus is well developed. The septum at the base of the specimen exposes the siphuncle close to the siphonal side of the shell. The phragmocone bears faint linear impressions interpreted as the molds of cameral deposits.

A second specimen figured by Foerste, as *D. cf. indianense* (Foerste, 1924, pl. 27, fig. 2) fails to expose the phragmocone but shows the surface of the shell on the dorsum as well as the shape of the early part of the shell. The septum is 90 mm. in length, expanding from 18 mm. near the base to 58 mm. in a length of 55 mm. In this length gibbosity is attained, the shell expanding rapidly so that the sides become faintly concave adapically. Farther orad, the sides become convex. Adorally the shell is incomplete. (Pl. 39, fig. 10.)

A slightly atypical specimen (Pl. 34, fig. 1) represents a shell which has been flattened obliquely so that the venter is slightly to the left of the center of the best preserved side. This shell expands from a widh of 42 mm. to 64 mm. in the length of the phragmocone which contains ephebic cameræ and one gerontic camera. The cameræ are shallower basally and deeper adorally than in other specimens of the species. The living chamber has a ventro-lateral length of 43 mm. and displays the hyponomic sinus clearly. The aperture in its present condition has a width of 55 mm. The living chamber attains its greatest width of 65 mm. slightly above its base. The internal mold retains traces of the growth lines which swing apicad on the venter forming the hyponomic sinus.

Another specimen shows a somewhat broader and more gibbous phragmocone, a feature which is regarded as the result of slight distortion, as the specimen was found nearly vertical in the bed from which it came. This shell has a phragmocone of nine cameræ, the last gerontically shortened, expanding from 44 mm. and 38 mm. to 64 mm. and 59 mm. The living chamber is incomplete but extends 35 mm. farther orad. (Pl. 37, fig. 10.)

Several portions of phragmocones doubtfully assigned to this species have been sectioned. None shows the siphuncle with particular clarity. However, they are adequate to show that the segments are typical in form, being essentially rectilinear in section and scalariform. They are broadly adnate to the septum adorally on the venter and adapically on the dorsum. Deposits are present in the siphuncle. These begin as annuli at the septal foramen but subsequently send out irregular processes which extend orad and apicad of the original annulosiphonate ring.

Discussion.—Much perplexity has attended the determination of the limits of this species, owing largely to the varied effects of distortion upon the shells. Indeed, no two specimens have been found showing precisely the same proportions. This is in part due to the different positions in which the various shells were buried and the different directions in which flattening has consequently occurred. Most of the specimens are from the arenaceous shales of the lower Whitewater beds in which shells are usually more or less distorted. Further, among these specimens there is indication of apparent lengthening and sometimes contraction of the length of the cameræ. This condition cannot occur in the flattening of a normal shell but may occur if the shell is first dissolved and its mud-filled internal mold is distorted. Similar phenomena have been observed in the associated *Charactoceras baeri.*

Foerste (1924) was in some doubt as to the validity of a distinction between *D. indianense* and *D. eos.* He figured the badly flattened holotype of *D. eos* but did not recognize any other specimens as conspecific. He did figure a considerable suite of specimens as *D. indianense,* all of which were relatively well preserved. With a larger series of specimens available for study, it was possible to trace a series showing progressive flattening of the shell from a relatively unaltered shell to the holotype. On the basis of such specimens I have included under *D. eos* some of the specimens which Foerste figured as *D. indianense.* Miller and Faber (1894) correctly recognized that their holotype of *D. indianense* was distinct from *D. eos* having considerably smaller maximum diameters and a somewhat shorter living chamber. Further differences are found in the shape of the shells. In *D. indianense* the venter is distinctly concave adapically, and the living chamber is relatively slender, not being so strongly inflated nor so strongly contracted as it approaches the aperture. Further, the cameræ in *D. indianense* are more uniform in depth, the phragmocone expands more gradually, without developing concave lateral profiles, and the venter is almost uniform in its curvature throughout the phragmocone, though becoming typically slightly less curved along the living chamber.

D. shideleri, on the other hand, is a species which approaches *D. eos* in size but retains the concave venter of *D. indianense* in the early part of the shell. Its cameræ are appreciably deeper than those of ephebic *D. eos,* and the living chamber is much less gibbous. Admittedly, badly distorted specimens cannot sometimes be assigned either to *D. eos* or to *D. shideleri* with absolute certainty, particularly as distortion may apparently elongate specimens of *D. eos* so that their cameræ approach those of *D. shideleri* in length. However, in such flattened specimens the more slender living chamber of *D. shideleri* serves usually to distinguish the species, for in flattened *D. eos* the living chamber contracts strongly toward the aperture.

In view of the distorted condition of most specimens of *D. eos* it is difficult to draw a clear distinction between it and species from other regions. Probably the closest is *D. scalare* of the Vaureal formation of Anticosti. This form has the gibbosity located higher on the shell and has somewhat deeper cameræ.

Happily most boreal species are much larger and quite different in aspect from *D. eos,* though closer to it in the general symmetry of the shell than to the more easily oriented *D. shideleri* or *D. indianense.*

Types.—Holotype, Ohio State University, No. 3082. Hypotypes, Shideler Collection, five specimens, Univ. of Cincinnati, Nos. 17176, 24500.

Occurrence.—This species ranges throughout the Whitewater. One specimen, suggesting the Saluda in lithology, is from Versailles, Indiana. Lower Whitewater specimens are from Little Four Mile Creek and Dodge's Creek near Oxford, Ohio. Upper Whitewater forms are from McDill's and Dodge's Creek. The holotype is from an unspecified horizon near Dayton, Ohio. The lithology suggests overwhelmingly the cephalopod beds of the lower Whitewater.

Diestoceras shideleri Foerste **Plate 38, figs. 1, 8**

Diestoceras shideleri Foerste, 1924, Denison Univ. Bull., Sci. Lab., Jour. vol. 20, p. 266, pl. 27, fig. 1A-B.

This is a large *Diestoceras* characterized by the deep ephebic cameræ and the relatively slight contraction of the aperture. In profile the venter is faintly convex throughout, less curved adorally. The dorsum is strongly convex over the phragmocone, the curvature decreasing on the living chamber. The living chamber is not strongly inflated nor contracted at the aperture; the greatest shell height is attained near its middle. A hypotype, consisting of an incomplete but undistorted shell from the Saluda, increases from 44 mm. and 39 mm. to 56 mm. and 46 mm. in the length of five cameræ of the phragmocone, in a length of 38 mm. ventrally and 30 mm. dorsally. The living chamber is 52 mm.

long laterally, increases in height to 60 mm. near its center. It is incomplete adorally, but the aperture is estimated at 55 mm. in height.

The siphuncle is ventral. Its structure has not been observed. The three basal cameræ are subequal in length; the last two are slightly shorter.

A second specimen, somewhat badly flattened, retains seven cameræ in a ventral length of 55 mm. and a dorsal length of 40 mm. The living chamber has a length of 53 mm., a basal height of 65 mm., which increases to 68 mm. and contracts to 58 mm. at the aperture. The hyponomic sinus is well developed, and the shell curves inward at the aperture.

Discussion.—The holotype of *D. shideleri* is not available for the present study, but Foerste's original illustration and description leave little doubt as to its identity. In size the species approximates *D. cos* and exceeds *D. indianense.* However, in form the phragmocone shows the marked dorsal convexity which suggests *D. indianense.* The living chamber is longer and less gibbous than in either species and shells consisting only of phragmocones can be recognized by the relatively deep cameræ. Foerste believed that the phragmocone was very rapidly expanded. A specimen retaining seven cameræ indicates that it is relatively slender at least in the middle part of the phragmocone.

Type.—Holotype, U. S. National Museum. Hypotypes, Shideler Collection and Univ. of Cincinnati Museum, No. 24508.

Occurrence.—From the lower Whitewater, Little Four Mile Creek, and from the Saluda of McDill's Mills. Additional specimens include one shell from a point a few inches below the base of the Saluda at Madison, Indiana, regarded by the writer as lower Whitewater.

Diestoceras cf. shideleri Foerste Plate 39, fig. 3

The only large *Diestoceras* thus far known from the Elkhorn beds is a large badly flattened shell incomplete adorally. In its present condition the shell is apparently depressed, the dorsum being the best preserved surface. Orientation by the siphuncle and aperture is impossible, since neither are well enough preserved, but the cameræ are typically deeper on the dorsum in

Diestoceras. The phragmocone increases rapidly in width from 52 mm. to 72 mm. in 35 mm. The three adoral cameræ are subequal in depth and are 25 mm. long dorsally and 19 mm. ventrally. The living chamber retains a small part of the aperture, showing its dorsal length as 55 mm. The sides are preserved only for the basal 35 mm. The shell expands very slightly above the base of the living chamber attaining a width of 74 mm. and then contracts slightly to 71 mm. The sides do not seem to be approaching each other strongly adorally. The shell surface shows the coarse transverse markings typical of the genus.

Discussion.—This single Elkhorn specimen is too badly distorted to be identified with certainty and is discussed here largely because of the importance of the few known Elkhorn cephalopods. The deep cameræ and the very slight gibbosity of the living chamber suggest *D. shideleri* and set this form apart from *D. eos* and *D. indianense.* However, the difference in the dorsal and ventral length of the cameræ is greater than in typical *D. shideleri,* the gibbosity is attained lower on the living chamber, most of the length of which is given over to a gradual contraction as the shell approaches the aperture. In view of these differences it appears probable that this form will prove to be a distinct species when it is studied from better material.

Figured specimen.—Collection of Dr. W. H. Shideler.

Occurrence.—From the Elkhorn beds, Seven Mile Creek, Eaton, Ohio.

Diestoceras attenuatum Flower, n. sp. **Plate 39, fig. 7**

The holotype is a shell 85 mm. in length of relatively slender form. The basal four cameræ are displaced and somewhat distorted, but suggest a rather rapid initial expansion, the shell increasing from 25 mm. and 19 mm. to 38 mm. and 28 mm. in this interval of 17 mm. The venter is uniformly and slightly convex over the remainder of the shell, the dorsum is slightly less strongly curved. The adoral part of the phragmocone, consisting of five cameræ, 30 mm. long on the dorsum and 22 mm. on the venter, increases from 38 mm. and 28 mm. to 42 mm. and 31 mm. The living chamber has a length of 40 mm. on the dorsum. The aperture is incomplete ventrally but was between 25 mm. and 30 mm. in height. The lateral lobes are vestigial, the siphuncle ventral. The sutures, as is usual in the genus, are slightly closer dorsally than ventrally.

Discussion.—This species is smaller and more slender than the associated *D. eos, D. shideleri,* and *D. indianense.* The holotype shows no contraction of the adoral cameræ but by its dorsal profile is close to maturity. The form may be readily recognized by its proportions. In addition to the holotype, only one other specimen among our material appears to belong to this species. This consists of a phragmocone 40 mm. long containing eight cameræ and the base of a living chamber 28 mm. long. The shell has been widened considerably by flattening but shows the same spacing of cameræ exhibited by the holotype. The adoral part of the living chamber of the holotype was badly broken and has been somewhat restored. The exact condition of the curvature of the ventral profile near the aperture is uncertain and may have been somewhat less than the present illustration suggests. The aperture is clearly preserved on the dorsum, where it is preserved as the carbonaceous film common among apertures in *Diestoceras.*

Type.—Holotype, University of Cincinnati, No. 24524.

Occurrence.—Lower Whitewater beds, Little Four Mile Creek, near Oxford, Ohio.

Diestoceras cyrtocerinoides (Flower) Plate 29, fig. 3; Plate 38, figs. 2, 3

Wetherbyoceras (?) *cyrtocerinoides* Flower, 1943, Ohio Jour. Sci., vol. 43, p. 55, pl. 1, figs. 9-11.

This species is known only from the holotype, a small compressed phragmocone which is essentially straight. At the base the shell is 21 mm. high and 16 mm. wide. In a siphonal length of 16 mm. and an antisiphonal length of 18 mm. the conch increases to a height of 33 mm. and a width of 29 mm. The greatest width is attained ventrad of the center of the cross section, and the dorsum, the antisiphonal side, is more narrowly rounded than the venter. Parts of five cameræ are preserved with the adoral end retaining some matrix suggesting that the cameræ were followed by a living chamber which has been weathered away. The siphuncle, close to the assumed ventral side, is made up of broadly expanded segments. The septal necks are long, strongly recurved, so that the length of the brim is great while the length of the neck, in its adapical extent, is very slight. The recurved brims are, however, free from the septum though only narrowly separated. On the venter the connecting ring leaves the tip of the neck swinging at once apicad; on the dorsum the ring expands before swinging apicad. At the adapical end of the segment the ring is broadly adnate ventrally but is free dorsally. Small annulosiphonate deposits occur at the septal foramina. Small patches of the same material occupy the inside of the siphuncle, but whether they represent actinosiphonate structure, or whether they are inorganic and adventitious in their similarity to the annuli is uncertain from the single specimen available. An anomalous feature of the specimen is the irregularity of spacing of the septa. The fourth camera is very much shorter than any of the others, and its septum is poorly preserved. The form of the segment is here indistinct, but the last siphuncular segment is similar to the earlier ones.

Discussion.—No additional material of this species has been available since its original description. However, study of other material has necessitated a revision of its taxonomic position. The species was originally referred to *Wetherbyoceras* with doubt, because it was recognized that the structure within the siphuncle was practically identical with that of such species as *Oonoceras seeleyi* Ruedemann which were related to *Wetherbyoceras* as described by Foerste. Subsequently the author described the genus *Valcouroceras* in which this and allied species fall. However, in one important respect this species is atypical of *Valcouroceras* and in fact the entire Valcouroceratidæ, the smaller interval occupied by the cameræ on the venter than on the dorsum. As this feature is known only in *Diestoceras*, I have no hestitation in removing the species to this genus. In the rapid rate of expansion it is probably most comparable to early stages of the large Richmond species, *D. eos, D. shideleri, D. indianense,* and *D. attenuatum.* All of these except *D. eos* differ from *D. cyrtocerinoides* in showing a definite convexity of the dorsum and concavity of the venter in early stages commensurate with the part of the shell known in this species. The cameræ of *D. eos* are known in a commensurate part of the shell, which is quite similar in rate of expansion but has deeper cameræ, and clearly differs in that the venter is more narrowly rounded than the dorsum in cross section.

This small and inadequately known species is extremely significant, in that in a shell with the proportions of a *Diestoceras* and apparently closely related to the large typical species which form the nucleus of this genus, the internal structure is essentially that of the older genus *Valcouroceras*. This presents the only evidence in support of the hypothesis proposed by the writer that the Diestoceratidæ may have arisen from the secondarily cyrtochoanitic cephalopods and even suggests further that it may have sprung from *Valcouroceras* of the Chazyan. However, more observations on the early stages of more species are badly needed before the relationship of the Diestoceratidæ can be established satisfactorily.

Type.—Holotype, University of Cincinnati, No. 23971.

Occurrence.—From the Hitz layer, at the top of the Saluda, at Madison, Indiana.

Diestoceras waynesvillense Flower, n. sp. **Plate 41, fig. 9**

This species is known from a single somewhat flattened but relatively complete shell with a maximum length of 102 mm. The shell is somewhat compressed by pressure. At the base it is 26 mm. high and 19 mm. wide. In the 50 mm. of the phragmocone the height increases to 50 mm., the width to 32 mm.; flattening is marked here. Farther apicad a width of 36 mm. is attained. The living chamber is 48 mm. long, incomplete adorally, 50 mm. high at the aperture and of undetermined width. The shell is convex in all profiles throughout its length, but less curved apicad than elsewhere. The greatest diameters are attained near the middle of the faintly gibbous living chamber. The sutures are straight and transverse. The cameræ are obscure, but near the base two subequal cameræ occur in a length of 9 mm. The siphuncle can be seen at the base of the specimen where it is 13 mm. in diameter and 1.4 mm. from the shell wall. The surface of the shell is preserved in places sufficient to show that it bore faintly rugose and rather irregular transverse ridges which slope apicad on the siphonal side, even near the base of the specimen, to form a well-defined hyponomic sinus.

Discussion.—This rare form is the only large-sized *Diestoceras* encountered in the Cincinnati section below the lower Whitewater beds. It may be distinguished from other forms of comparable size of the Cincinnati region by its relatively slender outline.

Type.—Holotype, collection of Dr. W. H. Shideler, Miami University.

Occurrence.—From the Clarkesville member of the Waynesville, from Harper's Branch, Oldenburg, Indiana.

Diestoceras, sp.

Diestoceras, sp., Flower, 1942, Bull. Amer. Paleont., vol. 27, No. 103, p. 38, pl. 1, figs. 5-6.

No new information is available for this species, which is known only as a compressed essentially straight rapidly expanding phragmocone. The siphuncle is ventral, the segments small for *Diestoceras,* but typical in their subquadrate form as seen in section.

Type.—Univ. of Cincinnati, No. 22699.

Occurrence.—From the cephalopod bearing lens in the Poindexter quarry, Cynthiana, Kentucky, in the Greendale phase of the Cynthiana limestone.

Diestoceras (?) edenense Flower, n. sp. Plate 15, figs. 5, 6

The holotype, the only known representative of this species, is a small complete brevicone of depressed section. The conch has a total length of 22 mm. and enlarges in the first 17 mm. to 17 mm. and 15 mm., then contracting to 9 mm. and 12 mm. at the aperture. The lateral outline is subangular at the point of gibbosity, the sides nearly straight below and only faintly convex above. The conch is plainly slightly curved, one side being more convex than the other, but which side is to be regarded as ventral is uncertain. The aperture is transverse but without any trace of a hyponomic sinus.

The sutures are straight but slope slightly orad on the more convex side of the shell. The only clearly preserved camera is 3 mm. deep and appears to be located at the base of the living chamber. The siphuncle is not known.

The surface markings are clearly preserved on various regions of the shell and consist of fine evenly spaced transverse striæ and liræ which retain no trace of a hyponomic sinus.

Discussion.—This remarkable little species is of uncertain generic position. It is atypical of *Diestoceras* in that the section is slightly depressed instead of compressed, and there is no development of the hyponomic sinus. However, enough of this form is not known to connect it even remotely with any other known genus. The specimen is apparently undistorted and occurred in pyritiferous shales of the Eden. The condition of preservation did not seem to warrant destruction of the specimen in search of the siphuncle, for pyritiferous specimens of the Eden frequently fail to preserve any trace of the interior.

Holotype.—Univ. of Cincinnati, No. 22700.

Occurrence.—From the Southgate beds of the Eden, Hillside Ave. Flats, Cincinnati, Ohio.

Diestoceras (?) bettinæ Flower, n. sp. Plate 9, fig. 8

This species is based upon a flattened living chamber and two attached cameræ. The specimen is strongly compressed as a result of pressure. It has a basal height of 19 mm. and a width of 11 mm. In the length of 16 mm. it contracts to 10 mm. and 7 mm., the living chamber contracting and being subconical in form. The two cameræ at the base are subequal and together measure 3 mm. in length. The septum at the base of the specimen is markedly convex, though this is in part, at least, the result of flattening. The siphuncle is well exposed and parts of two segments are seen protruding from the apical septum of the specimen. They are elongate, inflated slightly within the cameræ, and show traces of possible actinosiphonate deposits. The surface is unknown. The aperture is poorly preserved; there is no evidence of the development of a hyponomic sinus.

Discussion.—This small species is unique in the small size and the subconical contraction of the living chamber among Maysville and in fact all Upper Ordovician forms of the Cincinnati area. The flattening has had but little effect upon the surface of the interior, and the strong internal flattening indicates strongly that the section of the shell was originally compressed. The species is not strongly similar to any of those previously described in *Diestoceras* but does not suggest any other known genus. As is the case with *Diestoceras edenense*, it is probably not congeneric with the large Richmond species which constitute typical *Diestoceras*, but enough is not known of this group of smaller species to permit separating it upon legitimate structural characters at the present time.

Type.—Holotype, University of Cincinnati, No. 24230.

Occurrence.—Fairmount beds, Maysville from Cincinnati, Ohio.

Diestoceras reversum Flower, n. sp. Plate 37, fig. 5

This is a small *Diestoceras* which attains its greatest gibbosity early and contracts over the adoral part of the phragmocone and the living chamber. At the base of the type the height is 30 mm., the estimated width 28 mm. The three cameræ preserved occupy 9 mm. on the antisiphonal side and 12 mm. on the siphonal side of the shell. At their adoral end the height is 28 mm., the width estimated at 26 mm. The living chamber contracts more rapidly laterally than the earlier part of the conch. It is 15 mm. long, and the aperture, though incomplete, can be estimated at a height of 24 mm. and a width of 20 mm. The siphuncle is poorly indicated at the septum at the base of the specimen. It leaves an impression there 3 mm. across, probably representing the size of the expanded part of the slightly compressed segment, and is 3 mm. from the shell wall.

Discussion.—This small species is peculiar in a number of features, the low position of gibbosity, the rapid increase in lateral contraction on the living chamber, the great length of the cameræ on the siphonal side of the shell, and the position of the siphuncle well removed from the ventral wall of the shell.

Type.—Holotype, Shideler Collection.

Occurrance.—From the Saluda beds, Big Sains Creek, Laurel, Indiana.

Diestoceras (?) vasiforme Flower, n. sp. Plate 37, fig. 1

This is a straight rather slender brevicone, the type of which is 60 mm. long. The orientation of the specimen in the absence of the siphuncle is uncertain. The sutures suggest that the shell is somewhat flattened, probably laterally. The shell expands from 15 mm. and 13 mm. near its base to 28 mm. and 20 mm. at the base of the living chamber in a length of 20 mm. The living chamber has a length of 30 mm., and expands in the basal part of 29 mm. and 22 mm., contracting orad to an aperture estimated at 24 mm. and 18 mm.

The phragmocone consists of nine cameræ which arch forward on one flattened side of the specimen and are straight on the opposite side. The cameræ increase gradually in depth orad. No trace of the siphuncle is preserved. The aperture is preserved only in a very small part and fails to show any trace of a hyponomic sinus.

Discussion—The position of this species is rather problematical, particularly since its orientation in the absence of the criteria of the siphuncle and aperture is uncertain. It is quite distinctive in form and unlike any other species found in the Cincinnatian. The straight form of the shell and the contraction of the aperture are features by which *Diestoceras* is customarily recognized, and the species is, therefore, placed tentatively in this genus. Although a number of small and relatively slender species have been placed in this genus, there is none which resembles this form particularly closely.

Type.—Holotype, Earham Collection, No. 7948.

Occurrence.—No data. Evidently Cincinnatian and very probably from the vicinity of Richmond, Indiana. The lithology is strongly indicative of the Saluda.

Diestoceras pupa Flower, n. sp. Plate 41, figs. 3-5

Conch small, erect, breviconic, the holotype obliquely flattened slightly by pressure. The type has a length of 22 mm., and expands from 14 mm. and 10.5 mm. at the base to 19 mm. and 17 mm. in a length of 10 mm., and then contracts to 18 mm. and 13 mm. at the aperture. The shell is slightly compressed by pressure, probably only accentuating a slight original compressed condition. All profiles expand convexly over the apical part of the shell and contract as nearly straight lines converging orad. The septa are straight and transverse. Eight cameræ occur in the 10 mm. of the phragmocone, the last three shorter than the others. The siphuncle is marginal, small, its structure not shown. The surface of the shell bears transverse obscure coarse faintly rugose annular markings. The aperture is incomplete but preserves a shallow hyponomic sinus.

Discussion.—This species is among the smallest of the known species of *Diestoceras* and resembles *Diestoceras scotium* Teichert (1940, p. 112, pl. 5, fig. 15; pl. 6, figs. 4-7). It differs from that species in the lower position of the point of greatest gibbosity on the shell and in the greater length of the living chamber in proportion to its diameters. The type is considerably more flattened laterally in its present state than is *D. scotium*, but this difference is largely and perhaps entirely due to distortion of the shell. The species does not appear to be particularly closely allied to either of the two *Diestoceras* known from the Covington subseries of the Cincinnatian.

Type.—Holotype, Univ. of Cincinnati, No. 23905.

Occurrence.—From the upper part of the Saluda, equivalent to the upper Whitewater, in southern Indiana. Additional but poorer specimens have been found in the Hitz layer at Madison, Indiana.

Genus **DANOCERAS** Troedsson

Genotype.—Danoceras ravni Troedsson.

Danoceras Troedsson, 1926, Meddelelser om Gronland, Bd. 71, p. 101.
Hyperoceras Foerste, 1928, Canada Geol. Surv., Mem. 154, p. 315.
Danoceras Foerste, 1929, Denison Univ. Bull., Sci. Lab., Jour., vol. 24, p. 41; Strand, 1934, Norsk Geologisk Tiddskr., Bd. 14, pp. 79, 80.

The genotype is essentially a straight compressed shell, with a marginal siphuncle, sutures which develop lateral lobes separated by dorsal and ventral saddles, and a living chamber which contracts slightly at the aperture. The most distinctive feature of the genus is the form of the segments of the siphuncle. The necks are recumbent, in contact with the septa from which they spring, and probably the adoral end of the connecting ring is at least narrowly adnate to the dorsal septum. The connecting rings become free and are straight, approaching each other as seen in section as they approach the next adapical septum. They meet the septum at the foramen, producing segments which are elongate trapezoids as seen in section. At the septal foramen there are faint annular thickenings in the genotype, which are apparently derived from the connecting ring, and in other species give rise to irregular and discrete actinosiphonate rays, though actinosiphonate structure is not well developed in this genus.

Other species show that the segments of the siphuncle may assume a slightly more convex outline as they pass apicad from one septum to the next. The shell shows very faint traces of endogastric curvature, largely in the slightly closer spacing of the septa on the siphonal side of the shell. The aperture is not well known in the genotype, but one of the Cincinnatian species shows a faint sinus on the siphonal side of the shell.

Discussion.—Troedsson based this genus upon a single species known from a living chamber and a few attached cameræ. The siphuncle was known, and the sutures showed clear lateral lobes, but the aperture was not completely preserved. The form was, however, evidently an essentially straight compressed brevicone. Foerste (1928) subsequently named the genus *Hyperoceras* based upon *H. twenhofeli* Foerste of the Vaureal formation of Anticosti. The living chamber is inadequately known in this species, and the shell appears to be a compressed straight orthoceracone, differing from the *Danoceras* mainly in having deeper cameræ and straight sutures. Foerste subsequently noted that the two genera were the same but did not refer any species to it under either name.

In the Cincinnatian a number of species occur which appear to be best placed in this genus. The most striking is *Danoceras crater* of the Leipers formation, a species which is more rapidly expanding and more convex in profile than either of the two previously known but retains the distinctive siphuncular segments of the genus. In aspect the species is close to *Diestoceras* but is atypical in the high position of gibbosity on the mature living chamber. Associated with it is *D. bulbosum*, a larger and more gibbous species, which still has the gently expanding phragmocone of *Danoceras* and is again atypical of *Diestoceras* in the high position of the gibbous region near the aperture of the shell instead of close to the base of the living chamber.

Danoceras cynthianense agrees with the genotype closely in the lateral lobes of the sutures. Its internal structure is unknown. This species is closely similar not only to *Danoceras rayni* but to two slightly more gibbous species which have been placed in *Diestoceras*. These are small strongly compressed shells and are not typical of *Diestoceras*. Their internal structure is unknown, but it may easily be that these forms also should be placed in *Danoceras*. They are *Diestoceras anticostiense* Foerste of the Vaureal formation of Anticosti and *Diestoceras cooperi* Foerste of the Whitehead formation of Gaspé. Determination of the proper position of these species must await the discovery of their siphuncles.

A third Cincinnatian species, *Danoceras* (?) *gracile*, of uncertain horizon is placed here with doubt largely because the species is not well enough known. It is a small slender fusiform shell, originally compressed in section, but known only from a flattened shell. The species is believed to be from some part of the Maysville group of Indiana.

On the basis of form, no clear distinction is possible between the relatively slender compressed shells which constitute *Danoceras* and the more gibbous shells which properly constitute *Diestoceras*. The siphuncles of the two genera are typically very different. *Diestoceras* has broadly expanded segments, scalariform, and sometimes subquadrate in vertical section. The segments of *Danoceras* are slender and trapezoidal. However, the segments of the siphuncle are unknown for a large number of those species which appear to be border line cases on the basis of form. At the present time it is convenient to have a receptacle for these more slender forms apart from *Diestoceras*, as such forms appear to constitute a natural group, and further distinctions among the 40 odd species which have been placed in *Diestoceras* are eminently desirable. In the present work four Cincinnati species are included in *Danoceras*, *D. cynthianense* of the Cynthiana limestone, *D. crater* and *D. bulbosum* of the Leipers formation, and *D.* (?) *gracile* of uncertain position.

Strand (1934) discussed the genus, though without comparing it to *Diestoceras*, and described three species. *D. scandanavicum* (p. 82, pl. 11, figs. 9, 10) is internally typical of the genus and seems quite close to the Cincinnatian *Danoceras crater* (Pl. 10, figs. 1, 2) though slightly more contracted adorally. *D. breve* Strand (p. 81, pl. 11, fig. 6; pl. 13, fig. 1) is also faintly gibbous adorally and is perhaps closer to *D. bulbosum* of the present work. *D. broggeri* Strand (p. 80, pl. 8, fig. 6) expands nearly to the aperture where there is a slight rounding of form. This species in its straight slender form seems closer to *Danoceras twenhofeli* of Anticosti than to any other species.

Danoceras cynthianense Flower, n. sp. Plate 14, figs. 1, 2

Conch a small compressed brevicone. The type preserves in addition to an incomplete camera at the base, five complete cameræ and a nearly complete living chamber. In form the straight and evidently slender phragmocone is typical of the genus; the living chamber is somewhat more contracted toward the aperture than that of the genotype. The shell is 28 mm. high and 22 mm. wide at the base. In the interval of 17 mm. occupied by the five complete cameræ, the shell first expands to a height of 31 mm. and a width of 22 mm., and contracts in the adoral 3 mm. of the phragmocone to a height of 29 mm., while the width remains unchanged. The living chamber contracts further to a height of 24 mm, and a width of 18 mm. in its basal 13 mm. The complete aperture was 17 mm. beyond the base of the living chamber and the apertural diameters are estimated at 21 mm. and 15 mm.

The sutures develop broad rounded lobes which are separated by narrow rounded saddles on both dorsum and venter, the ventral saddles higher than those of the dorsum. The septa are relatively slightly curved. The extant cameræ, except the last, are 4 mm. in depth. The siphuncle is seen obscurely at the septal foramen. It is small, circular, and close to the venter. Its structure has not been observed.

Discussion.—This form differs from other *Danoceras* in the contraction of the shell orad from a point slightly apicad of the base of the mature living chamber. It is typical in the straight compressed breviconic shell and the lateral lobes of the sutures.

It is slightly more gibbous than the genotype, but the differences are not great. The species is comparable also to species which have been placed in *Diestoceras*, though these are forms with relatively slender phragmocones, lateral lobes, and might as easily be placed in *Danoceras*. *D. anticostiense* Foerste of the Vaureal formation of Anticosti is comparable, but this is a smaller species and a more slender one. *D. cooperi* Foerste (1926, p. 382, pl. 55, figs. 3, 4) of the Whitehead formation of Gaspé is quite similar to *Danoceras cynthianense* in the strongly compressed section and the lateral lobes of the sutures. It also approximates this species in size. Its greatest shell diameters are attained higher on the shell, the conch is more slender, contracts less rapidly orad, and the species is slightly larger.

Holotype.—Collection of Dr. W. H. Shideler.

Occurrence.—Cynthiana limestone, Cynthiana, Kentucky.

Danoceras crater Flower, n. sp. Plate 8, fig. 3; Plate 10, figs. 1, 2.

This is a moderate-sized species which expands fairly rapidly to a point near the aperture before contraction begins. The holotype is 54 mm. long, a rapidly expanding straight shell of compressed section. The dorsum and venter are both faintly convex in profile but diverge rapidly. The lateral profiles are faintly convex but less divergent. The phragmocone is 33 mm. long on the venter and 29 mm. on the dorsum. It expands from 12 mm. and 16 mm. to 29 mm. and 35 mm. The living chamber is 20 mm. in length on the venter. It expands from 29 mm. and 35 mm. to 32 mm. and 40 mm. at the aperture. The greatest height is at the aperture, although the convex sides give the effect of contraction.

The cross section of the shell is compressed, the venter only slightly more narrowly rounded than the dorsum. The sutures are essentially straight and transverse. Ten cameræ occupy the adoral 28 mm. of the phragmocone, the apical portion lacking all trace of the sutures. The last camera is slightly shortened, but the others increase orad in depth from 1.7 mm. to 2 mm. The siphuncle is small and lies close to the venter. As seen in a transverse longitudinal section the segments expand abruptly at the foramen, the necks being recumbent. The free part of the segment is but faintly curved, and the rings approach each other apicad, as seen on the two sides in the section, so that they join the next septum at the foramen. The connecting rings and the septal necks cannot be clearly differentiated. Probably the neck is recumbent and the adoral end of the ring also appears to be in contact with the adoral septum. There are small actinosiphonate deposits which are hardly more than small annulosiphonate rings with a few short irregular processes. They clearly spring from the connecting rings, and in one adapical segment three distinct rays can be seen extending from a mass of calcareous material developing from the adapical portion of one connecting ring. At other points similar masses are seen, but the actinosiphonate nature of the deposit is not evident. There is no trace of cameral deposits.

The aperture bears a faintly developed hyponomic sinus. The shell is preserved in part but shows no surface markings.

Discussion.—This species expands much more rapidly than the previously described species assigned to *Danoceras* but is placed in this genus because of the form of the segments of the siphuncle. The straight sutures recall *D. twenhofeli,* but the shell expands more rapidly, the cameræ are shorter, and the profiles of that species are straight and not convex. No species of *Diestoceras* is closely comparable. From typical *Diestoceras* this species is distinguished by the lack of a real apertural contraction and the form of the segments of the siphuncle. The species resembles *Danoceras scandavicum* Strand of the Gastropod limestone of Norway more closely than any other described species, but that species is larger and differs somewhat in proportions.

Type.—Holotype, Univ. of Cincinnati Museum, No. 24225.

Occurrence.—From the limestone immediately above the *Tetradium* reef beds of the Leipers formation, on the Cumberland River, just downstream from the ferry at Rowena, Kentucky. Collected by W. H. Shideler and the writer, 1942.

Danoceras bulbosum Flower, n. sp. Plate 17, fig. 16

Conch breviconic, compressed, essentially straight. The phragmocone is relatively slender, the living chamber strongly gibbous, the greatest shell diameters occur well orad of the middle of the living chamber. The supposed dorsum is faintly convex throughout its length. The supposed venter is convex over most of its length but becomes slightly concave near the aperture. The sides are divergent, nearly straight adapically but become convex over the living chamber. The holotype has a maximum length of 53 mm., of which the adoral 30 mm. pertain to the living chamber, the remainder to an incomplete and very imperfectly preserved phragmocone. The living chamber increases from 38 mm. and 31 mm. to 44 mm. and 33 mm. and then contracts to 41 mm. and 28 mm. at the aperture. The aperture is slightly oblique, sloping slightly apicad from the convex side to the concave side. No clear hyponomic sinus is developed.

The sutures are essentially straight and transverse. Only two adoral cameræ are well preserved; they are both 3.5 mm. in length. No trace of the siphuncle remains. The interior of the phragmocone is extensively recrystallized in the type and only known specimen. The surface appears smooth, but encrusting algæ may have obscured any original markings.

Discussion.—This form is a relatively gibbous one, and in this respect, is atypical of *Danoceras*. However, the phragmocone is relatively gradually expanded, and the gibbosity is high on the living chamber. In these respects the genus agrees more closely with *Danoceras* than with typical *Diestoceras*. The species appears to have no close relatives in American Ordovician faunas but is most similar to *Danoceras stœrmeri* (Strand) originally described as a *Diestoceras*.

Type.—Holotype, Univ. of Cincinnati, No. 24323.

Occurrence.—From the Leipers formation at the Painted Cliffs, on the south side of the Cumberland River west of Horseshoe Bottom, Kentucky.

Danoceras (?) gracile Flower, n. sp. Plate 41, fig. 8

This is a small straight breviconic shell, laterally flattened. The dorsum and venter are slightly convex throughout, though nearly straight adapically where they diverge moderately. Gibbosity is attained just apicad of the base of the living chamber. The shell expands in its present condition from a height of 13 mm. at the base to a maximum of 18 mm. in a length of 15 mm. and contracts to 16 mm. in the next 15 mm., not quite attaining the aperture. The phragmocone has a ventral length of 20 mm., a dorsal length of 17 mm. At its base the living chamber is 18 mm. high. It has a maximum (lateral) length of 12 mm. Apparently most of the living chamber is preserved, but the aperture is not shown. The siphuncle lies close to one side of the specimen and supplies the only basis for its orientation. The eight cameræ of the phragmocone scarcely vary from the average depth of 2 mm. Lobes are developed in the sutures on the right side of the specimen. These are lacking on the opposite side and are evidently the effect of distortion.

Discussion.—This shell is placed in *Danoceras* because the slender phragmocone and gradually contracted aperture seem to suggest this genus more than any true *Diestoceras.* The form is known only from the flattened holotype. No closely allied species are known. The shell is one of the smallest species placed in *Danoceras.* In size and shape it is perhaps most closely approximated by the larger *Diestoceras vasiforme* which has the aperture more contracted and then produced and also has much shorter cameræ. *Diestoceras bettinæ* is comparable in the low position of gibbosity, but is a larger species, and one which has a nummuloidal siphuncle, which, together with the stronger contraction of the aperture, has caused me to retain it in *Diestoceras.*

Types.—Univ. of Cincinnati, No. 24473.

Occurrence.—From an unknown locality in the Cincinnatian of Indiana. The lithology, consisting of arenaceous shale, is not diagnostic. The specimen, from the collection of the Cincinnati Society of Natural History, was associated with the two small species here described as *Vaupelia* (?) *minutum.* Since *Vaupelia* is known only from the Covington, it is possible that this species is also from this part of the section.

Superfamily **DISCOSOROIDEA** Flower

The superfamily Discosoroidea was erected for the reception of a group of cyrtoconic cephalopods characterized by broadly cyrtochoanitic and usually rather large siphuncles throughout life. The earlier members of the group are marked by the thickening of the connecting ring, usually by addition to the outer or cameral surface. Also there may be annulosiphonate deposits as in the Cyrtogomphoceratidæ and Westonoceratidæ. Higher members of the group may lose both the thickening of the connecting ring and the annulosiphonate deposits but possess endocones instead. Morphologically the group is rather diverse. From other cyrtoconic cephalopods of the early Paleozoic, the Discosoroidea may be distinguished by the appearance of broadly expanded siphuncular segments in the earliest known growth stages. The large broadly expanded siphuncles sometimes suggest the Actinoceroidea; indeed, *Discosorus* was originally regarded as an actinoceroid. However, the discosorids are largely cyrtoconic forms, while the actinoceroids are essentially orthoconic. The discosorids fail to show a siphonal vascular system and possess no perispatium. The early stages are as yet poorly known, but there is clearly no such large blunt apical end as is found in the larger Actinoceroidea.

The Discosoroidea was originally recognized as one of two groups of early Paleozoic cephalopods which have broadly expanded cyrtochoanitic siphuncles throughout life. There is no indication that they have any relation to the Actinoceroidea, the only other group of cephalopods with similar cyrtochoanitic siphuncles which appears in the Ordovician. Teichert (1933) proposed that the Actinoceroidea were more closely related to the endoceroids (in the broad sense) than to any other cephalopods. Although this view has been opposed by Schindewolf (1934) and Kobayashi (1935, 1936, 1937) their objections do not appear altogether valid. Subsequently the writer (1941) traced the ancestry of the Actinoceroidea through *Polydesmia* to the Bathmoceratidæ and ultimately to the Ellesmeroceratidæ. While the Ellesmeroceratidæ are not considered endoceroids at the present time (Flower, 1941), the term being restricted to cephalopods possessing endocones, they were grouped with the endoceroids at the time when Teichert made his proposal.

The origin of the Discosoroidea, however, is still very uncertain. There is not at the present time adequate evidence to warrant placing them either with the Stenosiphonata or the Eurysiphonata. The small early stages would suggest the Stenosiphonata but are hardly to be considered conclusive. The Sactoceratidæ of the Actinoceroidea differ from other members of that superfamily in having minute early stages, the shell beginning at a diameter of less than 5 mm., while in more typical, and presumably more generalized actinoceroids, the tip of the shell is bluntly rounded becoming tubular only at a diameter of 15 mm. or more.

Morphologically the discosorids are an exceedingly diverse group. The siphuncle may be on the convex side, the concave side, or may be centrally located. The necks are never so long as in the Actinoceratidæ, but the outline of the segments at the siphuncle is more like that of the Armenoceratidæ with short necks and sometimes extensive brims. The deposits of the siphuncle vary among the different families and sometimes within the genera. The thickened rings appear alone in the Chazyan Ruedemannoceratidæ. To these are added parietal annulosiphonate deposits in the Westonoceratidæ and Cyrtogomphoceratidæ. Some species of *Faberoceras* possess endocones in addition. Endocones alone mark the Lowoceratidæ and Discosoridæ of the Silurian. Schindewolf (1943) has reported diaphragms crossing the central canal of a Devonian *Endodiscosorus,* but otherwise the group is not definitely known in the Devonian, though it is possible that *Alpenoceras* and its allies may belong to this stock.

At present the Discosoroidea contain all of the early Paleozoic cephalopods with broadly expanded siphuncular segments throughout life which are not actinoceroids. The grouping was first recognized, but not named, on the basis of the study of the Chazyan cephalopods of the Champlain Valley. There an association was encountered which was unique for the preservation of early stages of most of the genera in a condition suitable for study by sections. On the basis of this material a grouping of ellipochoanitic cephalopods into six morphological groups was proposed. It was found that most of the cyrtoconic cephalopods which have ephebic cyrtochoanitic siphuncles possessed early stages which were suborthochoanitic, thereby suggesting that in these forms cyrtochoanitic structure was secondary, and that such cephalopods had descended from a primitively suborthochoanitic stock. This was found to be true of the Oncoceratidæ, the Allumettoceratidæ, and the Valcouroceratidæ. Such ontogenetic evidence as is available for the Diestoceratidæ, dealt with in the present work, suggests a similar early stage and, therefore, a similar origin for that family. The only remaining cyrtochoanitic cephalopods, which are known to lack such suborthochoanitic early stages, are grouped in the Discosoroidea. Such a morphological criterion may, however, fail in a strict application to younger cephalopods. There is indication of a tachygenetic reduction in the suborthochoanitic early stage even in the Ordovician cephalopods. It is possible that by Silurian time the secondarily cyrtochoanitic cephalopods may have eliminated the suborthochoanitic stage from their ontogeny. For this reason it is uncertain whether the phragmoceroids, which appear to be cyrtochoanitic throughout, as well as certain Mississippian cyrtoconic types of uncertain generic position with expanded siphuncles from the earliest stage, are allied to the discosorids or to the more prolific secondarily cyrtochoanitic stock.

As the Discosoroidea have previously been treated only in abstract form (Flower, 1940), an account of the superfamily and its divisions is included here before proceeding to the description of the Cincinnatian genera and species.

Family RUEDEMANNOCERATIDÆ Flower, 1940

This family is based upon the genus *Ruedemannoceras* Flower (1940) and should possibly include also the little known *Yabeites* Endo, the only other genus which appears to be at all similar. The shell of *Ruedemannoceras* (fig. 18 I, J, K) is cyrtoconic and slightly depressed in cross section. The siphuncle is subcentral throughout life. The septal necks are strongly recurved but the brim does not lie in contact with the septum. The connecting ring was apparently originally free and not adnate even adapically, but a secondary broad area of adnation is produced by a thickening of the ring by the addition of material to its outer surface. This produces broad areas of adnation at both ends of the connecting ring as shown in figure 18 K.

Ruedemannoceras is based upon *Cyrtoceras Boyci* Whitfield of the Chazy limestone of New York. Two other species are known. One is *R. champlainense* (Ruedemann) of the Valcour limestone, upper Chazyan, of the Champlain Valley, and the other is *R. stonense* (Safford) of the Murfreesboro limestone of the Nashville basin of Tennessee. The genus has not been recognized in the Mingan Islands and is one of several peculiar to the Murfreesboro and the Champlain Chazyan which lead to the belief that the Chazy fauna of the Champlain Valley may contain more south Atlantic elements than have previously been recognized.

The large siphuncles of *Ruedemannoceras* commonly contain much calcite, but thin section examination has failed to reveal any organic deposits other than the thickened connecting ring.

Family **WESTONOCERATIDÆ** Foerste and Teichert

This family is enlarged to include dominantly exogastric cyrtoceracones and brevicones. The siphuncle is composed of segments which vary from subspherical to subquadrate in vertical section. The connecting ring is thickened, though sometimes the thickening may be confined to certain parts, in particular the region near the septal necks. In addition, annulosiphonate deposits appear which develop into a parietal lining of the siphuncle very similar to that found in the Devonian orthoconic family Pseudorthoceratidæ. Some specialized species of *Faberoceras* possess, in addition, endocones within the siphuncle.

At the present time the genera *Westonoceras, Teichertoceras,* and *Faberoceras* comprise the family. With these I have tentatively placed *Winnipegoceras, Glytodendron,* and *Clarkesvillia.*

The ventral siphuncle and the annulosiphonate deposits distinguish the family from the Ruedemannoceratidæ. The Cyrtogomphoceratidæ are characterized by similar structure, but the siphuncle is characteristically on the concave side of the shell. The Discosoridæ and Lowoceratidæ lack annulosiphonate deposits and have apparently lost the thickening of the connecting ring.

The Westonoceratidæ were at first regarded as actinoceroids (Foerste and Teichert, 1930), but Teichert has subsequently recognized that this family must be placed elsewhere. The shells are cyrtoconic, sometimes breviconic, exogastric in general, and have the siphuncle close to the venter in the early stages of growth. The segments of the siphuncle vary from subspherical to subquadrate in section and are never so broadly expanded as those of *Ruedemannoceras.* The connecting ring is typically thickened in this family, also by the addition of material to its outer surface.

However, it is supplemented here by a true annulosiphonate de-

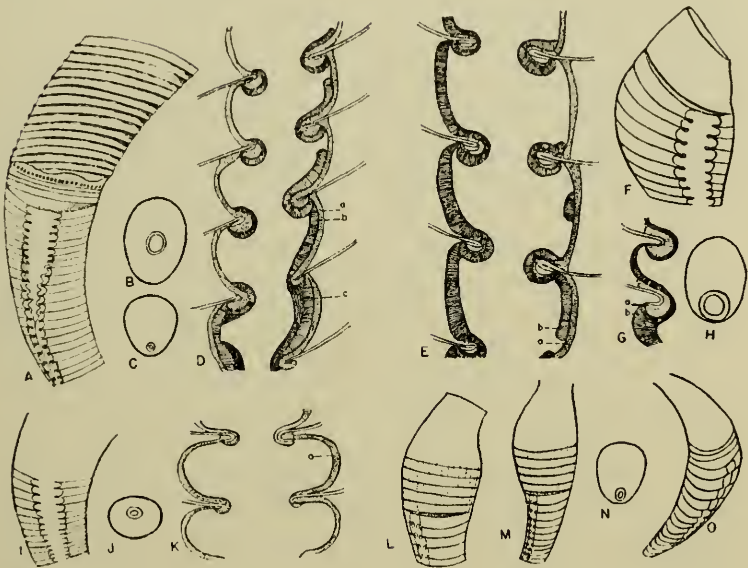

Figure 18. Essential characteristics of the Ordovician genera of the Discosoroidea. A-D. *Faberoceras* Flower. A, vertical section of phragmocone showing siphuncle attached to an adoral unsectioned portion. Internal mold of base of living chamber is exposed showing the basal zone. Siphuncle exposed in section showing ontogenetic change in position and size, also endocones developed adapically; B, cross section of *F. elegans* Flower showing the most central position of the siphuncle in the genus; C, cross section of F. *percinctum* Flower showing small marginal siphuncle; D, vertical section, venter on right, of siphuncle. E, vertical section of siphuncle of *Westonoceras cf. ornatum* (Troedsson), venter on left. F. Generalized vertical section of *Cyrtogomphoceras* Foerste. G. Section of wall of siphuncle of *Cyrtogomphoceras*, modified from Troedsson (1926). H. Cross section of *Cyrtogomphoceras*. I-K. *Ruedemannoceras* Flower. I, vertical section; J, cross section; K, vertical section of siphuncle showing thickening of connecting ring. L. *Westonoceras* Foerste, lateral view, venter on left. M. *Teichertoceras* Foerste, same orientation showing difference in curvature distinguishing it from *Westonoceras*. N. Typical cross section of *Westonoceras*. O. Vertical section of *Winnipegoceras* Foerste, venter on right. a.—Connecting ring; thickened secondarily where stippled. b.—Annulosiphonate deposit. Lines indicate position of rows of aragonite prisms. c.—Endocones of the *Discosorus* type.

posit which is always mural, lying close against the connecting ring (fig. 18 D, E). The deposit appears first at the septal foramen, appearing on the inner surface of the apical tip of the connecting ring. The deposit grows orad over the length of the connecting ring until adjacent segmental deposits fuse and form an apparently continuous lining within the siphuncle. The growth relations of these deposits have not been thoroughly worked out, but it is evident that in *Westonoceras* the segmental deposits form a complete ring at the septal foramen at an early growth stage, but that they grow orad over the free part of the connecting ring first on the venter, and later grow laterally, so that the deposit finally closes on the dorsum, as in *Pseudorthoceras* (Flower, 1939, pp. 139-142, fig. 17, p. 142). Figure 18E shows the fusion of segmental deposits on the ventral side of the siphuncle, on the left side of the figure, while on the dorsal side only the original annulosiphonate ring, the annulus, is perfected in the adoral segment. The middle segment shows in addition a deposit in the middle of the free part of the connecting ring. A similar structure in *Pseudorthoceras* has been determined to represent a pair of lobose processes which spring from the ventral deposit and grow laterally so as to meet on the dorsum in the middle of the segment. The adapical segment shows a more complete development of the deposit on the dorsum, though it is still not quite perfect. This section is drawn from a thin section of *Westonoceras cf. ornatum* Troedsson from the Ordovician of Baffin Land. It should also be noted that in this section the connecting ring is markedly thickened throughout on the dorsum, but ventrally the only trace of thickening is found at the point at which the rings invaginate to join the septa. Elsewhere the ring is only the usual thin structureless band outside of the annulosiphonate deposit. Where the ring is curved over the recurved septal necks it is free from the adapical surface of the recurved neck. The significance of this phenomenon is not clear, but it appears to be characteristic of the genus.

The species of *Westonoceras* are listed under the discussion of the genus. The shell is exogastric throughout, and the living chamber is contracted at its base, followed by a somewhat tubular prolongation of the aperture (fig. 18 L). *Teichertoceras*

Foerste is very similar to *Westonoceras,* but adapically it is curved endogastrically instead of exogastrically (fig. 18 M). Adorally the venter becomes convex and the living chambers are very similar in aspect. Both are compressed in cross section (fig. 18N) with the venter more narrowly rounded than the dorsum. The appearance of the siphuncle at the septal foramen is rather characteristic owing to the small foramen and the large area surrounding it at which the connecting rings touch the free part of the septum.

Faberoceras (fig. 18 A-D) is simpler in form being an exogastric compressed cyrtocone without any trace of an adoral contraction of the shell. The segments of the siphuncle are more rounded than those of *Westonoceras,* are sometimes broader, and the tip of the connecting ring is filled in solidly around the recurved septal neck, while the remainder of the ring is thickened both dorsally and ventrally as shown in figure 18D, a. The annulosiphonate deposits are similar to those of *Westonoceras,* though it is not obvious here that a complete lining of the siphuncle is formed on the venter before development of the deposit begins on the dorsum. In this respect *Westonoceras* is comparable to certain of the genera of the Pseudorthoceratinæ as is *Faberoceras* to those of the Dolorthoceratinæ.

In addition a third deposit appears in some species of *Faberoceras* which is similar to the annulosiphonate deposit in composition and sometimes cannot be distinguished clearly from it. This consists of additional lamellar material deposited within the siphuncle, but this time in the form of endocones and not as annuli. These cones are essentially similar to those of the Silurian Discosoridæ. The cones are indicated in figure 18A, while in figure 18D the adoral part of the cone is indicated as c. The endocones are also shown in figure 20. Their appearance in opaque section is shown in Plate 12, figure 3, Plate 16, figure 1, and Plate 17, figure 1. They are represented by the white calcite within the siphuncle of figure 10, Plate 29 (a section which is taken too far from the center of the siphuncle to show their true form) and better at the base of figure 1, Plate 30, a photograph of the thin section upon which text figure 18D is based. Such endocones are present in Covington species of *Faberoceras* but are unknown in Cathys and Cynthiana forms. Indeed, *Faberoceras* shows a marked advance from its Cathys and Cynthiana species to those of the Leipers. The early forms have siphuncles which are small and ventral. In younger forms the siphuncle tends to become larger and may become more centrally located (see fig. 18 B-C). The Covington species are more advanced in ornament, having a strong tendency toward the development of ridges, annuli, and constrictions of the shell, which the earlier forms lack. Finally, it is only in the Covington species that the endocones have appeared. The differences seem sufficient to warrant a subdivision of the genus, were it not for practical difficulties involved.

In the Waynesville *Clarkesvillia* occurs. The siphuncle is relatively far from the venter, but annuli of the surface and endocones of the interior are absent. The genus is distinguished from *Faberoceras* on the basis of the flattening of the venter, so that a true ventral face is developed set off from the sides by well-defined angles.

Winnipegoceras Foerste, I have tentatively included in this family. The genus may be interpreted as a strongly curved edition of *Westonoceras* (fig. 18 O), and the subquadrangular segments of the siphuncle are superficially similar to those of *Westonoceras*. However, the material by which this genus is represented fails to show any clear deposits within the siphuncle. Their absence, however, is only negative evidence, for the mode of preservation of the known species is unfavorable for the preservation of such internal structures and is therefore not conclusive. The possibility remains, however, that *Winnipegoceras* may not be a discosorid at all but instead a member of the Oncoceratidæ, as suggested earlier by the writer (Flower, 1942, fig. 1, p. 30). This is possible by the form of the shell, but the siphuncle is larger in proportion to the rest of the shell than is usual in the Oncoceratidæ.

The Brassfield genus *Glyptodendron* Claypole, formerly regarded as a plant, but shown by Foerste (1893) to be a peculiarly ornamented cephalopod, possesses a large siphuncle which suggests very strongly that it is a member of the Westonoceratidæ possibly allied to *Faberoceras*. However, the extant sections, while they indicate annular deposits and suggest a thickening of the connecting ring, are too poorly preserved to show these features conclusively.

Family **CYRTOGOMPHOCERATIDÆ** Flower, 1940

This family was erected for the reception of two genera similar to the Westonoceratidæ in internal structure but endogastric in form. The internal structure is not so well known as may be desired. *Cyrtogomphoceras* Foerste is developed in the Arctic Ordovician from the Big Horns to northern Greenland. Most specimens known fail to preserve the siphuncle very clearly. The vertical section shown in figure 18 F gives a conception of the form of the shell and the relative size of the siphuncle, also shown in cross section in figure 18 H. The walls of the siphuncle of the genotype exhibit an apparently continuous lining which is lamellar and is composed of several layers. However, all specimens studied failed to show the structure and arrangement of these layers very clearly, and the exact structure could not be determined, at least on the basis of opaque sections. Troedsson (1926) found deposits which he was reluctant to classify as either actinosiphonate or annulosiphonate in *Cyrtogomphoceras turgidum* of the Cape Calhoun formation of Greenland. His figure (1926, pl. 2, fig. 2) can, however, be interpreted in the light of the structures observed in the Westonoceratidæ, to which it is essentially similar. The annulosiphonate ring of Troedsson's species is a structure which passes orad of the septal foramen outside of the other deposits, which are bounded externally by a very clear dark line, the original thin connecting ring. The structure (a of fig. 18 G) appears to terminate in the matrix but might continue originally orad around the remainder of the outline of the siphuncle. This is clearly the homologue of the thickened connecting ring developed in the Westonoceratidæ, while the clear dark line bounding the outside of the continuous part of the siphuncle represents the thin original connecting ring. The siphuncle contains a conspicuous lamellar deposit. The section of Troedsson's specimen shows too little of the siphuncle to determine whether the adapical thickening of the lamellar deposit is merely annulosiphonate, or whether it is an annulosiphonate structure supplemented by endocones, or even, although this seems unlikely since such massive structures should be more universally preserved, whether massive endocones alone are present. Our figure shows an interpretation of the structures as annulosiphonate parietal deposits which were fusing to form a continuous lining within the siphuncle.

Landeroceras Foerste appears to be essentially a straight edition of *Cyrtogomphoceras*. The interior of the genus has not yet been studied from sections, but the large size of the siphuncle is such as to preclude placing it with any other known group of cyrtoconic or breviconic cephalopods known in the Ordovician. Further, the superficial features by which this genus is distinguished from *Cyrtogomphoceras* are concerned only with the habit of growth of the shell and suggest a close relationship.

Strandoceras Flower, new genus, is based upon *Protophragmoceras tyriense* Strand of the Upper Ordovician (*Trinucleus* limestone and Gastropod limestone) of Oslo, Norway. This species and *Protophragmoceras sphynx* (Schmidt), which is common to the Gastropod limestone of Norway and the Lyckholm formation of Esthonia, represent a genus quite distinct from true *Protophragmoceras*. The shell is an endogastric cyrtocone, compressed in section, the venter more narrowly rounded than the dorsum. The living chamber tends to be slightly less curved than the remainder of the shell. Growth lines indicate a sinus on the convex, supposed dorsal side as well as a small ventral sinus. The sutures develop slight lateral lobes, and tend to rise orad on the dorsum. The siphuncle, as illustrated by Strand, is composed of very broad segments showing clear indication of a thickening of the connecting ring and annulosiphonate deposits. These structures are characteristic of the Middle and Upper Ordovician Discosoroidea, and the endogastric position of the siphuncle the genus indicates that it should be placed with the Cyrtogomphoceratidæ rather than with the Westonoceratidæ.

This genus differs from *Protophragmoceras*, which is based upon *Cyrtoceras murchisoni* Barrande from the Middle Silurian (E2) of Bohemia. In that genus the cameræ are very closely spaced, the venter is not so narrowly rounded, the curvature of the living chamber is uniform with that of the rest of the shell, but, most important, the siphuncle is smaller in relation to the shell as a whole, and shows faint thickenings of the connecting rings (see Barrande, pl. 160, fig. 17), but lacks any trace of annuli.

Family **LOWOCERATIDÆ** Flower, 1940

The Lowoceratidæ contain cyrtoconic shells with large ventral siphuncles which are cyrtochoanitic and which are known to contain endocones. The type genus, which is known only from a loose siphuncle, was evidently a cyrtocone with a relatively slender cyrtochoanitic siphuncle. The siphuncle is filled with massive endocones as in the Discosoridæ, but no evidence of annulosiphonate deposits is preserved. The siphuncle is so slender as to be scarcely cyrtochoanitic. Unfortunately the only known specimen is a loose siphuncle which cannot be expected to preserve the connecting rings well enough to show whether they are thickened. There is clearly no inflation of the rings at the septal foramina within the septal necks. *Lowoceras* Foerste is based upon *L. southamptonense* from the lower Clinton of Southampton Island. The species, insofar as the writer is aware, is known only from the type. This has been studied from sections, prepared by the courtesy of the Canada Geological Survey, which show the discosorid affinities of the genus.

Tuyloceras Foerste and Savage, based upon *Tuyloceras percurvatum* Foerste and Savage (1927, p. 81, pl. 13, fig. 1A-B) from the equivalent Ekwan limestone of Hudson Bay, is apparently known only from the type specimen. This is a cyrtocone with a large cyrtochoanitic siphuncle. As no sections have been made, the presence of cones, or indeed of any deposit whatsoever, is an assumption. However, it seems unlikely that the siphuncle would be as well preserved as it is without the strong support furnished by the development of such cones. This supposition is further supported by the presence of cones within the similar Discosoridæ and *Lowoceras*. As the shell is relatively slender, I place the genus tentatively with *Lowoceras* in the Lowoceratidæ. Quite possibly *Tuyloceras* is the connecting link between *Lowoceras* and *Faberoceras*.

Family **DISCOSORIDÆ** Teichert

This family has been investigated by Teichert, who has supplied the essential known facts concerning the structure of the peculiar disembodied siphuncles which constitute *Discosorus* and allied genera. The segments are broadly cyrtochoanitic and are filled with endocones. No segmental deposits are known, and the connecting ring has not been fully observed, largely because most specimens which have been studied have been either broken along the connecting ring, or have been previously weathered out along it. *Discoscorus* Hall, *Endodiscosorus* Teichert, *Stokesoceras* Foerste, and *Kayoceras* Foerste constitute the fam-

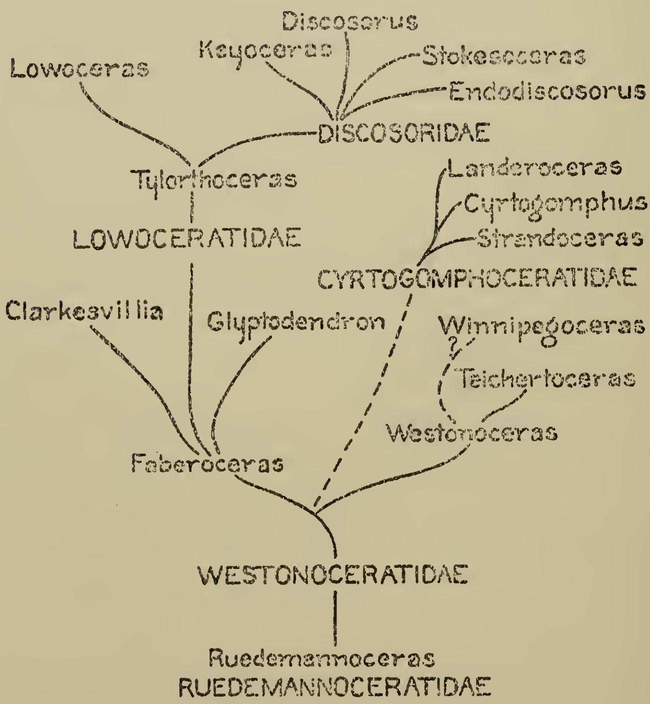

Figure 19. Phylogeny of the Discosoroidea. For morphological features, see figure 18. The Ruedemannoceratidæ lack an area of adnation but have thickened rings. In the Westonoceratidæ, *Faberoceras* possibly includes the simplest types, both in regard to shell form and internal structure; later the genus develops specializations of its own. The breviconic shells of the family including *Westonoceras, Teichertoceras,* and *Winnipegoceras* are united because of similarity of form. The Cyrtogomphoceratidæ must have sprung from generalized Westonoceratidæ,

while the Lowoceratidæ apparently came from specialized *Faberoceras* possessing endocones. The Discosoridæ differ from the Lowoceratidæ in being breviconic and scarcely curved, but the organization of the two families is very similar.

ily. The shells are, in general, little curved and the siphuncles expand quite rapidly orad. The exterior of the shell is known only in *Kayoceras,* although *Discosorus austini* Foerste preserves in addition to the siphuncle, a rough mold of the living chamber. The entire family is one of the most characteristic features of the lower Clinton beds of the Arctic embayment from Southampton Island to northern Michigan. *Discosorus* itself penetrates the Clinton of New York and Ohio, and *Kayoceras* is known only from the Hopkinton of Iowa. The family is best developed in northern Michigan and in the Silurian outlier of Lake Timiskaming which has unfortunately received thus far no better designation than the erroneous one of "Lockport".[14]

The Discosoridæ and Lowoceratidæ have no direct bearing upon the problems concerned in the Cincinnatian Discosoridæ and are only summarized here. The probable genetic relationship of the discosorids is indicated in text figure 19.

Family WESTONOCERATIDÆ Foerste and Teichert

Conch cyrtoconic, exogastric at least in the mature portion, compressed in section, the siphuncle close to the venter in at least the early stages of growth; connecting ring thickened in advanced stages of growth. The interior of the siphuncle bears parietal annulosiphonate deposits which develop orad from the septal foramina until adjacent segmental deposits fuse forming an apparently continuous lining of the siphuncle. In addition, endocones may develop but are not present in all genera.

Only two of the genera of the Westonoceratidæ are developed in the Ordovician of the Cincinnati region, *Westonoceras* and *Faberoceras.* The characters of the family have been discussed rather fully under the Discosoroidea.

[14] The Timiskaming Silurian beds are, as will be shown at a later time, not Lockport but much lower in the Silurian. As the name Lockport cannot be applied to them properly, the name Thornloe limestone is proposed from the town of Thornloe, Ontario.

Genus WESTONOCERAS Foerste

Genotype—*Cyrtoceras manitobense* Whiteaves.

Westonoceras Foerste, 1924, Denison Univ. Bull., Sci. Lab., Jour., vol. 20, p. 253; Foerste, 1926, Denison Univ. Bull., Sci. Lab., Jour., vol. 21, p. 331; Troedsson, 1926, Meddelelser om Grœnland, vol. 71, p. 90.
Thuleoceras Troedsson, 1926, *ibid.*, p. 93.
Westonoceras Foerste and Savage, 1927, Denison Univ. Bull., Sci. Lab., Jour., vol. 22, p. 54; Foerste, 1928, Michigan Univ., Mus. of Geol., Contrib., vol. 3, p. 48; Foerste, 1929, Denison Univ. Bull.., Sci. Lab., Jour., vol. 24, p. 219; Foerste and Teichert, 1930, Denison Univ. Bull., Sci. Lab., Jour., vol. 25, p. 280; Foerste, 1935, Denison Univ. Bull., Sci., Lab., Jour., vol. 30, p. 59; Teichert, 1934, Meddelelser om Grœnland, vol. 92, No. 10, pp. 36-38.

This genus is made up of compressed cyrtoconic shells. The early part of the shell is slightly exogastric or sometimes nearly straight. Adorally the venter becomes markedly convex, the dorsum slightly gibbous, and the conch contracts slowly over the entire length of the mature living chamber to the aperture. The general aspect of the genus is shown clearly in figure 18L, N. The sutures are variable, sometimes essentially straight and transverse, sometimes with shallow broad lateral lobes. The siphuncle lies close to the ventral wall in the early stages and is made up of cyrtochoanitic segments usually subquadrangular in longitudinal section. The septal necks are short, recumbent, that is, so recurved as to be in contact with the septum from which they arise (fig. 18E). The connecting ring lies in contact with the adoral septum and also with the adoral surface of the adapical septum, but it continues around the adapical surface of this septum without being in contact with it there until it joins the tip of the septal neck. In advanced stages of growth in a segment, the connecting ring may be thickened, the thickening usually occurring on the outside or the siphonal surface of the original thin ring. Annulosiphonate deposits are developed which grow orad, finally fusing, at least on the ventral side, to form an apparently continuous lining of the siphuncle. Completion of the lining on the dorsum has not been noted. Vestigial deposits within the cameræ are responsible for the low longitudinal markings which are characteristic of the internal molds within this genus and the allied *Teichertoceras*.

The genotype was first described as having siphuncular segments which expand only slightly within the cameræ, a condition due, in specimens of the genotype, to poor preservation of the strongly recurved septal necks. In the holotype of the genotype the apparent siphuncle wall is styliolitelike in structure and has been modified by loss, probably by solution, of some of the essential morphological features.

The deposits within the siphuncle consist of (1) annuli at the septal foramina which project orad along the free part of the connecting ring to the point orad where a new annulus appears and (2) a secondary organic deposit covering this, sometimes of uniform thickness, sometimes thinner over the annuli and over the free part of the connecting ring. These features, characteristic of the Westonoceratidæ, show some minor modifications but are easily recognized in opaque sections.

The phragmocone of *Westonoceras* often bears broad low longitudinal markings, here regarded as incipient cameral deposits.

Discussion.—Thuleoceras Troedsson differs from *Westonoceras* in having a less curved phragmocone, a feature which is not constant but was separated largely because of the supposed slender siphuncle of the type of *Westonoceras*. It is now properly regarded as a synonym of *Westonoceras*. *Teichertoceras* Foerste is very similar to *Westonoceras* in form and structure, differing mainly in that the early part of the shell shows a concave ventral profile. *Faberoceras* agrees with *Westonoceras* in the structure of the siphuncle, but differs from it in form, being expanded to the aperture. Though the adoral part of the shell may be slightly more slender than the adapical part, and the aperture may contract very slightly, complete shells of the two genera are not at all similar, as *Westonoceras* is gibbous well below the base of the mature living chamber, and the adoral part of the shell contracts to the aperture over not only the complete living chamber but also some of the phragmocone. Fragments of the adapical part of the phragmocone, however, are not distinguishable with certainty, at least, if they show marked exogastric curvature. While *Faberoceras* is more strongly curved in general than *Westonoceras*, adapical fragments of exogastric shells cannot be placed in either genus with certainty until the adoral part of the shell has been made known.

Westonoceras is widespread in America in strata deposited by seas connected with the Arctic embayment. It is still uncertain whether some of these beds are to be regarded as Trenton or Richmond. The described species are listed below:

W. deckeri Foerste. Viola limestone (Trenton), Oklahoma.

W. greggi Roy. "Richmond," Silliman's Fossil Mount, Frobisher Bay, Baffin Land.

W. gouldi Foerste. Red River equivalent, Putnam Highland, Baffin Land.

W. cf. gouldi Foerste. Red River equivalent, Putnam Highland, Baffin Land.

W. iowense Foerste and Teichert. Maquoketa shale, Iowa.

W. cf. iowense. Red River equivalent, Atpatok Island.

W. latum Troedsson. Cape Calhoun beds, Greenland.

W. manitobense (Whiteaves). Red River beds, Lake Winnipeg.

W. cf. manitobense (Whiteaves). Stewartville dolomite, Missouri.

W. ornatum (Troedsson). Cape Calhoun beds, Greenland; Iglulik Island.

W. minnesotense (Clarke). Prosser limestone, Minnesota.

W. cf. minnesotense (Clarke) Foerste. Cornell member, Trenton, Michigan.

W. nelsonense Foerste. Nelson limestone, Hudson Bay.

W. ortoni (Meek.). Southgate, Eden, Cincinnati.

W. putnami Foerste. Red River equivalent, Putnam Highland, Baffin Land.

W. ? rallsense Foerste and Teichert. Kimmswick limestone, Missouri.

W. ? septentrionale Foerste and Savage. Attawapiskat limestone, Hudson Bay (probably not a *Westonoceras*).

W. tumidum (Schuchert). Trenton or Richmond, Frobisher Bay, Baffin Land.

W. ?, sp. Foerste and Savage. Nelson limestone, Hudson Bay.

W., sp. Foerste and Teichert. Stewartville dolomite, Minnesota.

Strand (1939) has described *Westonoceras osloense* from the *Trinucleus* limestone and *W.* (?) *askerense* from the Gastropod limestone, both at the Oslo area. However, even *W. osloense* may be an oncoceroid from its form. The siphuncles of both species are inadequately known.

From the close relationship between the upper Richmond of Ohio and the Arctic embayment in which *Westonoceras* attained its optimum development, one would expect to find this genus there. However, only three little known species in the Cincinnati area show any relationship to *Westonoceras*. These are *W. ventricosum* (Miller), *W. ? ortoni* (Meek), and *W.* ?, sp. All three are known only from portions of phragmocones, and more material is needed before their generic position can be determined more accurately. *W. ? ortoni* and *W.* ?, sp, have relatively straight shells and are fairly typical of the phragmocones of *Westonoceras* in form insofar as they are known. *W. ventricosum* is an exogastrically curved form. The extant descriptions and material suggest that the shell may become gibbous adorally, but such a phenomenon may be the result of distortion by pressure. If the gibbosity is real, the species is a *Westonoceras*. If it is false, the species is to be placed instead in the closely allied genus *Faberoceras*. The presence of *Westonoceras* in the Eden and its absence in higher beds in the Cincinnati area is strongly suggestive that the so-called Richmond strata of the Arctic embayment, in which this genus is best developed, may range in age through the Covington.

Westonoceras ventricosum (Miller) Plate 9, fig. 1; Plate 4, figs. 3, 4

Cyrtoceras ventricosa S. A. Miller, 1875, Cincinnati Quart. Jour. Sci.,

vol. 8, pp. 131-132, fig. 16.
Cyrtoceras ventricosum James, 1886, Cincinnati Soc. Nat. Hist., Jour., vol. 8, p. 246; S. A. Miller, 1889, North American Geol., Pal., p. 435, fig. 731., Nickles, 1902, Cincinnati Soc. Nat. Hist., Jour., vol 20, p. 73; Bassler, 1915, U. S. Nat. Mus., Bull. 92, vol. 1, p. 358; Chappars, 1936, Ohio Jour. Sci., vol. 36, p. 18.

This species is known only from portions of phragmocones which enlarge relatively rapidly and are curved with the siphonal side convex, the opposite and supposedly dorsal side concave. The section is circular or nearly so according to the original description which was based apparently upon a less distorted specimen than that available to the writer. Expansion is fairly rapid, at least in a vertical direction, increasing from about 12 mm. to 21 mm. in a length of 20 mm. The sutures are apparently straight and transverse or nearly so in undistorted specimens, though adorally they tend to slope forward on the convex side of the shell. The siphuncle is close to but not in contact with the venter. At a diameter of 16 mm. the septal foramen is 1 mm. in diameter and lies 3 mm. from the venter. Here the segment is 2.5 mm. in length and attains a width ot 5 mm. Farther orad on the hypotype, a segment 4 mm. long has a maximum width of 6 mm. and is 1.4 mm. at the septal foramen. The segments are subquadrangular in form, slightly oblique in vertical section, due to the slope of the septum, and in every way typical of *Westonoceras*. The necks are recumbent, the connecting ring is adnate to the septum at both of its ends. The connecting rings are thickened in this species, apparently on both the dorsum and on the venter. Annulosiphonate deposits are developed, but in the portion known have not developed beyond the stage of widely separated annuli. The structure as observed in this species is typical of the genus.

Discussion.—This is a rare and apparently a very little known species. The original description was based upon a single specimen, from internal evidence, and is accompanied by a line drawing, rather diagrammatic, of a vertical section, apparently of the type. A specimen in the collection of the University of Cincinnati Museum listed as holotype by Chappars (1936) cannot from its condition or its measurements be the specimen upon which this description was based. The specimen was not sectioned prior to this study and was vertically flattened by pressure. The original label, apparently by S. A. Miller, indicates the specimen as a type. It is probably, therefore, one of the specimens mentioned by Miller in the original description as follows: "I found this specimen and other fragments in the excavation for Columbia avenue, east of Torrence road, in Cincinnati, at an elevation of about 150 feet above low water mark."

It is apparently this information which served as the basis upon which Nickles attributed the species to the middle Utica or *Batostoma jamesi* beds, and Bassler (1915) later attributed it to the same level in the modern stratigraphic nomenclature as Southgate. The location of the holotype is unknown. According to Foerste (*fide litt.*) this may have been among the group of cyrtoconic cephalopods the types of which have been lost. The above revised description is prepared partly upon the basis of the measurements of the original description but very largely upon the specimen mentioned above in the collection of the University of Cincinnati. This specimen is badly crushed adorally, flattening being vertical. However, while this has modified the proportions and has destroyed the septa in part, it has failed to disturb the siphuncle which upon sectioning yielded structure typical of the Westonoceratidæ.

The adoral part of the shell is unknown. The original figure suggests that at the adoral end of the holotype the venter was becoming more strongly curved! The paratype here studied also suggests that the shell becomes gibbous adorally, though from this specimen alone the phenomenon might be due to flattening. However, the suggestion of gibbosity from two different sources seems sufficient to warrant placing the species, at least tentatively, in the genus *Westonoceras* instead of in the simpler cyrtoconic genus *Faberoceras*. Further, both the original figure and the paratype show that the dorsum is only faintly concave adapically and straight adorally, a feature which is characteristic of *Westonoceras* but is at least not typical of *Faberoceras*.

Type.—Location of holotype uncertain. The above description is based largely upon a specimen labeled as a type in the University of Cincinnati Museum, No. 105, which is evidently among the specimens of Miller's original material of the species, bears his label, and is, therefore, regarded as a paratype.

Occurrence.—Known only from excavations for Columbia Avenue, Cincinnati, in the Southgate beds of the Eden.

Westonoceras (?) ortoni (Meck)

Orthoceras Ortoni Meek, 1872, Philadelphia Acad. Nat. Sci., Proc., p. 330; Meek. 1873, Geol. Surv. Ohio, vol. 1, Geol. and Pal., Part II, Pal., vol. 1, p. 155, pl. 13, fig. 8; Miller, S. A., 1875, Cincinnati Quart. Jour. Sci., vol. 2, p. 130; James, J. F., 1886, Cincinnati Soc. Nat. Hist., Jour., vol. 8, p. 239; Leslie, 1889, Geol. Surv. Pennsylvania, Rep. Progr., vol. 4, p. 555, fig.

Cyrtoceras ortoni Nickles, 1902, Cincinnati Soc. Nat. Hist., Jour., vol. 20, p. 73.

Orthoceras ortoni Bassler, 1915, U. S. Nat. Mus., Bull. 92, vol, 2, p. 912.

Westonoceras (?) *ortoni* Foerste, 1932, Denison Univ. Bull., Sci. Lab., Jour., vol. 27, pl. 33, fig. 3A-B; *ibid.*, vol. 28, p. 117.

This little known species I have not seen. The long list of bibliographic references contains no additions to the information accompanying the original description except for the revised description of Foerste which is based upon additional material.

The species is represented only by rather badly distorted fragments of phragmocones. Because of the distorted condition, Foerste referred *ortoni* to *Westonoceras* with doubt. Unfortunately his revised description was based upon a specimen in the collection of the U. S. National Museum which does not appear to be conspecific with the specimen which Meek figured as *Orthoceras ortoni.* This specimen, the original of Meek's pl. 13, fig. 8 (1873), is hereby selected as the lectotype of *Orthoceras ortoni.*

Meek's type, as well as other specimens available to him at the time when the description was written, are so poorly preserved that it is very doubtful whether an uncrushed specimen could be recognized as conspecific. Indeed, until the types are restudied it will not be possible to refer any other specimens to this species with certainty. Today such specimens would be regarded unsatisfactory as types upon which to erect a species, and the characters which made *O. ortoni* seem strikingly different from other cephalopods are known to be characteristic of a considerable number of species of the genera *Westonoceras* and *Teichertoceras.* These features consist of the longitudinal markings on the walls of the cameræ. These represent cameral deposits which have this striking pattern only in the Westonoceratidæ. Such markings may represent the internal molds of cameral deposits. Again, they may represent exfoliation of the shell and part of the cameral deposits along growth lines, leaving attached to the internal mold the inner and younger parts of the deposits. Such a condition of preservation is common in the Cincinnatian and is particularly abundant in the Eden. Insofar as the available information is concerned, *Orthoceras ortoni* is a member of the Westonoceratidæ which preserves only a small part of the phragmocone and occurs in a flattened condition in the Eden of the Cincinnati area. Until the species is restudied on the basis of the types, and probably additional material will be necessary, it will not be possible to make an intelligent comparison with other members of tthe Westonoceratidæ.

Westonoceras ventricosum (Miller) is based upon better material. It is clearly a *Westonoceras* of circular section in which the phragmocone is exogastric in the early portion. It fails to preserve the cameral deposits in the manner exhibited by *W. ortoni,* but that may be due to conditions of preservation. If it could become possible to recognize *W. ortoni* it may eventually prove that *W. ventricosum* should be reduced to synonomy. However, until this is demonstrated, it seems best to retain the name *Westonoceras ventricosum* although *W. ortoni* was described first, as *W. ventricosum* is based upon material which is adequate for the recognition of a species, while "*Orthoceras*" *ortoni* is not.

The specimen, which Foerste figured as *Westonoceras* (?) *ortoni* and upon which he based his revised description of the species, shows features not exhibited by Meek's original figure. The sutures are lobed, and from the condition of Foerste's specimen the lobation appears to be original. Typical *Westonoceras* bears broad lateral lobes separating rounded dorsal and ventral saddles. This feature is connected with a compressed section and is not developed in *W. ventricosum* in which the section is circular. The correlation between lobation and departure from a simple circular section is a common feature in nautiloids.

Foerste's specimen is clearly not conspecific with *W. ventricosum,* and cannot be placed in *Westonoceras ortoni* since (1) it is not possible to identify specimens as representing this species in the present state of our knowledge and (2) the compressed form and the lobation of the sutures indicates clearly that Foerste's specimen is quite different from the original of *ortoni.* The proposal of a new name for Foerste's specimen seems to be indicated. However, it is felt that this species is not well enough known so that it can be distinguished specifically from described species of *Westonoceras.* Comparable species are found in the Stewartville formation of Minnesota, the Red River fauna, and the Cape Calhoun beds of Greenland. In view of the restricted range of other nautiloid species, it would indeed be most remarkable if this Cincinnatian form should prove to be conspecific with any of these Arctic species. Nevertheless, the proposal of a new name should be delayed until clear specific distinctions can be pointed out.

Type.—The present location of the lectotype of *Westonoceras* (?) *ortoni* is unknown.

Occurrence.—From the Southgate formation of the Eden, Cincinnati, Ohio.

Westonoceras, sp. Plate 17, figs. 13, 14

Westonoceras (?) *ortoni* Foerste, 1932, Denison Univ. Bull., vol. 27, pl. 33, fig. 3A-B; 1933: *ibid.,* vol. 28, p. 117.

As noted under the discussion of *Westonoceras* (?) *ortoni* the specimen figured and described by Foerste cannot be regarded as a member of that species. The proposal of a new name should be delayed until better material makes possible a closer comparison with species of *Westonoceras* previously described, since the present specimen fails to show features on the basis of which it can be demonstrated to be specifically distinct.

Type.—U. S. National Museum, No. 48849.

Occurrence.—From the Southgate formation of the Eden, from Crawfish Run, Cincinnati, Ohio. This stream is no longer available, as a collecting spot, having long since been covered. (Bassler, *fide litt.*)

Genus FABEROCERAS Flower, n. gen.

Text figures 18A-D, 20

Genotype.—*Faberoceras multicinctum* Flower, n. sp.

This genus is erected for slender compressed exogastric cyrtocones with the dorsum more broadly rounded than the venter. Although the rate of expansion is reduced adorally so that the mature living chamber may be nearly tubular, the aperture is not contracted. The sutures are straight and transverse in the early stages. They may remain so throughout life or may slope orad from dorsum to venter in the later growth stages. Lateral lobes are developed only very slightly in the more compressed species. The siphuncle is highly variable in position (fig. 2A-C) being close to the venter throughout life in some species, but in others it becomes widely separated from the venter in the later stages of growth and may even become subcentral, as shown in figure 2A, while in other species it is subcentral throughout the ephebic stage. The segments of the siphuncle are broadly expanded within the cameræ. Early segments which are close to the venter are relatively slender and resemble superficially those of *Westonoceras*. As in *Westonoceras* the brims are recumbent. The connecting ring is more evenly rounded in section than is that of *Westonoceras*, and the segment contracts apicad of the center, the connecting ring joining the adoral septum at the point where the neck begins to curve, instead of outside of that region, as in *Westonoceras*. (Compare figs. 18D and E.) Adorally the segments may become broader and even more broadly rounded, and among the species there is considerable variation in the form of the segments.

The structure of the siphuncle has already been discussed under the Discosoroidea. Its essential features are shown in figures 18D and 20. The connecting ring becomes thickened over its entire length and is considerably inflated adapically where it bends around the adapical septal neck. These rings are often not obvious as such in opaque section, and the annular inflation over the septal necks is commonly replaced by white calcite and appears to be an annulosiphonate deposit. True annulosiphonate deposits are also present. These appear at each septal foramen and grow orad, fusing to form a continuous lining within the siphuncle. These structures appear on the venter before they appear on the dorsum, but most of the growth of the deposit is more comparable with that found in the Dolorthoceratinæ than in the Pseudorthoceratinæ (Flower, 1939), and the deposit is not completed ventrally before it appears in the dorsum as in *Westonoceras.* These deposits show two sorts of structure in thin section, lamellæ of growth and rows of aragonite prisms normal to the lines of growth. Identical in fine structure is a third deposit which is often not clearly set off from the annulosiphonate

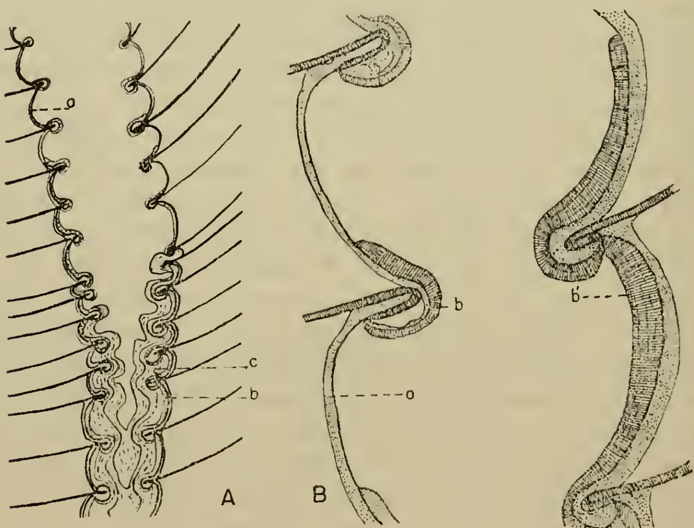

Figure 20. Siphuncles of *Faberoceras.* A. Section of siphuncle of *Faberoceras multicinctum* from paratype (Pl. 12, fig. 3). Crowding of the septa occurs at the middle which is probably abnormal. Orad of this the siphuncle is rapidly widened. Adorally the thickening of the connecting ring alone is developed. Farther apicad the ring is inflated about the neck forming annulosiphonate deposits. In the adapical half these structures are supplemented by endocones. B. Details of siphuncular structure from a thin section of *Faberoceras cf. percostatum* Flower. See also Plate 30, figure 1. Vent on right. a.—connecting ring. b.—annulosiphonate deposit. c.—endocones.

one. This consists first of additional calcareous material which is not confined to any one segment but passes through a considerable number of segments. As this deposit grows orad it develops into a clearly recognized system of endocones (fig. 18A, fig. 20, Pl. 12, and c of fig. 18) leaving as a cavity in the siphuncle only a small central canal. This structure has so far been observed only in the genotype and in *F. shideleri* and may not be developed in all species.

The base of the mature living chamber may develop a clear basal zone. Well-preserved internal molds of the phragmocone may show the same obscure shallow longitudinal grooves which are so characteristic of *Westonoceras* and which represent exfoliation of the incipient mural deposits of the cameræ. The dorsum has been observed to show also the septal furrow, or *ligne normale* of Barrande.

The shell surface bears only fine transverse markings which are faintly rugose in *F. anomalum.* The internal molds of *F. ooceriforme* and *F. magister* are smooth and show no trace of any surface markings. Other species, however, show a uniform development of annuli on the surface of the shell. These may be low and frequent, so slightly elevated that they are scarcely discernible on the internal molds alone. Again, the annuli may come to be widely spaced and greatly exaggerated in the gerontic stages, as is shown by *F. transversum* and *F. percostatum.* A hyponomic sinus is developed with variable clarity. Wherever the aperture or surface is known, some indication of it is found. It is strong and deep in *F. transversum* and *F. percostatum,* moderate in *F. multicinctum,* and vestigial only in *F. elegans.*

Discussion.—Few described genera are comparable with *Faberoceras.* The allied genera *Westonoceras* and *Teichertoceras* may be distinguished by the breviconic form of the complete shell. A further difference is found in the adnate condition of the adapical ends of the connecting rings in these genera, though this is a difference which may be found not to be very uniform. Early stages of *Westonoceras* and *Faberoceras* are not readily distinguished. In fact, in view of the probable close relationship between the genera, it is doubtful whether species known only from such portions of the shell can be assigned to either genus with certainty to the exclusion of the other. Tentatively three Eden species are included in *Westonoceras* although they are known only from such early stages. Determination has been based in such instances upon the more abrupt expansion of the segments of the siphuncle at their ends and the resulting subquadrangular form of the segments.

Tuyloceras Foerste and Savage (1927, p. 81) of the Ekwan limestone of Hudson Bay is somewhat similar to *Faberoceras* in general respect. It is a compressed cyrtocone. However, the large ventral siphuncle is so broadly expanded that it suggests the Discosoridæ rather than the Westonoceratidæ. The adoral sutures curve apicad instead of orad from dorsum to venter, and the adoral end of the shell is gently contracted over the entire length of the living chamber as in *Westonoceras*. Unfortunately the internal structure of the siphuncle is not known, and apparently this monotypic genus is known at present only from the holotype of *T. percurvatum* Foerste and Savage. The condition of the connecting rings is unknown. From the structures known in the genus *Lowoceras*, which occurs at the same horizon and differs, insofar as is known, mainly in the much more slender form of the segments of the siphuncle, only endocones are present, as in the Discosoridæ, and annulosiphonate deposits cannot be recognized.

The development of endocones in *Faberoceras* raises a problem in relation to its taxonomic position. Such structures are not known in other Westonoceratidæ but are found in the Lowoceratidæ and Discosoridæ. However, the Lowoceratidæ and Discosoridæ are not known to possess either thickened connecting rings or annulosiphonate deposits. Because these structures are well developed in *Faberoceras*, I have placed it in the Westonoceratidæ, though regarding it as an advanced genus in the family, presaging the development of the Lowoceratidæ and Discosoridæ, and quite probably ancestral to them. Endocones, as noted above, have been found in only two of the known species of *Faberoceras*. It is not certain whether they are actually absent in the other species, or whether they are only apparently missing because portions of phragmocones of those species far enough apicad of the living chamber for these structures to appear in have not been found. It is suspected that quite possibly cones are originally absent in some of the simpler and earlier species, and that in *Faberoceras* are included species with and without endocones. If this is so, *Faberoceras* is a name which is applied to a group of species some of which are typical Westonoceratidæ while others exhibit a marked advance beyond other members of that family. I have made no attempt to divide the genus into two groups on this basis, however, as such a feature is too difficult to seem to be of great practical value, significant though it may be in the phylogeny of the Discosoroidea. Further, it is felt that even if, as is suspected, the known species embrace an interval in evolutionary development within which endocones make their appearance, there is at present no need to express the development of these structures by the use of an additional generic name.

It is possible to trace the evolutionary trends of *Faberoceras* on the basis of the ontogeny of the species and their stratigraphic range. All of the known early stages agree in that the siphuncle is relatively small and lies close to the venter. Such siphuncles present a superficial similarity to those of *Westonoceras* in their subquadrangular form but lack the broad area of adnation at the adapical end of the connecting ring which is a specialization characteristic of that genus. The small ventral siphuncle is regarded as primitive not only because of its position in the ontogeny of the species, but also because it is a feature which is persistent in the older Cathys and Cynthiana species, while reduced to relatively early portions of the shell tachygenetically in many younger forms. The siphuncle is ventral throughout in *F. sonnenbergi*, *F. oonoceriforme*, *F. saffordi* of the Cynthiana and Cathys, and also in the large *F. magister* of the Eden. In the Eden species some advance is noted, for the segments of the siphuncle have become broader than long.

Two of the Leipers species, *F. transversum* and *F. percostatum*, belong in this group on the basis of the form and position of the siphuncle. Both, however, are specialized in another direction, in the strengthening of the annuli over the mature part of the shell.

In the Leipers formation for the first time species are encountered in which the siphuncle not only broadens adorally, but in which it also comes to lie some distance from the venter. The widening of the segments and the migration of the siphuncle from the venter toward the center seem to go together in *F. multicinctum* and *F. shideleri.* Both species have developed endocones. A striking feature of *F. multicinctum* is the crowding of the septa over a considerable interval of the adoral part of the phragmocone. This appears to be comparable to the gerontic shortening of adoral cameræ found in many cephalopods but normally confined to a region of not more than six gerontic cameræ at the base of the mature living chamber. This area is more expanded in *F. multicinctum,* and is expressed diagrammatically in figure 2A, and may also be seen in Plate 8, figure 1, Plate 12, figure 3, and text figure 4A. Figure 4A, which represents the section shown in Plate 12, figure 3, is probably abnormal in the crowding of the septa at the region where the rate of expansion of the siphuncle is increased abruptly, but the adoral rapid expansion of the siphuncle is characteristic of the species.

The youngest of the species of *Faberoceras, F. elegans,* of the Corryville, is more advanced tachygenetically. The adoral crowding of cameræ noted in the late stages of *F. multicinctum* begins earlier in *F. elegans* and embraces the entire extant portion of the phragmocone of the holotype. What may be considered a gerontic feature in older species has become a normal ephebic feature in this one.

The species which can be assigned to *Faberoceras* with certainty are, with one exception, those described in the following pages. The exception is *Faberoceras troedssoni* Teichert (1930, p. 296, pl. 8, figs. 32-33) of the Lyckholm beds of Esthonia. The siphuncle of this species is not known. However, the compressed section, the strong development of annuli on the surface, the prominence of the preoral constriction of the shell, the slender cyrtoconic condition of the shell, and the development of a hyponomic sinus on the convex side of the shell all favor the assignment of this species to *Faberoceras* and suggest further that the species is very closely allied to *F. transversum* and *F. percostatum* of the Leipers formation. The lack of gibbosity on the living chamber, the ventral and exogastric hyponomic sinus, as well as the annuli and preoral constriction, distinguish this shell from typical *Cyrtogomphoceras*, to which Teichert tentatively assigned this species.

Winnipegoceras (?), sp. (Teichert, 1930, p. 294, pl. 8, fig. 23) of the same formation suggests a *Faberoceras* rather than a *Winnipegoceras*. The species is known from an internal mold representing a large slender cyrtoceracone with deep cameræ. The living chamber contracts very gradually throughout its length toward the aperture, but otherwise the form is quite typical of *Faberoceras*, showing traces of costæ sloping apicad on the venter to form a hyponomic sinus. However, study of the siphuncle is necessary to establish the generic position of this species.

Two of the species described below were outlined in manuscript by the late Dr. Foerste. The descriptions bore specific names but were designated as "Genus?". Contrary to the usual procedure in this work, these descriptions are extensively revised. Unfortunately some of the specimens upon which his description of *F. saffordi* were based could not be located, including the specimen designated by Foerste as the holotype, but happily other material made possible a thorough knowledge of this species. "*F. shideleri*" of the Leipers formation was revised on the basis of much new material which required the recognition of finer divisions among the Leipers species of *Faberoceras*.

Faberoceras is a plastic genus, but the groups of species appear to be too closely related to justify further subdivision. The two smooth-shelled Cynthiana species, *F. sonnenbergi* and *F. ooceriforme*, are unlike other members of the genus in general aspect. *F. sonnenbergi* is a small form suggesting the phragmocone of an *Augustoceras*, while *F. ooceriforme* resembles the genus *Oonoceras*. Careful study of the siphuncle has been necessary in both cases to show the relationship. Eventually these forms may be set apart in a different genus. Possibly they are closer to *Reedsoceras*, but I have not placed them there since it is not even certain that *Reedsoceras* is a member of the Discosoroidea, the siphuncle of the genotype being very little known, while the affinities of the two Cynthiana species to other *Fabero-ceras* is quite evident from their structure.

No key to the species of *Faberoceras* is adequate, because recognition of the species in a fragmentary state will depend upon a careful examination of shell proportions. However, the following key is presented because it will at least serve to separate the species into groups which are believed to be natural.

KEY TO SPECIES OF FABEROCERAS

A. Shell without known transverse annuli; siphuncle close to venter.
  B. Segments of siphuncle longer than wide.
    C. Shell very small, slender .... *F. sonnenbergi*
    CC. Shell moderate in size, adoral portion nearly tubular, resembling *Oonoceras* .... *F. ooceriforme*
  BB. Siphuncle segments broader than wide; shell very large. .... *F. magister*

AA. Shell with transverse annuli on surface.
  D. Siphuncle close to venter throughout life.
    E. Siphuncle slender throughout life, annuli fine, closely spaced, inconspicuous; shell rapidly expanding. .... *F. saffordi*
    EE. Siphuncle widening adorally, annuli thickened to costæ over the mature living chamber; adoral part of shell slender.
      F. Section narrower than high .... *F. percostatum*
      FF. Section as wide as high .... *F. transversum*
  DD. Siphuncle moving toward the center of the shell in the adoral part of the phragmocone.
    G. Siphuncle expanding rapidly in adoral segments; endocones strongly developed .... *F. shideleri*
    GG. Segments of siphuncle of nearly the same width throughout the adoral part of the phragmocone.
      H. A region of about 10 very shallow cameræ at adoral end of phragmocone; costæ large and strong .... *F. multicinctum*
      HH. At least 17 shallow cameræ; costæ low and numerous, less conspicuous .... *F. elegans*

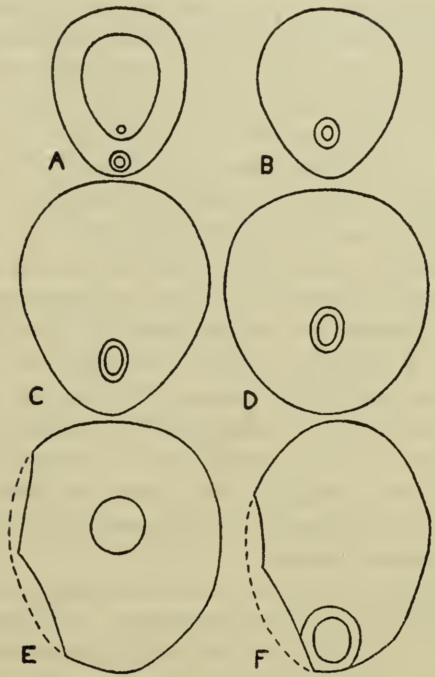

Figure 21. Cross sections of *Faberoceras*, showing variation in shape and in size and position of the siphuncle. A. *F. saffordi*, showing an early stage within a later one. B. *F. shideleri*. C. *F. percostatum*. D. *F. multicinctum*. E. *F. elegans*, missing portions restored. F. *F. magister*, missing portions restored. From base of type.

Faberoceras sonnenbergi Flower, n. sp.

Plate 13, figs. 4, 5; Plate 15, figs. 3, 4; Plate 16, fig. 7

This is a small slender species, known only from the phragmocone, which is slightly curved, compressed, with a small ventral siphuncle agreeing in general aspect more with the Leipers species of *Augustoceras* than with *Faberoceras*, with which it is actually allied as shown by the structure of the siphuncle.

The shell is gently curved exogastrically, compressed in section, and rather variable in proportions. The radius of curvature of the venter varies from 45 mm. adapically to 50 mm. and 65 mm. adorally, varying somewhat among different individuals. The section is compressed, more narrowly rounded ventrally than dorsally, but also shows some variation. One specimen shows the height and width both 14.6 mm. This, however, is atypical, and the height is usually about 1 mm. greater than the width. In the holotype, the longest specimen observed, though incomplete adorally on the venter, the shell increases from 11.5 mm. and 10.1 mm. to 15 mm. and 14 mm. in the basal 15 mm. as measured ventrally, and 13 mm. as measured dorsally. In the next 18 mm. on the dorsum the width increases to 18 mm. and the height is estimated at 19 mm. and in the last 24 mm. as measured dorsally, the width increases to 21 mm. and the height is probably 22 mm. Adorally the dorsum shows a slight flattening on this specimen. Extremes of vertical increase in diameter are shown by a paratype which increases from 11 mm. and 12 mm. to 16 mm and 20 mm. in a ventral length of 30 mm. and a dorsal length of 26 mm. This specimen may be slightly compressed by flattening. The specimen noted above in which the height and width are equal presents a compressed aspect by reason of the narrowly rounded venter.

The sutures slope orad from dorsum to venter without, however, the development of clear lateral lobes. The septa are shallow, nearly flat. The cameræ are closely spaced but somewhat variable, from six to eight and a half occurring in a length equal to the adoral shell height adapically, and from seven to nine in a similar length adorally.

The siphuncle lies close to the venter. The septal foramen is circular in section and not compressed. The septal necks are short, recurved, free, the brim and neck about equal. The segments are subquadrangular in vertical section, the rings being straight or even faintly concave in the center of the segment. They expand more dorsally than ventrally, at the adoral end, and dorsally the adapical end of the ring meets the septum without contraction, while strong contraction occurs on the venter. A somewhat later stage (Pl. 16, fig. 7) is shown in oblique section, where the segment is slightly broader and more quadrangular in form. Adapically the connecting ring appears to be narrowly separated from the septum. Actually this appearance is due to the presence of a white deposit derived from the apical end of the connecting ring itself and comparable with the first deposit to appear in other species of *Faberoceras*. Deposits within the siphuncle are not well developed in this species and are shown well only in this one individual.

The surface is marked by obscure transverse lines of growth. The living chamber and aperture are unknown.

Discussion.—This is a small species of the Cynthiana which is fairly abundant, though almost invariably represented by very small fragments of phragmocones. Many of the specimens have been more or less affected by pressure. Insofar as can be determined from the present material, there is no correlation between variations in cross section and variation in curvature and the depth of the cameræ. The quantity of material studied makes it reasonably certain that one variable species is involved here rather than several associated species.

Because of the absence of annuli, the very slender form, and the small ventral siphuncle, the relation of this form to other species of *Faberoceras* is not at once apparent. Indeed, in an early stage of this investigation this species was regarded as probably belonging to *Augustoceras* which it resembles more in habit of growth, but the structure of the siphuncle shows conclusively that this species belongs to the Westonoceratidæ rather than to the Augustoceratidæ.

This species can be differentiated from its congeners by the small size and very slender shell. All other species are much larger and expand more rapidly in commensurate portions of the shell.

Types.—Holotype, Univ. of Cincinnati Museum, No. 23909. Paratypes, Nos. 23908, 23910-12. Shideler Collection, two specimens.

Occurrence.—From the Cynthiana limestone of Cynthiana, Kentucky, and the vicinity. The species occurs fairly abundantly in the beds associated with *Orthorhynchula linneyi*. One specimen placed in this species with doubt is from the Cathys limestone of Tennessee, from a locality 3/4 mile east of Leipers, Tennessee.

Faberoceras oocceriforme Flower, n. sp. Plate 11, figs. 4. 5

Conch cyrtoconic, compressed, very slender and gently curved. The type is 90 mm. in length, expands from 43 mm. and 30 mm. at the base to a height of 46 mm. at the termination of the 40 mm. of the phragmocone, increases to 49 mm. near the middle of the living chamber, 55 mm. above the base, and contracts to 47 mm. at the aperture. One side is lost by weathering so that the corresponding widths cannot be determined, but it is evident that the shell retains a strongly compressed section throughout with the venter slightly more narrowly rounded than the dorsum, but the greatest width essentially at mid-height of the cross section.

The shell is gently curved, the radius of the curvature about 150 mm. ephebically, but decreased over the adoral part of the living chamber to 100 mm.

The sutures slope orad from dorsum to venter and bear shallow lateral lobes. The septum is equal to 1 1/2 cameræ in depth of vertical curvature. The cameræ are uniformly 4 mm. in depth except the last few, which are slightly shorter. The siphuncle lies close to the venter so that the expanded part of the segment is in contact with the ventral wall of the shell. A segment 4 mm. long is 4 mm. wide at the septal foramen and expands to 6 mm. within the camera. The septal neck is short, strongly recurved on the ventral side but free, and is recumbent and slightly longer on the dorsum, where the adoral part of the connecting ring is in contact with the septum also. At the adapical end of the segment the connecting ring joins the septum at the turn of the neck on the dorsum, but is narrowly adnate ventrally. Annuli which are similar in preservation to the thickened rings of other *Faberoceras* appear within the siphuncle. No thickening of the free part of the ring is noted, and no annulosiphonate deposits are developed.

The internal mold bears obscure longitudinal markings over the phragmocone representing incipient cameral deposits. The aperture appears to be normal to the curving axis of the shell dorso-laterally, the only point at which it is preserved.

Discussion.—This rare Cynthiana species has the external form of *Oonoceras* but differs from that genus and agrees with

Faberoceras in the form and structure of the siphuncle. It differs from other *Faberoceras* in that the growth of secondary deposits within the siphuncle is more delayed than in other known species, the shell form is more slender, and the siphuncle is closer to the venter than in any other known species. Slight thickening of the free part of the connecting ring is suspected in this form but cannot be demonstrated without the use of thin sections. A curious feature is that the annuli on the dorsum appear not to continue around the original ring, but such a development has been noted on the venter. Precisely the opposite arrangement has been found in *Westonoceras.*

The structures as known from this species are sufficient to raise doubt as to the correctness of the reference of other Cynthiana species to *Oonoceras.* However, the siphuncles of many, but not all, of the described Cynthiana species previously placed in *Oonoceras* have been observed, and agree with the genotype in being relatively slender although expanded. There remain several which are not adequately known internally. Such species are here placed with doubt in *Oonoceras,* pending the discovery of better material than is now available for the purpose of sectioning. It is singular to note that *Faberoceras* and *Oonoceras* in the Cynthiana are evidently associated and attain such a similarity of form as to result in almost perfect homeomorphy insofar as the internal molds are concerned. However, *Oonoceras* apparently passes with little change from the Ordovician to the Silurian and is a member of the Oncoceratidæ as employed here, while *Faberoceras* differs materially in the structure of the deposits of the siphuncle and in the ontogeny of known species as do other genera of the Westonoceratidæ, constituting primitively cyrtochoanitic cephalopods of the Discosoroidea.

Type.—Holotype, Shideler Collection, Miami University.

Occurrence.—From the Cynthiana limestone, near Paris, Kentucky.

Faberoceras saffordi Foerste, n. sp.

Plate 8, figs. 2, 5; Plate 12, fig. 2; Plate 15, figs. 7, 8. Text fig. 21 A.

This species is cyrtoconic, somewhat less slender, and smaller than the other and younger species of the genus. The cross section is compressed, the greatest width not markedly dorsad of the center, and the venter only slightly more narrowly rounded than the dorsum. The two most complete specimens show a radius of curvature of the venter ranging from 100 mm. to 120 mm. over an interval in which the ventral length is 145 mm. and the shell height increases from 38 mm. to 55 mm. The largest and most complete specimen increases from a height of 35 mm. and an estimated width of 30 mm. to 48 mm. and an estimated width of 43 mm. in the ventral length of the phragmocone of 73 mm. The living chamber is 35 mm. long ventrally and 33 mm. long dorsally. The height at the aperture is 53 mm. This specimen is somewhat compressed by distortion, and one side is badly weathered. (Pl. 15, figs. 7, 8.)

The sutures are curved, forming slight lateral lobes, and slope orad on the venter. In typical specimens the cameræ vary somewhat in depth. On the paratype, four and a half cameræ occur adapically in a length of 20 mm. where the shell height is 43 mm., while adorally at a height of 56 mm. slightly more than three cameræ occur in an equal length. The holotype has five cameræ in 20 mm. at a height of 37 mm., and four at a height of 46 mm. A fine sectioned specimen (Pl. 8, fig. 5; Pl. 12, fig. 2) is externally badly weathered so that the rate of expansion cannot be determined accurately, the dorsum being largely missing. This specimen differs from the others in having slightly more closely spaced cameræ, nearly five occurring in 20 mm. at a shell height of 56 mm. The apparent rapid expansion of this specimen (Pl. 8, fig. 5) is false and the result of weathering.

The siphuncle remains relatively small for *Faberoceras* and is close to the venter throughout life. The segments are typical of the genus in form and in the development of thickened rings and annulosiphonate lining. No endocones have been noted.

The surface is poorly preserved in all specimens. One paratype, however, preserves low frequent transverse annuli.

Discussion.—This species is distinctive in its moderate curvature, relatively small size and fairly rapid expansion, and in having a siphuncle which remains small and close to the venter throughout life. The present material shows some variation in the depth of the cameræ but is not adequate to indicate the presence of more than one species. The small ventral siphuncle is regarded as a primitive feature in *Faberoceras,* and one which is found in the early stages of more advanced species such as *F. multicinctum* and *F. shideleri.* This species differs from *F. transversum* and *F. percostatum* in the absence of prominent constrictions over the mature living chamber. Also the section, though narrower on the venter than on the dorsum, does not have the greatest width attained markedly dorsad of the center.

Types.—Holotype and one paratype, Shideler Collection. Paratype, U. S. National Museum.

Occurrence.—From the Cathys, east of Williamsport, Tennessee, near Franklin, Tennessee, and from the Cynthiana limestone of Cynthiana, Kentucky.

Faberoceras magister Miller Plate 13, fig. 3; Plate 14, fig. 5; Text fig. 21F.

Cyrtoceras obscura Miller, 1875, Cincinnati Quart. Jour. Sci., vol. 2, p. 132, fig. 17.

Cyrtoceras magister Miller, 1875, Cincinnati Quart. Jour. Sci., vol. 2, p. 284; James, 1886, Cincinnati Soc. Nat. Hist., Jour., vol. 8, p. 246; Miller, 1889, North Amer. Geol., Pal., p. 434, fig. 729; Nickles, 1902, Cincinnati Soc. Nat. Hist., Jour., vol. 20, p. 73; Bassler, 1915, U. S. Nat. Mus., Bull. 92, vol. 1, p. 354.

The type consists of a portion of a large cyrtocone with a maximum length of 102 mm. and a radius of curvature of the venter of about 160 mm. The right side of the specimen is preserved, the left side is destroyed. At the base the section is a compressed oval, with the dorsum and venter about equally rounded, 60 mm. in height and with an estimated width of 50 mm. In a ventral length of 80 mm., at the base of the living chamber as marked on the ventral side, the height has increased to 65 mm., and the width is estimated at 55 mm. Only the basal 25 mm. of the living chamber are preserved.

The sutures are nearly transverse at the base of the specimen, but adorally they slope increasingly orad on the venter. The sutures are straight without any clear development of lateral lobes. The cameræ, of which 15 are preserved on the specimen, are shallow and nearly uniform in depth, the first and the twelfth both measure 6 mm. in depth. The last few cameræ are shortened gerontically.

The siphuncle is compressed in cross section and is 14 mm. high in the expanded portion, 10 mm. wide, and 4 mm. from the ventral wall. A vertical section has been made through three adapical cameræ, though not attaining the center of the siphuncle. In such a section a segment 4 mm. in length expands from 9 mm. to 13 mm. The septal foramen is wide, the segment only slightly expanded, with the connecting rings largely free and uniformly convex. The septal necks are recumbent, longer on the dorsum than on the venter, and the connecting ring is in contact with the free part of the septum where it arises from the septal neck. Adapically the connecting ring is adnate for a length about equal to the brim of the septal neck. Deposits in the siphuncle show clearly the white annulosiphonate rings of the Westonoceratidæ covered by a thin and uniform lining of darker material which continues orad of the deposit and merges with the connecting ring. The connecting ring is not visible between the annulosiphonate deposits and the septal neck, clearly a condition of preservation.

The surface of the shell is not retained. The internal mold shows no trace of the annuli which are characteristic of most *Faberoceras*.

Discussion.—The above description is based upon Miller's holotype, apparently the only representative of this species which has been found. Miller's original figure is exceedingly diagrammatic, and represents the opposite side of the specimen from that figured here. That side is badly weathered adorally and fails to show the septa, which have been drawn in, apparently on the basis of the septa on the opposite side of the shell. Part of one segment of the siphuncle is outlined obscurely on the weathered surface, and a section farther apicad exposes three other segments and a part of a fourth. The adoral cameræ of that figure equal the others in depth, a condition contrary to that shown on the type specimen. Without the adoral gerontic cameræ, the type bears the 15 cameræ mentioned in Miller's original description, as occurring in 3.4 inches on the "dorsum," actually the venter. On the specimen the 15 cameræ occur in a length of 3.2 inches on the curving venter. The "transverse" diameter at the base of the specimen is given as 2.9 inches. The height of the shell at the base is 2.4 inches and the width in its present condition 1.65 inches. The diameter of the chamber of habitation is given as 2.9 inches, the height of the shell measured across the oblique break which terminates the specimen.

The uniform but slight expansion of the shell and the strongly compressed section suggest *Oonoceras,* but the siphuncle is much broader than in that genus and shows the essential features of the Westonoceratidæ. In spite of the absence of annuli, the species is, therefore, placed in *Faberoceras,* of which it is fairly typical in all other respects. It can be distinguished from other species of *Faberoceras* by the extremely marginal position of the large siphuncle and the strongly compressed section in which the venter is not markedly more narrow than the dorsum.

The species is known only from the type specimen insofar as the writer is aware. The form is evidently a very rare one and has no close relatives in the Cincinnati area. *Faberoceras elegans* may be readily distinguished by the more central position of the siphuncle as well as by the more expanded segments. *F. percostatum* and *F. transversum* are more similar in the ventral siphuncle, but both have the venter more markedly narrower than the dorsum, and the late stages of growth are marked by prominent costæ.

Type.—Holotype, University of Cincinnati Museum, No. 300.

Occurrence.—Listed from the Southgate formation of the Eden. The original description cites this as coming from the first ward of Cincinnati, 130 ft. above high water mark. Possibly the species may have come from the Economy instead of the Southgate.

Faberoceras percostatum Flower, n. sp.

Plate 8, fig. 4; Plate 11, fig. 3; Plate 13, fig. 2; Plate 14, fig. 9; Text fig. 21C

This is a large species which expands fairly rapidly in the early stages, becoming more slender adorally, and developing large rounded transverse costæ on the mature part of the shell. The section is compressed, markedly narrower on the ventral side than on the dorsum. Expansion is rapid in the early stages. A paratype increases from 26 mm. vertically to 56 mm. in a ventral length of 80 mm. The holotype increases in the length of the phragmocone from 47 mm. to 65 mm. in height and from 40 mm. to 60 mm. in width in a ventral length of 80 mm. The living chamber, which is 65 mm. long on the venter, is faintly contracted adorally so that the aperture is 60 mm. in height and 57 mm. in width.

The sutures are straight and nearly transverse adapically. Adorally they slope orad from dorsum to venter. The cameræ are shallow. At a shell height of 33 mm. three cameræ occur in a length of 10 mm. At a height of 54 mm. two cameræ occur in 10 mm. Fourteen cameræ are preserved on the type and vary from 4 mm. to 5 mm. in depth. The last four cameræ of the type are shorter than those preceding. The siphuncle remains close to the venter throughout life. Adapically the segments are small, and not markedly expanded, quadrangular in section, and similar in aspect to the siphuncle of a *Westonoceras.* The holotype (Pl. 8, fig. 4) shows a gradual adoral expansion of the segments of the siphuncle. At the adapical end at a shell height of 28 mm. the siphuncle is 3 mm. from the venter, 4 mm. across, and 21 mm. from the dorsum. At the adoral end of the same specimen, the siphuncle is 7 mm. from the venter, 10 mm. in diameter, and 40 mm. from the dorsum. The same proportions are shown on the holotype shortly apicad of the base of the living chamber.

Adapically the segments of the siphuncle are relatively narrow. A segment 4 mm. long expands from 1.7 mm. at the septal foramen, actually a smaller interval owing to the deposits, to a height of 4 mm. within the cameræ. Expansion of the siphuncle is abrupt at the ends of the segment and the central free part of the connecting ring is only slightly convex. Adorally the segments are very different in aspect, are much broader at the septal foramen, and have the free part of the connecting ring more uniformly curved. At a shell height of 50 mm., a segment expands from

7 mm. to 10 mm. The septal necks are always very short and recumbent and on the dorsal side are actually so recurved as to be in contact with the septa from which they arise. On the venter they are slightly shorter and very narrowly separated from the septum.

The deposits within the siphuncle consist of the annuli and the dark lining of *Westonoceras*. Though such deposits can be traced over an interval of 19 cameræ in the paratype, no trace of the endocones is found. This indicates that the endocones must be very much more delayed in their development than in related species and may signify that these structures are not developed at all in this species.

Adorally, the deposit first appears as small annuli of light calcite at the septal foramina. These deposits become prolonged adorally over the free part of the connecting ring. To this deposit, is added the dark lining such as is found in all *Westonoceras*. Adapically, where the cameræ are filled with calcite, it is often impossible to discern the adoral prolongation of the annuli, as this is of light calcite, and is often not distinct from the calcite within the cameræ, and the connecting ring under such circumstances cannot be discerned. Instead the apparent margin of the siphuncle consists of the outside of the deposit of dark calcite. The true nature of the structures involved may be determined, however, by the margin of the annular deposit, which under such conditions of preservation appears to merge with the calcite of the cameræ. The dark lining is slightly thicker adapically than adorally but fails to develop into endoncones.

The surface is generally obscure adapically. One specimen, placed in this species with doubt, shows numerous low transverse annuli such as characterize the entire shell of *F. multicinctum*. Other specimens have shown only smooth internal molds. Adorally the shell develops a series of broad rounded constrictions with broad rounded costæ between them. On the holotype there are eight such constrictions with the spacing between them quite irregular. The first is low, the second broad and prominent followed by a conspicuous annulation, the third is low and narrow, the fourth also shallow but broader, the fifth narrow and sixth broad. Farther orad the spacing and strength become slightly more uniform, and the costæ come to take on the appearance of the annuli of *F. multicinctum,* though they are never so closely spaced. The eight constrictions occur in a length of 65 mm., the first appearing at the base of the living chamber. A specimen regarded as belonging to this species shows a considerably earlier appearance of annuli and costæ. They appear at a shell height of 50 mm., in contrast to 63 mm. on the holotype. The specimen shows five constrictions, the first the broadest and deepest. This shell is atypical in being slightly more slender than the type at such a stage in development, and in that the costæ are developed over the phragmocone and are not confined to the mature living chamber.

The transverse markings slope apicad on the venter to form a rather conspicuous hyponomic sinus.

Discussion.—This species and *F. transversum* are characterized by siphuncles which remain close to the venter throughout life and the shells which develop prominent costæ in the mature portion. *F. transversum* may be readily distinguished by its smaller size and the broad whorl, which is as wide as high. Also, the adoral part of the shell does not become so slender in that species. *F. magister* (Miller) of the Eden remains the only species in which the siphuncle retains a position close to the venter throughout life. That form has no known costæ or annuli and has a siphuncle which is even closer to the ventral margin than that of *F. percostatum.*

In one respect this species appears to be peculiar in the development of the primary annuli of the siphuncle orad along the free part of the connecting ring. Other species may exhibit this phenomenon, however, though the adoral portion of the deposit is lost in the calcite. However, a similar phenomenon has been noted in *F. shideleri* and may be found in other species also.

F. percostatum is known from several specimens. The paratype, a section specimen showing the structure of the siphuncle with exceptional clarity, is very slightly broader than the holotype, but its exterior was protected from distortion by calcareous algæ and the holotype is clearly very slightly compressed by pressure, at least adorally.

Types.—Holotype and paratypes, Univ. of Cincinnati Museum, Nos. 24214-24216.

Occurrence.—From the Leipers formation of the Cumberland River. The holotype is from the pelecypod bed immediately overlying the *Tetradium* layers at the Rowena Ferry. One paratype is from the uppermost of the *Tetradium* layers at the same locality. One other specimen is from the pelecypod bed between the upper end of Belk Island and Horseshoe Bottom near the Painted Cliffs. One other specimen is from the *Tetradium* reef at Rowena, Kentucky.

Faberoceras transversum Flower, n. sp. Plate 10, figs. 5, 6

This is a small species with unusually broad whorls. The holotype consists of a living chamber and 16 attached cameræ. The section is as broad as high, but the venter is much narrower than the dorsum, giving the shell a compressed aspect. In the 67 mm. of the phragmocone as measured on the venter, the shell expands from 38 mm. and 38 mm. to 50 mm. and 50 mm. The adoral end of the shell is not quite complete. In a ventral length of 50 mm., diameters of 53 mm. are attained. This is believed to attain the aperture on the venter where a hyponomic sinus is developed.

The sutures slope strongly forward on the ventral side of the adoral part of the phragmocone. The cameræ vary from 4 mm. to 5 mm. in depth on the venter. Although a good basal zone is developed, the adoral cameræ are not shortened as in most gerontic individuals. The siphuncle is 4 mm. high, 3 mm. wide, and 5 mm. from the venter at the apical end of the type. Its structure has not been studied in the holotype.

The internal mold is smooth adapically. On the living chamber, however, constrictions appear between which are developed rounded low annuli as in *F. percostatum.* Five unevenly spaced constrictions occur over the length of the living chamber. These slope apicad on the venter, indicating a hyponomic sinus. Beyond the last constriction the shell is produced orad without the usual expansion, suggestive of the approach of the gerontic aperture.

Discussion.—This species is similar to *F. percostatum,* but mature individuals do not attain the size of that species, the shell is much too broad in section, and the cameræ are shallower. Further, in commensurate portions of that species the shell expands more rapidly vertically, and the sutures do not slope so far forward on the ventral side.

Holotype.—Univ. of Cincinnati Museum, No. 24219.

Occurrence.—From the Leipers of the Cumberland River, at Rowena, Kentucky. From the pelecypod limestone immediately overlying the *Tetradium* beds. Flower and Shideler Collection, 1942.

Faberoceras multicinctum Flower, n. sp.

Plate 8, fig. 1; Plate 9, fig. 2; Plate 12, fig. 3; Text fig. 20 A, 21 D

This is a large very slender form, in which the section is a compressed oval, not markedly narrowed on the venter as in associated forms. The large specimen expands vertically from 50 mm. to 63 mm. in a ventral length of 150 mm. and has a radius of curvature of the venter of about 200 mm. The width is only 3 mm. less than the height throughout. The sutures are straight and transverse adapically, but adorally they slope orad from dorsum to venter without, however, the development of clear lateral lobes. The siphuncle is peculiar in its ontogeny, is farther from the venter throughout the known part of the shell than in any other species of the Leipers, and agrees only with *F. elegans* of the Corryville. The early stages of the siphuncle are composed of relatively slender segments. This is shown by one paratype (Pl. 12, fig. 3) which increases vertically from 34 mm. to 42 mm. in a ventral length of 70 mm. Adapically the segment is 12 mm. from the venter, 5 mm. vertically, and 18 mm. from the dorsum. Adorally it is 15 mm. from the venter, 12 mm. vertically, and 25 mm. from the dorsum. Adapically a segment 5 mm. vertically in its expanded portion is 4 mm. in length and 3.5 mm. at the septal foramen. The first seven cameræ of the paratype enlarge only slightly. The next five segments of the siphuncle are believed to be abnormal. They occupy a length of only 16 mm. and are considerably shorter than the preceding segments. The first four are subequal in length but broaden rapidly orad, the increase in diameter being the result of expansion at the septal foramen, while the connecting rings and septal necks are only slightly changed in form. The first four of these segments occupy a length equivalent to that of three of the earlier segments. The fifth segment is only 1 mm. in depth. The septum to which it belongs is deeper than the others, so that the sutures are evenly spaced, but this siphuncular segment is shortened and the next one is abnormally lengthened. Indeed the segment is so short that the annulosiphonate ring which surrounds the neck is nearly in contact with the next adapical ring. The connecting ring expands very much as does that of the other segments. The next segment of the siphuncle is 6 mm. deep, after which appear two shorter ones, each 4 mm. deep, and a slightly longer one 7 mm. deep. The same specimen is the only one which shows in this species the discosorid deposits in addition to the usual structures of a *Westonoceras,* as other specimens represent portions of the conch too close to the living chamber for the development of the endocone structures. At the adoral end of the specimen the discrete rings of the *Westonoceras* deposit are vestigial and merge with the connecting ring. Farther apicad the annuli and the dark covering are differentiated, but, curiously, they are not distinct adapically. The endocones develop rapidly, appearing shortly apicad of the westonoceroid deposit and occupy the greater part of the length of the siphuncle.

The holotype, which represents a considerably later stage of growth, shows only the early ontogenetic stages of the deposits of the siphuncle. It retains 20 segments of the siphuncle in an interval of the shell which expanded vertically from probably 55 mm. to 60 mm. This lies farther orad than the portion noted on the paratype just described, and unfortunately it is not possible to determine in what way the siphuncle passes in development from narrow adapical segments to broader adoral ones. In the the holotype, however, the segments of the siphuncle show a slight tendency to vary erratically in depth, but become broader adorally, where the cameræ become markedly shorter. Adapically on the holotype a segment 16 mm. from the venter is 10 mm. vertically and 4.5 mm. long. Here five cameræ occur in a length of 20 mm. Adorally, seven cameræ occur in an equal length.

The living chamber, as known from two specimens, shows somewhat similar proportions in both. The holotype expands vertically from 60 mm. to 65 mm. in a ventral length of 55 mm. The dorsal length here is 50 mm. The suture at the base of the living chamber is inclined strongly orad from dorsum to venter. A larger paratype shows a living chamber with a ventral length of 60 mm., in which the height of the whorl increases from 56 mm. to 61 mm.

The surface of the shell bears numerous narrowly rounded low annuli separated by broader concave interspaces. These average six in a length of 20 mm. In the interspaces there are faint, numerous transverse markings and fainter, but larger and more distant, longitudinal ridges.

Discussion.—This species can be recognized by the slender form, the rounded section, in which the venter is only slightly more narrowly rounded than the dorsum, the position of the siphuncle not far ventrad of the center, and the rapid expansion of the siphuncle from relatively narrow to relatively broad segments. While the expansion of the siphuncle is known only in one individual, and there is modified by conditions which are possibly abnormal, the expansion is in itself clearly a phenomenon typical of this species, for other specimens show plainly the very broad adoral siphuncular segments. Just what conditions were responsible for the erratic spacing of the septa in the smaller paratype at the point of siphuncular enlargement cannot be determined from the fragmentary condition of the specimen. There is, however, clear indication in the variation in the curvature of the septa there of a definite abnormality. Similar close spacing of septa is a phenomenon which is not confined to this species, but is occasionally met with in other species and genera, and has been found in *Treptoceras* from the Waynesville shale of Ohio. Clearly owing to some sort of injury normal shell growth was retarded while secretion of the septa continued. It seems highly probable that such conditions might result from extensive damage to the aperture of the shell, which would have to be repaired by the organism before further adoral progression in the shell would have been possible. However, wherever minor damage to the aperture has been repaired, a thing which is by no means uncommon in cephalopods, there is no trace of abnormal crowding of the septa.

Types.—Holotype and paratype, University of Cincinnati Museum Nos. 24210, 24211. Paratype, Shideler Collection.

Occurrence.—From the Leipers formation of the Cumberland River, southern Kentucky. From the pelecypod limestone immediately capping the *Tetradium* beds. The exact stratigraphic origin of one of the types is uncertain. The two other types, as well as two additional specimens, were collected in place.

Faberoceras shideleri Foerste and Flower

Plate 11, fig. 6; Plate 16, fig. 1; Text fig. 21 B

Shell an exogastric cyrtocone, expanding moderately, compressed in section. The paratype, a portion of a phragmocone, increases vertically from 33 mm. to 44 mm. in a ventral length of 68 mm., and the holotype increases from 43 mm. in height and 40 mm. in width to 48 mm. and 45 mm. in the 40 mm. of the phragmocone, and the rate of expansion remains uniform as far as the incomplete aperture, 48 mm. farther orad, where the height is estimated at 56 mm. and the width at 53 mm.

The sutures are straight, inclined orad on the venter in the late stages. The cameræ are relatively deep, though varying somewhat erratically. In the paratype the cameræ, of which 11 are complete, vary from 4 mm. to 8 mm. in depth, but average 6 mm. On the holotype the cameræ vary from 5 mm. to 7 mm. on the venter. The adoral cameræ are not shortened, and the type probably does not represent a mature individual.

The siphuncle is uniformly rather far from the venter. Adapically the segment is 6 mm. across, 7 mm. from the venter, and 20 mm. from the dorsum. Adorally it is 12 mm. from the venter, 11 mm. across, and 27 mm. from the dorsum. The figured section attains the center of the siphuncle adorally but not adapically. Adapically the segments do not expand so broadly as they do adorally. Deposits within the siphuncle consist of the discrete annuli, now of white calcite, the darker segmental lining, and the obscure discosorid endocones.

The surface of the shell bears numerous closely spaced low rounded annuli with shallow concave interspaces. These are shown, though only faintly, on well-preserved internal molds. They slope slightly apicad on the venter to form a shallow hyponomic sinus, which is shallower and not so clearly defined as that of *Faberoceras percostatum.* Adorally four annuli occur in a length of 10 mm.

Discussion.—This species can be readily distinguished from *F. transversum* by the absence of adoral strong annuli alternating with deep but irregular constrictions. The hyponomic sinus is shallower and the siphuncle is farther from the venter than in either of those species. The cameræ are relatively deep in this form, and the shell expands relatively rapidly. The section is subtriangular, having the greatest width well dorsad of the center, and the venter quite narrowly rounded. *F. multicinctum* resembles this species superficially but has a more oval section, the venter not so conspicuously narrowed, the siphuncle is slightly more central in position, the cameræ are more shallow, and the shell is considerably more slender.

This species, which was among those described in Foerste's manuscript, I have considerably revised on the basis of supplementary material, which has served largely to show that among the specimens originally referred to this species more than one species was actually involved.

Types.—Holotype and paratype, collection of W. H. Shideler, Miami University.

Occurrence.—From the Leipers of the Cumberland River. Both specimens are from outcrops opposite the upper end of Belk Island, on the south side of the river, near Horseshoe Bottom. The species has not been found at the Rowena Ferry. By lithology, the holotype is clearly from the pelecypod limestone immediately capping the *Tetradium* beds. The paratype is from the upper *Tetradium* bed.

Faberoceras elegans Flower, n. sp. Plate 12, figs. 1, 4; Text fig. 21 E

This species is known only from the holotype, the adoral portion of a large cyrtocone, which has been crushed very slightly so that the greatest width of the shell lies slightly oblique to the vertical axis of the specimen, and the specimen, as shown in Pl. 12, fig. 4, shows the mid-ventral region on the left side, as indicated by the center of the crests of the ventral saddles. The orientation was not ascertained until a section had been made, and as a result, the sectioned surface shows an apparent decrease in the diameter of the siphuncle in the central portion because the siphuncle curves there toward the venter out of the plane of the section.

The conch is very slender, compressed, with a basal height of 62 mm. and a width of 43 mm. The phragmocone is 60 mm. in length on the venter, and 50 mm. in length on the dorsum, the sutures increasing in obliquity orad. At the end of the phragmocone the shell extends at least 40 mm. farther as a living chamber, but is too incomplete for further measurement, and shows no evidence of modification of the form of the shell. The compressed section is not narrower ventrally than dorsally as in most species of the genus.

The sutures are strongly curved orad on the venter, more so adorally than adapically. The septa are strongly arched, one at the base of the type measuring 16 mm. in depth, which is equal to the depth of about four and a half cameræ. The cameræ themselves are exceedingly shallow but vary somewhat in depth. Three occur in a length of 11 mm. on the venter at the base of the type. Three occur in 15 mm. near the middle of the phragmocone, again as measured on the venter, and adorally the same proportions noted at the base are attained. The adoral cameræ are not shorter than those at the base of the specimen and cannot be considered as gerontic. However, comparison with other species of the genus suggests that quite probably the entire part of the phragmocone shown on the holotype is that in which the cameræ have become slightly shortened, and earlier parts of the shell may be expected to show both slightly deeper cameræ and narrower siphuncular segments.

The siphuncle is located with its center 22 mm. from the venter and 40 mm. from the dorsum. The segments are very broad and short, wide at the septal foramen, with the short septal necks strongly recurved and the connecting rings so broadly expanded as to suggest the segments of an *Armenoceras.* The expansion is greater than in any other species of *Faberoceras.* A segment 3 mm. in length expands from 7 mm. to 14 mm. within the cameræ. Calcite obscures the exact outline of the septal necks, but they are evidently recumbent or nearly so. The necks are surrounded by annular masses of calcite which are continuous, apparently, with the rather thick connecting ring. These are evidently primary annular deposits similar to those noted under better conditions of preservation for *Faberoceras percostatum*. These deposits are not present adorally, but extend throughout the adapical two thirds of the phragmocone and are not markedly more developed at the apical end of the specimen than in the middle portion. The interpretation of the structure shown by this species alone would not have been possible. However, in the light of the better preserved species from the Leipers, it is evident there is no reason to assume the structure of *F. elegans* differed from that of those species in any essential feature. The surface of the holotype bears obscure low rounded annuli which are spaced equally over the phragmocone with septa. Happily the annuli can be traced onto the nonseptate living chamber. The surface, though poorly preserved and considerably weathered, appears to have been very similar to that of *Faberoceras multicinctum*. The annuli are not very clear upon the venter. There is only a very faint indication of a hyponomic sinus.

Discussion.—This species is more closely allied to *Faberoceras multicinctum* of the Leipers of Kentucky than to any other known species. Indeed, it differs from that species mainly in the rather different form of the segments of the siphuncle, though there are also minor differences in shell proportions. The shell is more slender than in *F. multicinctum*, and there is no indication that the venter was more narrowly rounded than the dorsum. This last feature, however, may have been altered by the slight pressure to which the holotype and only known species of *F. elegans* has been subjected. The very shallow cameræ are slightly deeper than the gerontic ones noted in *F. multicinctum* at a considerably earlier shell diameter, and the septa are not so deeply curved in vertical section as the last septum of that species, though in earlier septa, and a lesser diameter, the condition found throughout *F. elegans* is duplicated. The siphuncle agrees with that of *F. multicinctum* in its position, but the segments are considerably broader, both at the septal foramen, and also in their greater expansion within the cameræ. Indeed, no other *Faberoceras* is known in which in a late stage of growth the segments of the siphuncle expand as markedly. Quite probably the earlier portion of the phragmocone of this species would show, as does that of other species, segments of the siphuncle which are narrower at the septal foramen and markedly less expanded within the cameræ. No discosorid endocones are known, for the type consists only of the adoral part of the shell where such structures cannot reasonably be expected to be found.

Type.—Holotype, Univ. of Cincinnati Museum, No. 22860.

Occurrence.—The specimen was originally labeled "Hudson River beds, Cincinnati." The lithology of the specimen suggests the Corryville. Happily, the living chamber contained a bryozoan. This was studied by Miss Helen Duncan who identified it as *Hallopora ramosa rugosa*, a species which ranges from the Bellevue into the Mount Auburn and which is best developed in the Corryville. The species could not, by its lithology, have come from the Mount Auburn and is regarded as probably Corryville.

Genus **CLARKESVILLIA** Flower, n. sp.

Genotype.—*Clarkesvillia halei* Flower, n. sp.

This genus is closely related to *Faberoceras* with which it agrees in general form and internal structure but differs in having the venter flattened in the late growth stages with corresponding modifications of the sutures, and in lacking all traces of annuli.

Conch cyrtoconic, slender, compressed in section, with the venter and dorsum about equally rounded basally, but with the greatest width dorsad of the center adorally, while the ventral face is flattened and clearly set off from the rounded converging lateral faces. The sutures slope strongly orad from dorsum to venter. Lateral lobes, however, are only poorly developed as in *Faberoceras*. Adorally the broad rounded saddle which occupies the venter because of the obliquity of the sutures is interrupted where the suture crosses the ventral face. Instead of forming an evenly curved rounded saddle, it is directly transverse over the ventral face and set off from the remainder of the suture sharply. The surface is unknown. The internal mold shows no trace of annuli. The siphuncle is very similar in the form of its segments to that of *Faberoceras*. It is situated between the venter and the center of the shell. As in *Faberoceras*, the segments are closer to the center adorally than adapically, and there may be a considerable region of adoral cameræ and siphuncular segments which are shorter and broader than those found adapically. The thickening of the connecting ring and the development of annulosiphonate parietal deposits are as in *Faberoceras*. No endocones are known in the genus.

Discussion.—This genus, based upon a single Waynesville species, is separated from *Faberoceras* by the obvious but superficial differences supplied by the adoral section and sutures. The close relationship between the two is evident. *Faberoceras multicinctum* is probably closer to the point of origin of *Clarkesvillia* than any other known species. The siphuncle of *Clarkesvillia* agrees with that of *F. multicinctum* in position, form of the segments, and in the development of a broad adoral zone in which its segments, as well as the associated cameræ, are much shorter than in the early part of the shell. Further, both species appear to lack endocones. *Clarkesvillia* has lost the characteristic section, for the venter is not more narrowly rounded than the dorsum, but the sides which converge ventrad are truncated by a distinct ventral face, clearly defined only in the later growth stages. *Clarkesvillia* is known from an internal mold clear enough to preserve any annuli had they been present. The smooth interior of the shell distinguishes it from those species of *Faberoceras* which it resembles most closely in other features, but apparently smooth-surfaced forms of *Faberoceras*, where the siphuncle is always smaller and closer to the venter, occur in lower strata.

The genus is known only from one species, *Clarkesvillia halei*, described below, from the Waynesville shale. Other than *Faberoceras*, the genus is not known to have any close relatives.

Clarkesvillia halei Flower, n. sp. Plate 42, figs. 3, 4; Plate 43, figs. 1, 4

This form is known only from a single specimen which represents a portion of a phragmocone 100 mm. in length with a ventral length of 104 mm. and a radius of curvature for the venter of about 100 mm. The specimen is an internal mold of the cameræ, but the middle portion fails to preserve the wall of the cameræ or of the shell, and proved upon sectioning, to consist only of segments of the siphuncle. One side of the specimen was weathered nearly to the center, and the width of the shell is therefore estimaed in the following description.

At the base of the type the section is compressed, 48 mm. high and 40 mm. wide, the siphuncle is 6 mm. in diameter and 9 mm. from the venter. The cross section is probably slightly distorted here. The section appears to be nearly oval, with a very slight ventral flattening. At the adoral end of the shell the section is very different. Measurements taken 100 mm. farther orad show a height of 64 mm. and an estimated width of 45 mm. The venter is conspicuously flattened, the ventral face being 13 mm. across. The siphuncle is 11 mm. from the venter and has a maximum diameter of 11 mm. Basally the cameræ average 7 mm. in depth and the sutures are oblique, forming a broad indistinct rounded saddle over the venter. Adorally the cameræ are shorter, varying between 6 mm. and 5 mm. over the six cameræ following the break in which no cameræ are preserved, and decreasing adorally to 4 mm.

The segments of the siphuncle are 5 mm. long basally and expand from 3 mm. to 8 mm. within the cameræ. The septal neck is recurved, but short on the dorsum, and the adjacent part of the connecting ring immediately becomes free and is nearly straight as it extends apicad to the next septum to which it is broadly adnate. On the dorsum, however, the neck is longer, the connecting ring adjacent to it adnate to the adoral septum. After an abrupt bend the ring approaches the adapical septum with scarcely any area of adnation. Here the rings are thickened, especially about the septal foramen, and annulosiphonate parietal deposits are well developed. The condition of these segments is very close to the condition observed in *Faberoceras saffordi* of the Cynthiana and Cathys limestones. Adorally where the segments are broader, the short neck on the dorsum is sometimes not quite recumbent and the ring is free adorally but joins the adapical septum with a broader area of adnation than is seen basally, while dorsally the neck is recumbent. The adjacent part of the ring is broadly adnate, while the adapical end of the ring is free joining the adapical septum at the foramen. A curious phenomenon of the siphuncle is that the parietal deposits are better developed in the central segments than at the extreme base. A cross section taken basally shows that the annulosiphonate deposits are best developed dorsally and ventrally while absent laterally. The internal mold is smooth. Here the segment of the siphuncle appears to expand from 4 mm. to 11 mm., but because of deposits developed at the foramen, the actual cavity there is narrower, varying from 2 mm. to 3 mm..

Discussion.—The characters of the genus will serve to separate this species from species of *Faberoceras,* the only genus with which *Clarkesvillia* is likely to be confused. The species is unique among Richmond cyrtocones in the structure of the siphuncle, and, for all practical purposes, may be distinguished from other compressed cyrtoceracones by the large size of the shell, the flattened venter, and the position of the siphuncle relatively far from the ventral wall. In *Oonoceras, Richardsonoceras,* and other Oncoceratidæ which may approach this genus in form, the siphuncle is close to the venter, relatively narrow, void of deposits, and the ventral face is never developed.

The ventral face and the presence of a cyrtochoanitic siphuncle far from the venter suggest the family Apsidoceratidæ. While the Apsidoceratidæ appear in Trenton time, where *Clarkesvillia* is at least as yet unknown, and are not known to have siphuncles either as broadly expanded or as elaborately constructed as any of the Westonoceratidæ, this genus presents a possible clue to the origin of that family. Whether or not the Apsidoceratidæ are derived from the Westonoceratidæ is, however, a very uncertain problem. They have siphuncles which are not only free from any deposits, insofar as the present evidence indicates, but they have much less expanded siphuncles. The Westonoceratidæ, and in fact the entire Discosoroidea, are characterized throughout by very broadly expanded segments.

Type.—University of Cincinnati Museum.

Occurrence.—From the Waynesville beds of Clarkesville, Ohio. The precise origin of the specimen is unknown. By lithology it may have come from the trilobite beds of the lower Waynesville or from certain beds of the middle Waynesville (Clarkesville). The lithology suggests the middle rather more than the lower Waynesville but is not conclusive. Collected and donated by Dr. Kelley Hale.

BREVICONIC GENERA OF UNCERTAIN POSITION

Three of the genera of nautiloids which occur in the Cincinnati rocks are not well enough understood to permit their reference to any family with certainty. These are grouped here as genera of uncertain position, a course which is considered preferable to placing them in any family without adequate morphological justification. *Vaupelia* is an exogastric depressed cyrtocone, which might belong to the Oncoceratidæ or to the Valcouroceratidæ. The forms are rare, and preservation is not adequate to show whether deposits are naturally absent or absent through poor preservation or, as is clearly the case in *Manitoulinoceras,* through a delay of the appearance of the structures to the gerontic stage of the shell.

Reedsoceras is inadequately known internally. It is believed that this genus may be a member of the Discosoroidea, closely allied to *Faberoceras.* However, nothing is known of the interior of the two species of this genus thus far recognized.

Fayettoceras has not been studied at first hand owing to a lack of suitable material. The form of the shell is such as to suggest a close relationship with *Manitoulinoceras,* and, therefore, suggests a reference to the family Valcouroceratidæ.

Genus VAUPELIA Flower, n. gen.

Genotype.—*Vaupelia russelli* Flower, n. sp.

This genus is erected for breviconic exogastric cyrtoceracones of depressed section. The phragmocone is gibbous, the living chamber is slightly contracted orad if at all. The sutures are characteristically oblique, sloping strongly orad from dorsum to venter. The cameræ are relatively deep and the large ventral siphuncle is made up of broad rounded segments, slightly scalariform in vertical section, having the brim recumbent dorsally and scarcely bent ventrally, and having a broad area of adnation on the venter but none on the dorsum. No organic deposits are known within the cameræ or the siphuncle. The aperture has not been clearly observed but appears to be simple and without a hyponomic sinus.

Discussion.—This genus is erected for two very characteristic species from the Fairview of Cincinnati, which are distinct in the peculiar form of the shell, the strongly oblique sutures, and the large ventral empty siphuncles. To these are added a third species from an unknown horizon and locality in the Cincinnatian of Indiana. The contemporaneous *Augustoceras* though sometimes depressed in section, always has the dorsum markedly flattened and the venter narrowly rounded. Also, it has a smaller siphuncle and actinosiphonate deposits. *Staufferoceras* Foerste (1932, 1933) agrees with this genus in being a depressed cyrtocone but is only slightly contracted adorally. Its siphuncle is not well known but is obviously small. *Schofieldoceras* expands to the adoral third of the living chamber where the shell begins to contract abruptly. The sutures are not oblique and the siphuncle is obviously small.

The relationship of *Vaupelia* is still uncertain. It differs from other depressed cyrtoceracones in the large size of the siphuncle. It differs from other genera with the relatively large siphuncles in the absence of organic deposits. Specimens of the two known species are unfortunately very rare. In spite of the years in which collections have been made in the region of Cincinnati, each species is known at the present time from a single specimen. Strangely enough, the contemporaneous Leipers formation of southern Kentucky, which is so rich in cyrtoconic material, has failed to reveal any representatives of this genus.

This interesting genus has been named for Mr. Charles E. Vaupel, the last of the oldtime Cincinnati collectors.

Vaupelia russell Flower, n. sp. Plate 9, figs. 3-5

Conch breviconic, slightly curved exogastrically, depressed in section. The holotype, and only known specimen, is convex over the venter to the base of the living chamber, where it becomes straight or nearly so. The dorsal profile, probably slightly concave adapically, is slightly convex over the adoral part of the phragmocone, becoming essentially straight over the living chamber. The sides are convex over the adoral part of the phragmocone, constricted at the base of the living chamber, and nearly tubular, very faintly convex, to the aperture. The type preserves a phragmocone 27 mm. in length, very incomplete. Adapically this must have had a width of 25 mm., and a height which was considerably less. In 18 mm. the greatest diameters of 30 mm. and 23 mm. are attained, and in 9 mm., at the base of the living chamber, the conch contracts to 25 mm. and 21 mm., and in the 17 mm. of the living chamber the aperture attains a width of 22 mm. and a height of 17 mm.

The phragmocone contains eight cameræ, subequal in length. The sutures slope strongly orad from dorsum to venter. The siphuncle is close to the venter, unusually large, and is composed of segments which are subspherical. Owing to the obliquity of the septa, the neck is more strongly recurved on the dorsum than on the venter, and the area of adnation is strongly developed at the apical end of the segment on the venter. The wall of the siphuncle is replaced in part by pyrite, but there are no organic deposits which can be recognized with certainty.

The aperture appears to be rounded and simple. However, it is possible that the adoral end of the specimen does not represent the true aperture of the shell. Both the aperture and the septa are strongly inclined orad on the venter suggesting distortion of the shell. However, the condition of the septa suggests that this phenomenon is more probably normal, as fracture or uneven curvature of the septa, which usually result from such modification, is lacking.

Discussion.—In general aspect and proportions, this species is unique. The strongly depressed section, in which the venter is not narrowly rounded, distinguishes it from the contemporary *Augustoceras,* with which it also fails to agree in the shape and large size of the siphuncular segments and the absence of actinosiphonate deposits. Cyrtoceracones of depressed section in the Richmond are few and fail to agree with this form generically. The siphuncles are smaller, and the living chamber is not distinct in outline from the phragmocone.

This species is known from a single incomplete specimen, but happily the essential structural features are shown, and the only closely related species, *V. seiberti,* is a much larger and a more gibbous species.

Type.—Holotype, Univ. of Cincinnati, No. 24226.

Occurrence.—From the Fairmount beds at Bald Knob, Cincinnati. Collection by Mr. R. T. Russell.

Vaupelia seiberti Flower, n. sp. Plate 9, figs. 6, 7; Plate 16, fig. 3

This name is erected from the reception of a single known specimen consisting of only a phragmocone, agreeing in structural features with *V. russelli,* but much larger and more gibbous. The holotype is 32 mm. long, increasing from 16 mm. and 25 mm. to 23 mm. and 17 mm. in a ventral length of 35 mm. and a dorsal length of 27 mm. The type is vertically flattened slightly by pressure, more so adapically than adorally. The extant portion of the specimen consists of six cameræ averaging 5 mm. in length on the venter. The sutures slope forward from dorsum to venter. The septa arch normal to the suture and are equal in convexity to the depth of a camera. The siphuncle is large, placed close to the venter, and is composed of rounded segments scalariform in vertical section, with the area of adnation developed on the ventral side adapically, and the septal neck only slightly recurved there, while in the dorsum the brim is recumbent and no area of adnation is present. A segment 6 mm. long expands from 3 mm. to 7 mm. within the camera. No organic deposits are known.

Discussion.—The extant part of the phragmocone retains a very faintly gibbous aspect which, together with the resemblance found in the form and large size of the siphuncular segments, indicates a close relationship with the smaller *V. russelli.*

Type.—University of Cincinnati Museum, No. 24227.

Occurrence.—From the Mount Hope beds, Rapid Run Creek, Cincinnati, Ohio. Collected and donated by Mr. H. J. Seibert.

Vaupelia (?) minutum Flower, n. sp Plate 41, figs. 6, 7

This is a tiny brevicone represented in our material by two flattened specimens from an unspecified horizon and locality in the Cincinnatian of Indiana. The holotype, the better of the two specimens, is a flattened shell 28 mm. long. It is flattened obliquely, but the sutures, as well as the shape, show exogastric curvature and suggest that this was a shell originally depressed in section. The phragmocone of six cameræ is 15 mm. wide at the base, expands to 17 mm., and contracts to 16 in a length of 15 mm. The shell is constricted at the base of the living chamber which then expands to a width of 18 mm. and contracts to an aperture of 15 mm. The aperture is obscurely preserved and no hyponomic sinus is evident. The siphuncle is obscure. A second specimen is somewhat less distorted but is badly weathered. It is depressed in section, 15 mm. wide and 12 mm. high at the base, has a phragmocone of four cameræ with a ventral length of 9 mm., a constriction at the base of the living chamber, which is abruptly expanded beyond and then contracts gradually to the aperture. The sutures slope orad from dorsum to venter as in the holotype. The living chamber has about the same proportions but is so badly weathered that the aperture cannot be recognized.

Discussion.—This species is known to me only from these two small specimens. Nothing approaches it in proportions and aspect elsewhere in the Cincinnatian. The constriction at the base of the living chamber has been found elsewhere only in the genotype of *Maupelia*, the only form which seems to resemble this even remotely. It is typical of the genus, insofar as it is known, in the form of the shell. However, it is so little known that its generic position can not be regarded as a certainty.

Types.—Holotype and paratype, Univ. of Cincinnati.

Occurrence.—The original label reads "Hudson River group, Indiana." The locality and horizon are unknown. The known range of *Maupelia* suggests that this species is probably Maysville, but the inference is hardly a safe one.

Genus REEDSOCERAS Foerste

Genotype.—*R. macrostomum* (Hall).

Conradoceras Foerste, 1928, Denison Univ. Bull., Sci. Lab., Jour., vol. 23, p. 298. Not *Conradoceras* Foerste, 1926.
Reedsoceras Foerste, 1929, Denison Univ. Bull., Sci. Lab., Jour., vol. 24, 24, pp. 233-234.

The shell is a rapidly expanding exogastric cyrtocone, the expansion continuing to the aperture. The shell is oval in cross section, slightly higher than wide in the genotype, and slightly broader than high in the specimen described below, which may be the result of vertical flattening of the shell in this case. The sutures are straight and transverse to the shell axis. The siphuncle lies close to the venter and is composed of relatively large cyrtochoanitic segments. The details of its structure are known. The aperture is straight and transverse without any development of the hyponomic sinus.

Discussion.—Although of very generalized aspect, this genus is known only from two rare species, the genotype, *R. macrostomum* (Hall) (see Foerste, 1928, pp. 208-9, pl. 44, fig. 1A-C) of the Platteville limestone of Wisconsin and *R. mcfarlani* Flower, n. sp., from the Cynthiana of Kentucky. As nothing is known of the details of the structure of the siphuncle, the position of this genus is uncertain. The large size of the siphuncle of the genotype suggests the Westonoceratidæ, and the genus may belong to that family, being related to *Faberoceras*. Superfically it resembles members of that genus somewhat, but *Faberoceras* has the adoral part of the shell more tubular, is strongly compressed in section, and has a well-developed hyponomic sinus. *R. mcfarlani* does not show the aperture clearly on the venter, but resemblance to the genotype is so strong that a close relationship is quite evident.

Reedsoceras mcfarlani Flower, n. sp. Plate 16, figs. 4-6

Conch cyrtoconic, rapidly expanding, slightly depressed in section. The type has a ventral length of 90 mm., with the radius of curvature increasing from 80 mm. over the adapical portion to 150 mm. on the mature living chamber. The dorsum is much less curved than the venter throughout. The shell expands from 14 mm. and 16 mm. at the base to 34 mm. and 36 mm. in the 50 mm. of the phragmocone, and to 37 mm. and 53 mm. in the 40 mm. of the venter of the living chamber.

The sutures are straight and transverse dorsally and laterally but form low rounded rather obscure saddles over the ventral side. The cameræ are shallow, the 15 present on the type occupying a maximum (ventral) length of 80 mm. and varying in depth from 3 mm. to 4.2 mm. The last two cameræ are shorter than those preceding, suggesting the approach of maturity. The siphuncle is poorly exposed, but clearly lies close to the venter, and is made up of expanding segments, which are probably subspherical.

The middle of the living chamber bears a faint constriction, evidently a feature of the mature shell. The aperture is wide and is straight and transverse on the dorsum. It is less clearly preserved on the venter but shows no indication of the presence of a hyponomic sinus. The ornament consists of transverse lines of growth.

Discussion.—This species is quite typical in form of the genus

Reedsoceras, to which it is referred. The single specimen came into my hands, with no data as to its origin, as part of the collection of the Cincinnati Society of Natural History. The matrix showed clearly by lithology that the material was from the Cincinnati area. Furthermore, fossils embedded within the matrix make it reasonably certain that the specimen is from the upper part of the Cynthiana limestone, probably from the Ohio River. The matrix, though scanty, contained among other fossils two heads of *Cryptolithus tesselatus*. This species is abundant in the Cynthiana and Eden, and though it has been reported higher in the section from the Maysville (Bassler, 1915), it has not to my knowledge been encountered there in any such abundance. The condition of the matrix, a fine-grained silty limestone, is common in the Cynthiana but not known in the Eden. I, therefore, regard the specimen as Cynthiana in age.

Type.—Holotype, No. 23911, Cincinnati Society of Natural History Collection, University of Cincinnati Museum.

Occurrence.—Probably from the upper part of the Cynthiana limestone in the vicinty of Cincinnati.

Genus FAYETTOCERAS Foerste

Genotype.—*Cyrtoceras thompsoni* Miller.

Fayettoceras Foerste, 1933, Denison Univ. Bull., Sci. Lab., Jour., vol. 28, p. 134; Foerste, 1935, *ibid.*, vol. 33, p. 47.

The position and even the validity of this genus are uncertain. Foerste erected it for moderately slender cyrtoceracones of exogastric curvature and depressed section. The sutures are straight and transverse, the siphuncle is expanded within the cameræ and is located on the convex ventral side of the shell. Growth lines of the surface are transverse but may form a hyponomic sinus.

Foerste has placed in this genus three species, *Fayettoceras thompsoni* (Miller) of the upper Richmond, probably Whitewater, of Indiana, *Fayettoceras* (?) *beloitense* Foerste of the Black River Platteville limestone, and *Fayettoceras canyonense* Foerste of the Fremont limestone.

None of the specimens available for this study appear to be conspecific with the genotype. Although this species was redescribed by Foerste, it is still quite inadequately known and appears to be represented only by its holotype. In the opinion of the writer it is highly probable that *Fayettoceras* is either a synonym of *Manitoulinoceras* or a very closely related genus. Of the species of *Manitoulinoceras, M. erraticum* is closer to the genotype of *Fayettoceras* than any other species, but this form develops from a fairly rapidly expanding cyrtocone in the younger stages to a considerably more slender shell in the mature part. As this change in proportions occur on a part of the shell commensurate with the part of *Fayettoceras thompsoni* shown on the genotype, the species are regarded as distinct. Further study of the siphuncle of *Fayettoceras* is needed to determine whether it is closely similar to that of *Manitoulinoceras*. *Fayettoceras* seems to differ from *Manitoulinoceras* mainly in its greater rate of expansion and deeper cameræ. It is to be feared that no natural boundary exists separating the genera.

Foerste's figure of *Fayettoceras thompsoni* is reproduced here, together with his description. No other Cincinnatian species appears to be typical of the genus.

Fayettoceras thompsoni (Miller) Plate 31, figs. 1, 2

Cyrtoceras thompsoni Miller, 1894, Indiana Dept. Geol. Nat. Res. 18th Ann. Rep., p. 323, pl. 10, figs. 7, 8; Cumings, 1908, Indiana Dept. Geol. Nat. Res., 32nd Ann. Rep., p. 1029, pl. 49, figs. 3, 3a; Bassler, 1915, U. S. National Museum, Bull. 92, vol. 1, p. 357.

Fayettoceras thompsoni Foerste, 1932, Denison Univ. Bull., Sci. Lab., Jour., vol. 27, pl. 31, fig. 6A-B; Foerste, 1933, *ibid.*, vol. 28, p. 135.

This species appears to be known only from the holotype. This specimen in the collections of the U. S. National Museum has not been available for the present study. Foerste's redescription and figures are therefore reproduced here.

Only a fragment of the phragmocone is known. This is 43 mm. in length when measured along the curvature of the ventral side. The radius of curvature of the venter is 100 mm., the curvature of the dorsum is about the same. The shell increases from a height of 18 mm. and a width of 20 mm. to a height of 27 mm. and a width of 30 mm. The basal 12 cameræ of the phragmocone are subequal in length and occupy 30 mm. on the venter. The adoral six cameræ are shorter, occupying a length of 12 mm. The sutures are essentially straight and transverse. The septa are only slightly concave. The siphuncle is ventral, the segments expanding from 1 mm. to 3 mm., nearly globular, but slightly elongated. Shell surface with transverse striae. These are obscure ventrally, where they may slope apicad forming a hyponomic sinus.

Discussion.—The temporary storage of types of the U. S. National Museum has made it impossible to restudy this specimen. Foerste's figure of the shell fails to show the septa which are evidently very obscure. The siphuncle is described but not illustrated. This species is regarded by the writer as probably allied to *Manitoulinoceras* and close to *M. erraticum.* That species has a rapidly enlarging phragmocone, but one which becomes straighter adorally. Apparently no adoral reduction in expansion occurs in commensurate parts of *F. thompsoni.* This species is included here for completeness, though it is still quite inadequately known. It is quite possible that it is not distinct enough from *Manitoulinoceras* to be set aside in a distinct genus. Typical *Manitoulinoceras* is more slender and has more closely spaced cameræ. However, in the early stages of the genus the cameræ are deeper and the shell expands more rapidly, a condition better developed in *M. moderatum* and its allies. *Fayettoceras* seems to be closely allied to such species.

Holoytpe.—U. S. National Museum, No. 64334.

Occurrence.—From the upper part of the Richmond, at Longwood, Indiana. The horizon is probably Whitewater but may possibly be Elkhorn.

COILED CEPHALOPODS

Family APSIDOCERATIDÆ Hyatt

This family, as emended by the writer (Flower, 1943) is confined to curved and generally coiled shells, exogastric, externally smooth or with only lines of growth and sometimes lateral costæ. The hyponomic sinus is always developed. The whorl is broad, usually with the venter conspicuously flattened. The sutures develop lateral lobes in primitive forms, in which the section is relatively narrow and high, but these are lost in broader and more specialized types. Instead, with the broadening of the shell, a lobe comes to be developed on the broad ventral face. The siphuncle is cyrtochoanitic, the segments empty, and is somewhat variable in position, though never close to either the dorsal or ventral faces.

The family seems to be dominantly arctic in origin, as can be seen by the distribution of the known species, briefly reviewed elsewhere by the writer (Flower, 1943). Only two genera and species of this interesting group have been found in the Ordovician of the Cincinnati region, *Charactoceras,* represented here by the genotype, which is perhaps the most characteristic cephalopod of the Whitewater beds, and the rarer *Charactocerina faberi* which occurs sparingly in the upper Whitewater beds.

Genus CHARACTOCERAS Foerste

Genotype.—*Trochoceras ? baeri* Meek and Worthen.

Charactoceras Foerste, 1924, Denison Univ. Bull., Sci. Lab., Jour., vol. 20, p. 234; Troedsson, 1926, Meddelelser om Grønland, vol. 71, p. 39; Foerste, 1929, Denison Univ. Bull., Sci. Lab., Jour., vol. 24, p. 171; Foerste, 1935, *ibid.*, vol. 30, p. 83; Roy, 1941, Field Mus. Nat. Hist., Geol., Mem. vol. 2, p. 133; Flower, 1943, Jour. Pal., vol. 17, p. 262.

Conch coiled, rapidly expanding, developing an impressed zone from the completion of the first whorl. Section broad, the venter flattened, the sides rounded, converging dorsad toward the impressed zone. Sutures essentially straight laterally, but tending to form a broad shallow lobe on the venter, and another lobe, usually not clearly displayed, in the impressed zone. The siphuncle is nummuloidal, located ventrad of the center, expands slightly within the cameræ, and is free from any accessory deposits.

The surface bears transverse lines of growth which slope apicad from dorsum to venter in the young. In the adult they are somewhat more transverse laterally but form a clearly defined hyponomic sinus on the broad flattened venter. Foerste (1935) states of the genus that "there is no trace of transverse ribs" and placed all species with transverse ribs in *Charactocerina*. Though the genotype, *Charactoceras baeri*, does have transverse ribs in the early growth stages, these are well developed only on the first whorl and are apparently wanting in most specimens owing to unfavorable conditions of preservation. However, the writer believes that a natural distinction remains between those species which lack ribs on the mature whorl and those which show a persistence of costæ to or close to the aperture, and that *Charactocerina* is a suitable receptacle for the latter group of species. The two are undoubtedly very closely related. It is uncertain whether *Charactoceras* represents a modification of *Charactocerina,* in which costæ are being suppressed by tachygenesis, or whether *Charactoceras* is ancestral to *Charactocerina* and the costæ are being developed proterogenetically. Both genera occur in the late Trenton boreal and Richmondian faunas, and it is difficult at the present time to say which, if either, genus appears first. Kay has listed a *Charactoceras* from the Stewartville, but the species has not been described nor illustrated, and it is probable that his observations were made prior to the recognition of a distinction between *Charactoceras* and *Charactocerina*. An undescribed *Charactoceras* from the Trenton of New York, though poorly preserved, perhaps too poorly preserved, to retain costæ had any been present originally, suggests that *Charactoceras* is the older genus. Further, of all the Arctic cephalopod associations, the two yielding *Charactoceras*, the Cape Calhoun series of Greenland and the "Richmond" (Roy, 1941) of Mt. Silliman, Frobisher Bay, Baffin Land, contain a preponderance of species of Trenton affinities suggesting strongly that they are at least pre-Richmond in age.

The species currently placed in *Charactoceras* are listed below.

C. baeri (Meek and Worthen). Lower and upper Whitewater beds, Indiana and Ohio.

C. baeri (?) Troedsson, 1926. Cape Calhoun beds, Greenland.

C. (?) *canyonense* Foerste. Fremont limestone. Colorado.

C. hercules (Billings). English Head formation, Anticosti.

C. laddi Foerste. Maquoketa shale, Iowa.

C. rotundum Troedsson. Cape Calhoun series, Greenland.

C. schucherti Foerste. Trenton? Frobisher Bay, Baffin Land.

C., sp. indet. I. Troedsson. Cape Calhoun series, Greenland.

C., sp. indet. II. Troedsson. Cape Calhoun series, Greenland.

C., sp. (listed) Kay, 1935. Stewartville dolomite, Minnesota.

C., n. sp. Trenton limestone, western New York.

Charactoceras baeri (Meek and Worthen) Plate 31, figs. 6-8; Text fig. 22

Trochoceras ? *baeri* Meek and Worthen, 1865, Acad. Nat. Sci., Philadelphia, Proc., p. 263; Meek and Worthen, 1873, Ohio Geol. Surv., Pal., vol. 1, p. 157, pl. 13, fig. 9; Miller, 1875, Cincinnati Quart. Jour. Sci., vol. 2, p. 133; Ulrich, 1880, Cat. Foss. Cincinnati Group of Ohio, Indiana and Kentucky, Cincinnati, p. 22.

Lituites baeri James, 1886, Cincinnati Soc. Nat. Hist., Jour., vol. 8, p. 248.

Gyroceras baeri Miller, 1889, N. A. Geol., Pal., p. 441.

Lituites baeri Lesley, 1890, Pennsylvania Geol. Surv., Rep. Progr. 4, p. 1228, figs.

Gyroceras baeri Harper and Bassler, 1896, Cat. Foss. Trenton and Cincinnati Periods, occurring in the Vicinity of Cincinnati, Cincinnati. p. 27; Cumings, 1908, Indiana Dep. Geol. Nat. Res., Ann. Rep., 32, p. 1032, pl. 51, fig. 1; Nickles, 1902, Cincinnati Soc. Nat. Hist., Jour., vol. 20, p. 95.

Charactoceras baeri Foerste, 1924, Denison Univ. Bull., Sci. Lab., Jour., vol. 20, p. 235, pl. 31, fig. 1; pl. 32, fig. 1A-B; pl. 33, fig. 1A-B; pl. 34, fig. 1A-B, 2.

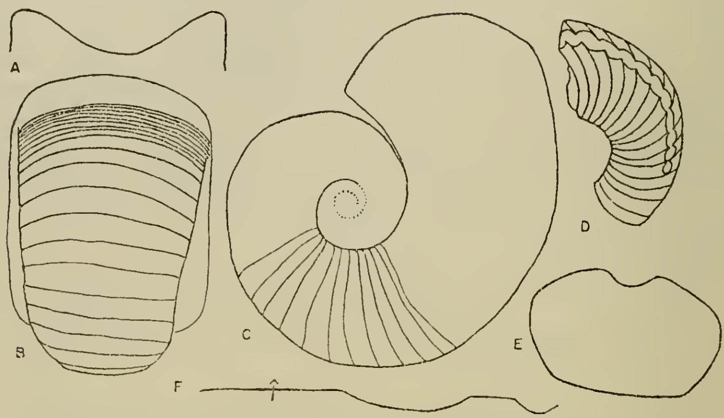

Figure 22. *Charactoceras baeri* (Meek and Worthen). A. Aperture, seen from the ventral side. From Foerste, 1924, pl. 32, fig. 1. B. Same specimen, ventral view, showing gerontic cameræ at adoral end of phragmocone. C. Same specimen, lateral view, showing the gyroconic condition of the living chamber. D. Section through phragmocone showing form of siphuncle. E. Diagrammatic cross section. F. Projection of suture. A-C. After photographs of Foerste, 1924. All figures about 1/3 natural size.

This is a large coiled shell, the whorls rapidly expanding in the early portion. There is apparently an appreciable umbilical perforation, the shell is depressed in section from the earliest portions observed, and an impressed zone appears at the completion of the first volution of the shell. This is retained throughout life with little change, until the gerontic living chamber is reached. This becomes free dorsally and apparently loses the impressed zone, though clearly preserved dorsums of such living chambers have not been observed.

The cross section of the shell is exceedingly difficult to determine, inasmuch as nearly all of the extant specimens are more or less distorted by pressure. However, it is evident that the venter is flattened, forming a rather distinct face, the sides are strongly rounded laterally, becoming less curved upon approaching the dorsum, so that they become nearly flat as they approach the impressed zone. The impressed zone is concave.

The sutures are transverse ventrally, develop slight lateral lobes, and prominent annular lobes on the impressed zone. The sutures are essentially straight in the earlier stages which are, however, rarely observed.

The siphuncle lies about twice as far from the dorsum as from the venter. Its segments expand slightly within the cameræ but are definitely longer than wide. The septal necks are only slightly recurved, and the segments are only faintly scalariform in vertical section. No deposits are known in the siphuncle or cameræ.

The living chamber occupies about a quarter of the outer whorl. The shell diameter at the point at which the living chamber becomes free from the earlier whorls appears to be variable, but much of the variation may be the effect of distortion of the shell.

The surface of the mature shell bears transverse lines of growth which slope apicad over the venter describing a broad hyponomic sinus. The curvature of the growth lines toward the venter begins slightly ventrad of the umbilical shoulders and increases as the ventral surface is approached. Early parts of the shell show a fasciculate ornamentation and are obscurely costate. This is shown on one specimen at a diameter across the disc of 45 mm. (Pl. 31, fig. 6.) In earlier stages the surface has not been clearly observed. One small specimen from the Hitz bed at Madison shows transverse markings of the shell clearly which are rather coarse alternating striæ and liræ, but this shell is so crushed that the condition of the costæ there is uncertain. There can be little doubt, however, but that the early stages of *Charactoceras* show the costate condition typical of mature *Cyrtocerina*.

Discussion.—This species is one rarely met with in collections. It is confined to the upper part of the Richmond and is really abundant only in the cephalopod zone which it characterizes just above the base of the Whitewater. At this horizon, on Little Four Mile Creek, a layer packed with shells of this species was found, which yielded probably a hundred specimens. Many, however, were fragmentary, many were poorly preserved, and practically all were distorted. In such an association living chambers and the outer whorls are common but the early stages are almost always missing and the surfaces were very poorly preserved.

The same species has been found, though less abundantly at other localities where the lower Whitewater is exposed, on Flat Fork Creek near Oregonia, in various localities other than Little Four Mile Creek at Oxford, and at a locality (which was probably the source of the type specimen) in Richmond, Indiana, now covered by a piano factory. Other specimens have been known from the basal Whitewater on the old road from Versailles, Indiana, north to Osgood, but the species has not been found in the basal Whitewater farther south. The species is rarer in the upper Whitewater beds, but occurs there, and was collected by the writer from above the Saluda at Versailles, Indiana. The upper Whitewater form appears sometimes to have a slightly more quadrate cross section, with a more definitely flattened venter. However, the inspection of a large suite of species has lead to the conclusion that this is merely a difference due to preservation, for upper Whitewater forms are usually less distorted than those from the lower Whitewater, largely because they are not found in the higher horizon in shale but in limestone better adapted to preserving the original form of the shell.

This species presents various aspects owing to the effect of flattening of the shells in different directions, which depends on the position of the shell in the rock, flattening always being vertical with reference to their original position. For this reason, precise measurements have little value in the recognition of this form, and it has not been possible to make as close comparisons as might be desired among the different specimens. It is not possible to say whether the presence of only a single species of *Charactoceras* in the Cincinnati area is actually the case, or whether the distortion to which most shells have been subjected makes it impossible to recognize more.

Measurements of a number of the finest specimens of this species have been given by Foerste (1924) together with copious illustrations of this species. These are supplemented in the present work by some other specimens, but due to Foerste's already numerous figures, some of which are reproduced here, the species is not so fully illustrated in our plates as would have been necessary without his work.

Types.—Holotype, location unknown. Hypotypes, U. S. National Museum, a number of specimens figured by Foerste, from the collection of Dr. W. H. Shideler and a large suite of specimens in the collections of the University of Cincinnati Museum.

Occurrence.—Lower and upper Whitewater beds. The species ranges from Elk Run, near Winchester, Ohio, westward to practically all good exposures of the lower Whitewater, at Camden, at Flat Fork Creek, and around Oxford, continuing into Richmond, and south nearly to Versailles, Indiana. The geographic range of the species in the upper Whitewater is more restricted, but it occurs at this horizon at Richmond, and Versailles, Indiana, and the form is present in the Hitz layer at Madison, Indiana. I have no record of upper Whitewater forms in Ohio.

Genus CHARACTOCERINA Foerste

Genotype.—*Eurystomites plicatus* Whiteaves.

Charactocerina Foerste, 1935, Denison Univ. Bull., Sci. Lab., Jour., vol. 30, p. 85; Flower, 1943, Jour. Paleont., vol. 17, p. 262.

Conch coiled, involute, with a broad conspicuous impressed zone in the later whorls, a section which is strongly flattened on the broad venter, with rounded sides converging strongly dorsad and interrupted by the impressed zone. Shell rapidly expanding, whorls few. Sutures with a broad ventral lobe, and a lobe in the impressed zone, largely transverse on the lateral faces. Siphuncle central or slightly ventrad of the center, composed of slightly expanding empty segments. Surface with prominent lateral costæ, usually closely spaced, persisting at least to within a half whorl of the mature aperture. Aperture with a ventral hyponomic sinus.

Discussion.—This genus is distinguished from *Charactoceras* only by the persistence of the costæ throughout life. *Charactoceras* itself has costæ only in the first whorl. *C. faberi*, the only species of the Cincinnati region remotely referable to this genus, I place here because of the prominence of the lateral costæ, although properly this species is known only from a portion of the shell evidently included in the first whorl. *Charactoceras,* itself, may have costæ in this stage, but I know of no species in which the costæ are as distant and as distinct even in the first whorl.

The known species of *Charactocerina* are confined to the Richmond and the Arctic boreal faunas of Red River affinities.

The species are as follows:

C. costulata (Miller). Bighorn formation, Wyoming.
C. faberi (James). Upper Whitewater beds, Indiana.
C. multicamerata (Foerste). Bighorn formation, Wyoming.
C. plicata (Whiteaves). Dog Head and Selkirk beds, Manitoba.
C. kirki Foerste. Bighorn formation, Wyoming.
C. washakiensis (Miller). Bighorn formation, Wyoming.

Charactocerina (?) faberi (James) Plate 27, figs. 4, 5

Cyrtoceras faberi James, 1886, Cincinnati Soc. Nat. Hist., Jour., vol. 8, p. 245, pl. 4. figs. 3a-b.

The holotype is a small cyrtoconic portion of a phragmocone with a maximum length of 39 mm., a length along the curved ventral margin of 49 mm., a radius of curvature increasing from 21 mm. to 23 mm. The height of the shell increases from 10 mm. to 15 mm. The section was probably nearly circular, certainly about 10 mm. in width at the base. The right side of the specimen is missing, and the specimen has been ground, showing the siphuncular passage of the septa adapically. Adorally the section is oblique and the center of the specimen is lost. It may be this which gives the false impression that the shell becomes slightly compressed adorally. The section is circular adapically; adorally the venter is slightly flattened.

The sutures are essentially transverse on the venter, and the plane of the suture is normal to the curvature of the conch. Laterally slight lobes develop in the adoral region. The ten cameræ which comprise the type increase in depth from 4 mm. to 4.9 mm. About four cameræ occur in a ventral length equal to the adoral height of the shell. The siphuncle, seen only near the apical end, has very short straight septal necks. The septal foramen is about .8 mm. in diameter and is 2 mm. from the ventral wall of the shell. The connecting rings are missing.

None of the original fine markings of the surface are preserved, if any were present. The adoral portion of the shell shows conclusive evidence of the presence of oblique costæ which slope rapidly apicad upon approaching the venter but disappear leaving the ventral surface of the shell smooth.

This species seems to be known only from the small and very incomplete holotype which is adequate for recognition of the species but is not sufficient to show the correct generic position beyond doubt. The species resembles two genera, or perhaps three, which are doubtfully distinct. The writer has elsewhere questioned the distinction between *Metaplectoceras* and *Plectoceras,* largely because the genera were separated on a feature (namely, whether the whorls were in contact) which varies in individuals of the genotype of *Plectoceras.* This species is quite typical of *Plectoceras* in the broader sense in section, costæ, the slight flattening of the venter, curvature, and the condition of the siphuncle. Usually, however, the siphuncle of *Plectoceras* is closer to the ventral margin of the shell, and the absence of connecting rings in the present species leaves some room for doubt as to whether the siphuncular segments were perfectly tubular as in *Plectoceras,* or whether they might have expanded slightly in the cameræ. The genus *Charactocerina* Foerste (1935, p. 83) was based upon *Eurystomites plicatus* Whiteaves of the Red River beds of Manitoba. Foerste separated this genus from *Charactoceras* on the basis of the development of ribs on the dorso-lateral region which usually become obsolete ventro-laterally. The siphuncle is more in accord with that of the present species in position and is reported as enlarging very slightly within the cameræ, less so than in *Charactoceras.* Mature specimens of *Charactocerina* may be differentiated from *Plectoceras* by the broad section of the whorl and the conspicuous development of an impressed zone. They differ further from most *Plectoceras* in aspect because the shell enlarges more rapidly at the initial portion, so that the diameter of an early stage of the conch is considerably greater. This does not seem to supply a very reliable difference, differing greatly within *Plectoceras,* and within species which have been referred to *Metaplectoceras. Plectoceras undatum* and *Plectoceras halli,* both of the Black River limestone of New York, furnish an excellent example of the contrast which can hold in *Plectoceras* in this respect.

On the basis of the only stage known of the present species it is not possible to determine with certainty whether it should be placed in *Plectoceras* or *Charactocerina.* On the basis of its strong resemblance to Foerste's (1935, pl. 20, fig. 3) illustration of *Charactocerina kirki,* which is much larger in diameter where the rate of curvature of the venter is similar, I have tentatively placed the Richmond species in this genus. Whichever genus this species may eventually be shown to belong in, it is clearly another example of the incursion of "arctic" elements in the Cincinnati area in Richmond time.

Holotype.—University of Cincinnati, No. 102.

Occurrence.—From the Whitewater formation of the Richmond, from Richmond, Indiana. The specimen is yellow and dolomitic, quite unlike anything known to me from the basal portion of the section which has yielded many of the cephalopods of the Richmond area. Quite probably it is from the upper part of the Whitewater, at or above the horizon of the Saluda.

Family **BICKMORITIDÆ** Foerste

Foerste (1925, p. 57) erected the family Bickmoritidæ to include the genera *Bickmorites, Jolietoceras,* and *Gigantoceras,* Hyatt, now *Heracloceras* Teichert. Although no clear definition is presented, Foerste was largely influenced by the presence of annuli as one of the criteria of the family. It is upon the basis of annuli in *Jolictoceras* that Foerste wished to separate it from the smooth *Heracloceras.*

Flower (1939, p. 77) pointed out that very probably *Heracloceras* (=*Gigantoceras* Hyatt) agreed with *Uranoceras* in being cyrtochoanitic, although this is not proved, for thus far a good siphuncle has not been observed in any species of the genus. Indeed, *Heracloceras* at present consists of two strongly homeomorphic elements, a Silurian group, believed to be allied to *Uranoceras,* and a (typical) Devonian group of species which are to be traced instead to the family Rhadinoceratidæ.

The Bickmoritidæ may be defined as coiled cephalopods, characterized by prominent annuli which form a hyponomic sinus. The siphuncle is subcentral and orthochoanitic.

Bickmorites is coiled, sometimes with the whorls free, and sometimes with the whorls in contact. As here recognized, Ordovician species formerly assigned to *Antiplectoceras, Tyrrelloceras, Leuronotoceras,* and *Goniotrochoceras* are included. *Tyrrelloceras* of the Silurian is so closely allied that the distinction between the two genera might be questioned. The Silurian *Jolietoceras* is an uncoiled edition of *Bickmorites.* The early stages are cyrtoconic and annulated; the later portion is orthoconic and essentially smooth. The secondary nature of *Jolietoceras* and its derivation from *Bickmorites* are suggested by the greater antiquity of the coiled annulated shells of the aspect of *Bickmorites.* The origin of the family is not as yet certain. Probably it should be traced to the Middle Ordovician genus, *Centrocyrtoceras,* a cyrtoconic annulated shell with a subcentral orthochoanitic siphuncle. Whether this stock has any close relationship with the Chazyan *Barrandeoceras* which differs from it in the strongly compressed section and the appearance of a slight impressed zone, is uncertain. The origin of *Barrandeoceras* is uncertain. The thin connecting rings show structures strikingly unlike those of *Aphetoceras.* It is suspected that the family Deltoceratidæ (Ulrich, Foerste, Miller, and Furnish, 1942) is not a natural one and that all these authors have placed in it a suite of converged homeomorphs.

Genus **BICKMORITES** Foerste

Genotype.—*Lituites bickmoreanum* Whitfield.

Bickmorites Foerste, 1925, Denison Univ. Bull., Sci. Lab., Jour., vol. 21, p. 47.
Tyrrelloceras Foerste, 1925, *ibid.,* vol. 21, p. 56.
Leuronotoceras Foerste, 1928, Canada Geol. Surv., Mem. 154, p. 283.
Goniotrochoceras Foerste, 1928, *ibid.,* Mem. 154, p. 285.

Conch gyroceraconic, circular or slightly compressed in section, slender, describing several volutions, but with the mature living chamber often straight and tubular. The surface bears prominent ribs which slope apicad on the venter to form a hyponomic sinus. Finer transverse surface markings occur, and longitudinal markings have been observed in the gerontic stage. The sutures are essentially transverse but develop slight lateral lobes. The siphuncle is subcentral, slightly ventrad of the center and is orthochoanitic.

Discussion.—This genus is typically developed in the Middle Silurian, being known from Indiana, Illinois, Wisconsin, and

Port Daniel. It is extremely improbable that the little known Richmondian species properly belongs here, but in the present state of our ignorance of these cephalopods it is not possible to do better. Two other genera of curved annulated shells are very similar, and it is not at all certain that they are distinct as genera. One is the Ordovician genus *Leuronotoceras* Foerste (1928), and the other is the Silurian genus *Tyrrelloceras*. *Leuronotoceras* has faint longitudinal markings but is characterized mainly by the flattened venter and the sides which converge dorsad as in *Apsidoceras*. The form of the siphuncle is unknown, and so it cannot be determined whether this genus is a modification of the Aspidoceratidæ, or whether it is the forerunner of the orthochoanitic Bickmoritidæ. *Tyrrelloceras* Foerste, (1925, p. 56) is based upon *Trochoceras insigne* Whiteaves of the Silurian of Manitoba. The shell is a gyroceracone and seems to differ from *Bickmorites* only in the superficial feature of the presence of strong longitudinal markings. As faint longitudinal markings are present in *Bickmorites* also (Foerste, 1925) it is extremely dubious whether a natural division exists between these genera.

A small group of inadequately known species of the Ordovician, I tentatively place in this genus. Previously species have been assigned to *Tyrrelloceras, Sphyradoceras,* and *Leuronotoceras*. The reference to *Sphyradoceras* is clearly erroneous. In the belief that *Tyrrelloceras* and *Leuronotoceras* are not well enough known to be separated from *Bickmorites,* which has priority over both names, it does not appear that at the present time the genera serve any useful purpose, though it is recognized that further investigations lying outside of the scope of the present work may necessitate a revision of these views.

The curved Ordovician conchs, characterized by the presence of prominent annuli or costæ, are all known from rather inadequate fragments. They differ in section and ornament, but little is known of the phragmocones and nothing of their siphuncles. In view of the inadequate morphological data, their taxonomic position is extremely dubious, but faunally they appear to be significant, for they form by themselves one of many groups of species of the boreal Richmondian which made their way into Ohio in the lower Whitewater.

Tyrrelloceras striatum Foerste and Savage (1927, pp. 59-60, pl. 9, fig. 9), of the Shamattawa limestone of Hudson Bay, is known only from a small aseptate portion of a curved shell. Costæ cross the dorsum and the sides and slope apicad toward the venter before disappearing over the mid-ventral surface where fine cancellate markings are found. The section appears to be compressed, but as the width decreases orad this is partly and perhaps entirely due to pressure. Accepting momentarily the surface differentiation between *Bickmorites* and *Tyrrelloceras*, this species is not typical of either genus, having the transverse markings of the former and also the longitudinal liræ of the latter.

Foerste (1928) described three somewhat similar species from the Upper Ordovician of Anticosti. *Leuronotoceras anticostiense* Foerste (1928, pp. 283-4, pl. 41, figs. 6-7) is a curved annulated shell with the annuli disappearing on the broad flattened venter. The broad venter and the rounded sides which converge dorsad show a strong similarity to *Apsidoceras* in section. This genus differs from *Apsidoceras* in the strong costæ and in fine longitudinal markings, but in the absence of information as to the nature of the segments of the siphuncle it is uncertain whether it belongs to the cyrtochoanitic Apsidoceratidæ. The species is from the English Head formation of Anticosti.

Two similar curved annulated shells from the Ordovician of Anticosti were more generalized in section, and Foerste described these in terms of *Sphyradoceras*. *Sphyradoceras* is a sinistral trochoceroid with an impressed zone, asymmetric section, and is not known outside of the Middle Devonian. The genus is treated elsewhere by the writer (Flower, Middle Devonian Cephalopods of New York, in press, New York State Museum Bulletin). The Anticosti species are not definitely trochoceroid and lack an impressed zone. One, from the English Head formation, described as *Sphyradoceras*, sp. (Foerste, 1928, p. 284) is a fragment of a very large shell, annulated, and ornamented by fine longitudinal markings. The condition of the costæ and surface markings on the venter is unknown. The other species is *Sphyradoceras* (?) *anticostiense* Foerste (1928) of the Vaureal formation of Anticosti. Here the annuli continue over the venter, where they form a broad and shallow sinus. The fine surface markings have not been observed.

One European species appears to be related. This was described as *Antiplectoceras ? askerense* Strand (1934, pp. 47-48, pl. 2, fig 12; pl. 10, figs. 1, 2, 7) from the Gastropod limestone of Asker, west of Oslo, Norway. This species is a gyroceraconic shell marked by prominent costæ which slope apicad on the venter and disappear on the mid-ventral region. Fine lines of growth parallel the costæ. The siphuncle is subcentral, and the section is flattened on both dorsum and venter. This species belongs to the same group as those discussed above and *Bickmorites rarum*. It differs from *Antiplectoceras* Foerste and Savage in that the whorls are not in contact and, which is probably more important, in that the costæ slope apicad on the venter and are transverse laterally. *Antiplectoceras* proper is known only from the genotype, *A. shamattawaense* (Parks) (see Foerste and Savage, 1927, pp. 58-59, pl. 24, fig. 2), of the Shamattawa limestone of Hudson Bay. This is a coiled shell, the whorls in contact, which differs from *Bickmorites* in that the ribs form rounded lateral lobes separated by dorsal and ventral saddles. The features of the phragmocone are unknown, and the genus is of uncertain relationship.

One other little known genus and species belongs to this form group of inadequately known coiled costate Upper Ordovician shells. This is *Goniotrochoceras* Foerste (1928, p. 285) based upon *G. twenhofeli* Foerste (1928, pp. 285-6, pl. 38, figs. 1-2) of the Vaureal formation of Anticosti. This is known from a portion of a curved shell with transverse costæ, strong ventrally, weaker laterally and apparently absent dorsally, and longitudinal liræ, as in *Tyrrelloceras,* already discussed. The section is clearly compressed in the only known specimen of the genotype and keeled ventrally. The writer would question, however, how much of the ventral keel and any eccentricity of the section, upon the basis of which this was considered a trochoceroid shell, may not be due to distortion. Nothing is known of the siphuncle. The sutures develop lateral lobes, but whether the lobes are the result of distortion cannot be definitely determined. Foerste compared this genus with the high spired smooth-shelled *Mitroceras* and pointed out differences between this and his new genus but failed to compare it with any of the costate coiled genera noted above. It is quite possible on the basis of the present known material, that the trochoceroid condition and the keeled venter and compressed section which might serve to distinguish it from *Bickmorites* as defined above, may all be the result of distortion.

The proper taxonomic relationship of all of these Ordovician species discussed above is uncertain, but it is plain that, together with the species described below from the lower Whitewater of Ohio, they form a group of boreal "Richmondian" cephalopods which probably form a more closely knit group than their previous distribution among four different genera would indicate. In placing these species (among which I do not include the little known monotypic *Antiplectoceras*) together under *Bickmorites* the writer is not influenced by any conviction as to their relationship but is merely giving taxonomic expression to the fact that the known morphological information does not warrant the recognition of finer divisions at the present time. The siphuncle of these Ordovician species must be studied to determine whether they are orthochoanitic Bickmoritidæ or whether, as Foerste suggested for *Leuronotoceras*, they are derivatives of the cyrtochoanitic Apisdoceratidæ. At the present time the known material is not adequate for such an investigation of a single one of the Ordovician species concerned.

Bickmorites rarum Flower, n. sp. Plate 17, figs. 2, 3

This is known from a single fragment, apparently including the complete length on one side of a living chamber. The shell is slightly curved, increasing from a width of 12 mm. and a height of 11 mm. at the base to 13 mm. and 14 mm. in a ventral length of 12 mm. The maximum length of the shell, shown ventro-laterally, is 16 mm. and the aperture is 15 mm. high and has an estimated width of 16 mm. In its length the shell bears three prominent narrowly rounded raised annuli separated by broader and strongly concave interspaces. The annuli are faint dorsally, but increase in strength toward the venter. On the venter they slope apicad describing a very well-defined hyponomic sinus. Fine surface markings consist of narrow threadlike transverse liræ separated by broader interspaces. These occur about 17 in the length between two annuli. They occur on the annuli as well as in the interspaces and are slightly more crowded on the crests of the annuli than in the interspaces.

Discussion.—This species may be differentiated from *B.* (?) *striatum* Foerste and Savage by the prominence of the annuli on the venter and the absence of ventral longitudinal markings. The specimen described by Foerste as *Sphyradoceras*, sp., from the English Head formation has fine longitudinal markings both laterally and dorsally. The surface features of *S.* (?) *anticostiense* Foerste are unknown, but the species may be distinguished by the prominence of the annuli dorsally and the very broad shallow ventral sinus. Comparable also is *Leuronotoceras anticostiense* Foerste (1927, p. 283, pl. 41, figs. 6-7). This monotypic genus is characterized as curved annulated shells by the presence of fine longitudinal markings and a cross section reminiscent of *Apsidoceras,* particularly in the flattened venter.

Type.—Holotype, collection of Dr. W. H. Shideler.

Occurrence.—From the cephalopod bed of the lower Whitewater, Little Four Mile Creek, Oxford, Ohio.

ARCHAIC CEPHALOPOD TYPES

Two of the Cincinnatian genera of nautiloids, *Cyrtocerina* and *Shideleroceras,* exhibit structural peculiarities which set them apart from all other known post-Canadian genera. Both possess aneuchoanitic septal necks supplemented by connecting rings. Those of *Shideleroceras* are thin and apparently homogeneous; those of *Cyrtocerina* are inflated and complex in structure.

Similar aneuchoanitic necks are known to occur in genera of the Ozarkian (Wanwanian) and Canadian. Unfortunately, while a large number of species and genera have now been described, very little information is available upon the essential features of their construction. Much of the available material of these older cephalopods consists of chert internal molds, which fail to show the structure of the siphuncle properly (Ulrich, Foerste, Miller, and Furnish, 1942; Ulrich, Foerste, and Miller, 1943; Ulrich, Foerste, Miller, and Unklesbay, 1944). Meanwhile other investigations have shown that the proper understanding of the structures of many of the genera not only requires study by opaque sections, but often thin section study. Therefore at the present time it is possible to recognize the two Cincinnatian genera as survivors of archaic stocks, but it is not possible to determine precisely to which of the older genera they are most closely related. Neither is it possible to determine whether these forms should be placed in the Stenosiphonata or Eurysiphonata, or whether perhaps this dichotomus division of the Nautiloidea may have to be either abandoned or supplemented by the addition of a third group for some of these archaic types.

Family **CYRTOCERINIDÆ** Flower, n. fam.

The family Cyrtocerinidæ is erected for endogastric breviconic cyrtoceracones with marginal aneuchoanitic siphuncles characterized by septal necks which are strongly inflated within the cavity of the siphuncle. The structure of the only genus thus far recognized, *Cyrtocerina,* was described by the writer (Flower, 1942) and is summarized in the following pages.

In form *Cyrtocerina* is most similar to *Levisoceras* Foerste, a genus which is confined to the equivalents of the Gasconade horizon in America. *Levisoceras* is not adequately known internally. The extant information fails to suggest that its connecting rings are thickened after the manner of those of *Cyrtocerina.* Specimens placed in *Levisoceras* with doubt by Ulrich, Foerste, and Miller (1943) from the Ellenberger of Texas show aneuchoanitic necks, relatively thin connecting rings, and diaphragms crossing the siphuncle. If these forms are representative of *Levisoceras,* it seems unlikely that the genus has any close relationship with *Cyrtocerina.*

Ulrich, Foerste, Miller, and Unklesbay (1944) have described the genus *Eothinoceras,* based upon a single species, *E. americanum* from the Rochdale limestone of southern New York. The few specimens by which this species is represented indicate that it agrees with *Cyrtocerina* and with no other known genus, in the structure of the siphuncle, having the aneuchoanitic necks and inflated connecting rings very similar to those of *Cyrtocerina* in form. The shape of the shell of *Eothinoceras* can, however, only be inferred from the extant material. It is evident that the shell is relatively slender, although it is questionable whether the shell is straight, as its describers believe, or slightly curved. Ulrich, Foerste, Miller, and Unklesbay believe that *Cyrtocerina* and *Eothinoceras* are not closely related. The presence of *Eothinoceras* only in the Canadian Rochdale limestone, and the confinement of *Cyrtocerina* to the Middle and Upper Ordovician, suggest, together with the differences in form which distinguish these genera, a considerable gap in relationship. However, they are identical in internal structure as far as can be ascertained, for *Eothinoceras* is known only from opaque sections, and are more closely related to each other than to any other genera in the light of our present knowledge. In view of the little information available concerning the siphuncles of many of the Ozarkian and Canadian genera now described, it is not impossible that some of these forms may prove to have similar structure when they are known from better material.

Genus CYRTOCERINA Billings

Genotype.—*Cyrtocerina typica* Billings.

Cyrtocerina Billings, 1865, Pal. Foss., Geol. Surv. Canada, p. 178; Barrande, 1867, Syst. Sil. du centre de la Bohême, vol. 2, pt. 1, p. 451; Hyatt, 1884, Boston Soc. Nat. Hist., Proc., vol. 22, p. 266; Miller, North American Geol., Pal., p. 436; Holm, 1892, Geol. Foren. Stockholm, forh., vol. 14, pp. 126, 209; Clarke, 1897, Geol. Minnesota, vol. 3, pt. 2, p. 774; Hyatt, 1900, Cephalopoda, in Zittel-Eastmann Textb. Paleont., vol. 1, 1st ed., p. 517 (reprinted with different pagination in later editions); Foerste, 1924, Denison Univ. Bull., Sci. Lab., Jour., vol. 20, p. 198; Foerste, 1925, *ibid.*, vol. 21, p. 11; Foerste, 1933, *ibid.*, vol. 28, p. 138; Flower, 1943, Ohio Jour. Sci., vol. 43, pp. 51-54.

The writer (Flower, 1943) has presented an extensive discussion of the morphological features of this genus, the redescription and illustration of the Cincinnatian species, and the structure and relationship of this genus. For completeness, a brief diagnosis of the genus and of the Cincinnatian species is appended here.

Conch rapidly expanding to aperture, nearly patelliform, slightly curved. The surface shows coarse lines of growth which indicate no trace of a hyponomic sinus. The section is compressed, the convex side slightly more narrowly rounded than the concave side. The sutures are straight and transverse adapically but may slope slightly orad from the concave to the convex side adorally. The phragmocone is distinctive in the extremely short cameræ and the nearly flat septa. The siphuncle is located close to the concave side of the shell, expands conically adorally through the phragmocone. The septal necks are aneuchoanitic and are supplemented by thick complex connecting rings which are inflated and extend into the cavity of the siphuncle so that an internal mold of the siphuncle will have an annular appearance. (Fig. 5A, p. 7.) The four Cincinnatian species are known only from the Saluda beds and the Hitz layer of Indiana.

Additional material, recently received, indicates the presence of the genus in the Kimmswick limestone of Missouri and the Platteville limestone of Wisconsin. Primarily the genus was known only from the genotype from the Black River of the Paquette Rapids at Ontario, and the Cincinnatian species.

Cyrtocerina madisonensis (Miller)

Plate 28, figs. 1, 6-8; Plate 29, fig. 4; Plate 30, figs. 2, 3

Tryblidium madisonense Miller, 1894 (adv. sheets, 1892), 18th Rep. Indiana Dept. Geol. Nat. Res., p. 318, pl. 9, fig. 38.

Cyrtocerina madisonense Miller and Faber, 1894, Cincinnati Soc. Nat. Hist., Jour., vol. 17, p. 32; Flower, 1943, Ohio Jour. Sci., vol. 43, pp. 53-54, pl. 1, figs. 3-4, 12-14; pl. 2, figs. 1, 3-7, 9.

Conch breviconic, compressed, the convex side more narrowly rounded in section than the concave (siphonal) side. In the profile the convex, and supposed dorsal side is slightly convex adapically but becomes increasingly curved adorally so that the rate of expansion decreases adorally. The venter is essentially straight over the known portion, probably faintly concave at the extreme apex. Lateral profiles are faintly convex but very rapidly diverging. The conch increases in height from 4 mm. to 26 mm. in the basal 12 mm., beyond which the increasing dorsal convexity causes the shell to expand more slowly. At a height of 29 mm. the shell has a width of 25 mm. The length of the living chamber is not known, all specimens thus far observed being incomplete.

Types.—The location of the holotype and the hypotypes of Miller and Faber is unknown. Hypotypes which supply the basis for the revision of this species are Univ. of Cincinnati, Nos. 23965-66.

Occurrence.—From the Hitz layer at the top of the Saluda, Madison, Indiana.

Cyrtocerina patella Flower Plate 28, fig. 4; Plate 29, figs. 7, 8

Cyrtocerina patella Flower, 1943, Ohio Jour. Sci., vol. 43, pp. 54-55, pl. 1, figs. 1, 5, 8.

This shell is very rapidly expanding initially, and the convexity of the antisiphonal side increases only very slightly adorally; the increase more delayed than in *C. madisonensis.* The conch expands in the basal 11 mm. to 24 mm. and 21 mm., the venter (siphonal side) straight, the dorsum only faintly convex, the lateral profiles straight and rapidly diverging. A second specimen consisting of a portion of a mature living chamber and gerontic cameræ expands from 22 mm. and 25 mm. to a width of 40 mm. and an estimated height of from 45 mm. to 48 mm. in a length of 23 mm. The aperture is not preserved. The phragmocone shows no features strikingly different from that of the above species. The cameræ are exceedingly closely spaced gerontically, eight or nine occurring in the last 5 mm. of the siphuncle. The siphuncle is conical, close to the ventral side of the shell. At diameters of 22 mm. and 25 mm. it is 4.8 mm. wide and 5.2 mm. high at the septal foramen.

Types.—University of Cincinnati Museum, Holotype, No. 23967, paratypes, 23968, 23969, 2368.

Occurrence.—From the upper beds of upper Whitewater equivalence, but with Saluda lithology from the road cut at the eastern limits of Versailles, Indiana. The paratypes are from Madison, Indiana, presumably from the Hitz layer.

Cyrtocerina modesta Flower Plate 28, figs. 2, 5; Plate 29, figs. 5, 6, 9

Cyrtocerina modesta Flower, 1943, Ohio Jour. Sci., vol. 43, p. 55, pl. 1, figs. 2, 6-7; pl. 2, figs. 2, 8.

This is a smaller and more slender species than the two described above, and is also relatively broad in cross section. The ventral side is obscurely flattened, the dorsal side narrowly rounded, and obscurely ridged. Dorsal profile slightly and uniformly convex, the venter very faintly concave, nearly straight. The shell increases to a width of 2 mm. and a height of 24 mm. about 23 beyond the apex. At comparable distances from the apex other species are both higher and broader. The lateral profiles are slightly convex, though divergent to the aperture. Siphuncle close to venter, cameræ possibly slightly deeper than those of the other species, but with the septa still very closely spaced.

Discussion.—The types of this species show some differences in proportion, due largely and perhaps entirely to distortion. The form is widely set apart from its congeners by the more gradual expansion, the more prominently ridged dorsum, and more strongly triangular section.

Types.—University of Cincinnati, holotype, No. 17170; paratypes, No. 23970.71.

Cyrtocerina (?) carinifera Flower, n. sp. Plate 29, figs. 1, 2

This species is known only from a living chamber. It is 30 mm. high and 23 mm. wide at the base where the section is narrower on the antisiphonal side than on the siphonal side. The dorsum and venter diverge at an angle of between 50 and 60 degrees. The venter is straight, the dorsum apparently very slightly convex. The venter is inclined about 40 degrees from the plane of the suture, the dorsum about 80 degrees. The sides are very faintly convex and diverge to the aperture. The living chamber has a ventral length of 28 mm., a dorsal length of 20 mm., and a lateral length of 24 mm. The ventral wall is marked by a linear rounded ridge running to the aperture, flanked by shallow furrows. The septal surface is moderately curved. The siphuncle protrudes from the septal surface and is extremely large, being 9 mm. high and 5 mm. wide. The surface of the shell bears regular transverse markings. These do not slope apicad on the venter to form a hyponomic sinus.

Discussion.—Without information concerning the phragmocone of this singular form, its generic position must remain uncertain. However, the very large size of the siphuncle at the base of the living chamber, the rapid expansion of the conch to the aperture and the absence of a hyponomic sinus all suggest *Cyrtocerina* very strongly, and are features not known in any other post-Chazyan genus of the Ordovician. The carinate venter, as well as the large size of the shell, will distinguish it from its congeners.

Holotype.—Shideler Collection.

Occurrence.—From the Saluda beds, McDill's Mills, Oxford, Ohio.

Family SHIDELEROCERATIDÆ Flower, n. fam.

The family Shideleroceratidæ is proposed for the genus *Shideloceras* which does not seem to have any close relatives. The family may be characterized as follows: conch cyrtoconic, slender, cross section only slightly depressed, sutures transverse, straight or sinuate. Siphuncle subcentral, necks aneuchoanitic, connecting rings thin and homogeneous in structure. Growth lines show a crest on the convex side of the shell, a lobe in the concave side, and are sinuate laterally. The orientation of the shell is uncertain.

The aneuchoanitic necks distinguish *Shideleroceras* from all other post-Canadian genera thus far known except *Cyrtocerina*, which differs in the thickened connecting rings, breviconic form, and the marginal siphuncle. Among the pre-Chazyan genera, none are thus far known which are particularly close to *Shideleroceras*, none combining the slender cyrtoconic form with a subcentral siphuncle.

Genus SHIDELEROCERAS Flower and Foerste

Genotype.—*Shideleroceras sinuatum* Foerste.

Conch cyrtoconic, slender, very gently curved and presumably exogastric. Section slightly broader than high, the dorsum and venter equally rounded. The sutures may be straight and transverse, although the genotype is characterized by a narrow low saddle on the venter which may be strengthened adorally by the development of a very slight lobe on either side. The ventral saddle is vestigial or absent in the other known species. The siphuncle lies between the venter and the center of the shell. The segments may be perfectly tubular or faintly concave. The septal necks are vestigial, and this genus is therefore probably to be grouped with early Paleozoic aneuchoanitic cephalopods rather than with those which are properly orthochoanitic. The connecting rings are thin and apparently structureless. Obscure longitudinal markings are seen within the siphuncle, but their organic nature has not yet been demonstrated, and it appears that both cameral and siphonal deposits are absent in this genus.

The course of the transverse filiform markings of the surface which reflect the condition of former apertures present one of the simplest criteria for recognition of the genus. There is no hyponomic sinus. Instead, the lines of growth describe a low broad saddle over the ventral surface. Laterally they slope adapically abruptly and resume a nearly transverse course on the dorsum, though this time fairly concave orad instead of convex as on the venter.

Discussion.—In forming this description the venter is assumed to be the convex side of the shell. No reliable criteria of orientation have been found within the genus, however, septal and conchial furrows not being observed. The genus is not closely similar to any other Ordovician cyrtoconic genus. The hyponomic sinus is absent in *Eorizoceras* and that genus shows prominent filiform transverse markings, but the siphuncle is close to the venter and the shell is rapidly expanding. In the Chazyan *Graciloceras* the siphuncle is also close to the venter. Genera more closely approximating *Shideleroceras* in age generally show in addition a well-developed hyponomic sinus. *Ehlersoceras* Foerste (1932, 1933) is more similar in form than most other genera, but a hyponomic sinus is developed, and the siphuncle is again close to the venter.

Shideleroceras differs from most post-Canadian cyrtoconic genera in the relatively central siphuncle. Further, its apparent aneuchoanitic condition suggests that it is a survival of a stock thus far known only from the Cambro-Ordovician. Unfortunately the available material from *Shideleroceras* has been characterized by very poor preservation of the internal structures, for replacement is such that thin sections will be of little use in clarifying the structure of the siphuncle. The presence of obscure longitudinal elements within the siphuncle tube suggests that perhaps there may be here some structure akin to that reported, but not figured[15], for the Canadian genus *Buttsoceras* Ulrich and Foerste. On the other hand, the structures noted in *Shidelceroceras* may be adventitious, since in texture, color and apparently in composition, they can be duplicated within siphuncles of other genera observed in the same bed, where their adventitious nature is very evident since the structure of these genera is adequately known from better preserved material in other horizons.

The name *Shideleroceras* was proposed in manuscript by Dr. Foerste, though his only use of the term was in the description of his species *Shideleroceras sinuatum*. The generic description is the work of the present writer.

At the present time the only known species of *Shideleroceras* are those described below. The three species appear in a part of the section in which the invasion of arctic cephalopod types into the Ohio area is most striking, yet strangely enough nothing similar to *Shideloceras* has been found in the arctic or Anticosti cephalopod faunas in spite of the fact that they have received very careful attention.

Shideleroceras sinuatum Foerste, n. sp.

Plate 25, figs. 14, 15, 20; Plate 26, figs. 17, 18; Plate 27, figs. 6-8
Text fig. 6 D

Conch is a slender cyrtoceracone of depressed section. The known part of the shell is very gradually expanded, slightly curved, the radius of curvature varying more between individuals than among various parts of the same specimen, from 125 mm. to 200 mm. The section is from 2 mm. to 4 mm. broader than high. On the holotype the shell increases from 20 mm. and 22 mm. and 28 mm. in the basal 50 mm.; in the next 42 mm. it increases to 32 mm. and 35 mm. There is some variation in the size of mature individuals. The largest observed attains a width of 38 mm. and a height of 36 mm. Other specimens are somewhat smaller, a paratype which is essentially complete adorally measuring 34 mm. and 32 mm.

The sutures are nearly straight and transverse in the adapical portion, showing as the only modification a slight ventral saddle. This becomes more conspicuous adorally owing to its narrow

[15]Figures appeared after this was written. They fail, however, to explain the nature of the structures within the siphuncle of *Buttsoceras*. (Ulrich, Foerste, Miller, and Unklesbay, 1944.)

condition and the development of very slight lobes flanking it ventro-laterally. In some early portions of the shell the ventral saddles are very inconspicuous, and the sutures appear straight and transverse. The cameræ vary in depth as they become more closely spaced over a considerable adoral interval of the phragmocone. Eight cameræ occur in a length equal to the shell width adapically on the holotype at a width of 26 mm., but where the width is 35 mm., the cameræ are shorter so that 11 lie in a length of 36 mm.

The depth of the septum varies with the growth stage, early septa being relatively flat, while those farther orad are quite deeply curved. At a shell height of 20 mm. the septum is 3.5 mm. in depth, but at a height of 24 mm. it has become 6 mm. deep.

The siphuncle is located between the center and the venter. At a shell height of 20 mm. it is 3 mm. in diameter, 7 mm. from the venter and 10 mm. from the dorsum; 50 mm. farther orad the siphuncle is 3.5 mm. in diameter, 9 mm. from the venter and 13.5 mm. from the dorsum.

The siphuncle appears to be orthochoanitic upon casual inspection. The septa, however, are scarcely bent apicad at the siphuncle and the segments are formed almost completely by very thin connecting rings which produce a tubular outline or an outline which is very faintly concave. This type of structure is aneuchoanitic rather than orthochoanitic. Within the siphuncle traces of longitudinal structures have been observed, but these may be inorganic, since not dissimilar phenomena have been noted within other shells from the same bed. Unfortunately the siphuncles are fragile, and material has not been available for the desired study of its structure by thin sections.

The growth lines consist of narrow filiform raised transverse lines which follow the course of the aperture. They describe a broad low crest over the entire ventral (convex) surface of the shell. On the lateral region they are bent abruptly apicad and resume a nearly transverse condition over the dorsum, where they are very slightly concave orad. There is very faint rhythmic crowding of the growth lines.

Discussion.—This species can be distinguished from the two known congeneric forms by the steeply inclined growth lines on the lateral region of the shell, the development of ventral saddles of the sutures, its moderate rate of expansion, and the relatively large size of mature individuals. *S. gracile* is a smaller and much more slender species in which the growth lines are inclined only slightly on the lateral portion of the shell. *S. simplex* is more rapidly expanding, but has simple sutures and is intermediate between *S. gracile* and *S. sinuatum* in size, and also in the degree of modification of the growth lines on the lateral part of the shell.

Types.—Holotype and three paratypes, collection of Prof. W. H. Shideler.

Occurrence.—The species is known mainly from the lower Whitewater beds at Little Four Mile Creek, near Oxford, Ohio. This single locality has yielded a suite of 14 specimens. A single specimen was obtained by the writer from the same horizon at Dodge's Creek, Oxford, Ohio.

Shideleroceras simplex Flower, n. sp. Plate 25, figs. 18, 19

Associated with *S. sinuatum* in the lower Whitewater is another and a rarer species which is smaller, more rapidly expanding, and less curved, but which is differentiated principally by the shorter cameræ and the absence of more than a vestigial ventral modification of the sutures. The two specimens available are both incomplete and distorted. The holotype is slightly flattened obliquely with a maximum length of 65 mm. The smaller diameter increases from 22 mm. to 27 mm. in 50 mm. The radius of curvature of the venter is 230 mm. adorally and this is probably uniform adapically, though a greater adapical curvature appears to be developed probably as the result of distortion.

The nine cameræ of the phragmocone occupy a dorsal length of 16 mm., so that in a length equal to the shell width probably 15 cameræ would be present. The sutures are essentially straight and transverse, with only vestigial lobation on the venter. The living chamber, apparently mature, judging from the closely spaced adoral septa, has basal diameters of 24 mm. and 27 mm. in its present state. It has a maximum length of 43 mm., and probably this approaches very close to the aperture. The lines of growth slope apicad from the venter somewhat more gently on the lateral region than in *S. sinuatum*, and are concave orad over the dorsum and not so transverse as in *S. sinuatum*.

The shell did not attain a width of over 30 mm. The septa and siphuncle have not been observed.

Discussion.—This species is associated with *S. sinuatum* in the cephalopod zone at the base of the Whitewater beds. It may be distinguished by the much smaller size of mature individuals, the less abrupt bend of the growth lines apicad from venter to dorsum on the sides, the more curved condition of growth lines on the dorsum, and by the absence of the ventral saddles of the sutures.

Types.—Holotype, W. H. Shideler Collection.

Occurrence.—Cephalopod zone of the lower Whitewater, from Little Four Mile Creek, near Oxford, Ohio.

Shideleroceras gracile Flower, n. sp. Plate 29, figs. 16, 17

The only *Shideleroceras* noted in the Saluda beds is a form much smaller and much more slender, at least adorally, than either of those known from the lower Whitewater beds. The type consists only of a complete living chamber, which has been slightly crushed laterally, a process which produced a fold down the venter which the animal never had in life. The living chamber has a ventral length of 45 mm., and a dorsal length of 35 mm. It expands from 25 mm. and 18 mm. at the base to 25 mm. and 20 mm. at the aperture. The vertical discrepancy is partly due to vertical crushing at the base of the type, and the living chamber was originally very nearly tubular. An undistorted shell would probably show an adoral width of 26 mm., but lateral crushing has resulted in very slight adoral compression.

The shell is preserved as a carbonaceous film, on which the growth lines are well displayed. The lines of growth are more transverse mid-ventrally than in other species, but slope apicad on the sides toward the dorsum only gradually and are faintly concave orad on the entire dorsum. The characters of the siphuncle and septa are not shown. The lines of growth show that the species is a *Shideleroceras*.

Discussion.—This species is smaller and more tubular than either of those known from the lower Whitewater. Further differences are found in the less oblique growth lines on the lateral region, the more transverse condition of the growth lines on the mid-ventral area, and the broadly concave lines on the dorsum.

The condition of ornament is perhaps closest to *S. simplex,* but the undulations are even more gentle than in that species, which is larger and more rapidly expanding.

Type.—Holotype, collection of W. H. Shideler.

Occurrence.—From the Saluda beds, Big Plum Creek, 1½ miles northeast of Osgood, Indiana.

SUBORDER EURYSIPHONATA

The Eurysiphonata, as noted in the discussion of cephalopod phylogeny, are characterized primitively by aneuchoanitic septal necks and thick connecting rings. By Ordovician time neither feature is generally retained, but the thickening of the ring has become reduced in the Actinoceroidea, but is retained in the Endoceroidea. The septal necks have become relatively long in the generalized members of the Actinoceroidea and the Endoceratidæ of the Endoceroidea.

For purposes of recognition the Cincinnatian Eurysiphonata are best defined in terms of the two groups of which they are composed: the Actinoceroidea, characterized by a generally large cyrtochoanitic siphuncle which is characteristically filled adapically by annulosiphonate deposits, leaving only a series of canals and a perispatium in each segment. The larger of the Cincinnati Actinoceriodea are treated in the present section. The remainder, together with the endoceroids, are reserved for the second part of this work. The Endoceroidea are characterized by large tubular, rarely concavosiphonate siphuncles containing endocones.

Superfamily ACTINOCEROIDEA Foerste and Teichert

Space does not permit an adequate review of the treatment of the actinoceroids in the past. Modern understanding of the group may be dated from Teichert's (1933) careful study of the structure of the group. The basis of the present classification is that of Foerste and Teichert (1930) who employ Actinoceroidea in much the sense in which Hyatt (1900) used the term Actinoceratidæ. The actinoceroids are largely straight shells characterized by large nummuloidal siphuncles. Within the siphuncles there are heavily annulosiphonate deposits which may, where mature, fill the segments except for a series of tubes which Teichert termed the endosiphoncular vascular system. These tubes consist of a central canal from which radial canals pass toward the connecting ring. Near the ring they tend to branch and terminate in a space close to the ring free from the annulosiphonate deposit, which is known as the perispatium. The perispatium and the canal system are the essential diagnostic features of the group. There are other cyrtochoanitic orthoceracones, in particular, the Pseudorthoceratidæ and the little understood Stereoplasmoceratidæ. The only certain method of recognizing an actinoceroid is by the presence of the radial canal system and the perispatium within the siphuncle. The problem becomes particularly acute in some of the Sactoceratidæ. Here some shells have small and relatively narrow siphuncles in relation to other actinoceroids, and in section may resemble pseudorthoceroids and stereoplasmoceroids quite closely insofar as the form and proportions of the siphuncle and septa are concerned. Such shells can be identified as actinoceroids with certainty only by a study of the deposits within the siphuncle. When these are lacking, as may often happen particularly if an immature shell is all that is available, or if only the adoral part of the phragmocone is preserved, it can be recognized only by inference as a member of one group or another.

The typical actinoceroids may be recognized by the extremely large and heavy siphuncles. Also, they are characterized by blunt apices. This does not apply to the Sactoceratidæ, however, where the initial part of the shell is small and slender, and the siphuncle is relatively narrow. Indeed, so great is the contrast, that the writer has more than once wondered whether the Sactoceratidæ were related to the other actinoceroids.

The classification of the Actinoceroidea, as at present recognized, is as follows:

1. Family Polydesmiidæ Kobayashi. Actinoceroids with large siphuncles, broadly expanded, thick connecting rings simulating continuations of the septal neck; radial canal system complexly branched and irregular. This contains only the genus *Polydesmia*. (See Kobayashi, 1940; Flower, 1941.)

2. Family Actinoceratidæ Hyatt (restricted, Foerste and Teichert). Siphuncle large; septal necks and brims about equal, both very long. *Actinoceras* Bronn, *Kochoceras* Troedsson, *Saffordoceras* Foerste and Teichert, *Troostoceras* Foerste and

Teichert. Doubtfully retained here are *Leurorthoceras* Foerste and *Paractinoceras* Hyatt.

3. Family Armenoceratidæ Troedsson. Septal necks recumbent; length of neck less than brim, sometimes negligible. *Armenoceras* Foerste, *Nybyoceras* Troedsson, *Cyrtonybyoceras* Teichert, *Elrodoceras* Foerste, *Megadiscosorus* Foerste, *Selkirkoceras* Foerste, (?) *Metarmenoceras* Flower.

Family Huroniidæ Foerste and Teichert. Septal necks very short, ring broadly adnate to septum adapically but not adorally, much of free part of septum incorporated into siphuncle wall; segments of siphuncle inflated adorally, but attenuated adapically. Foerste and Teichert have included here, *Huronia* Bigsby, *Huroniella* Foerste, and *Discoactinoceras* Kobayashi.

Family Gonioceratidæ Foerste and Teichert. This family contains actinoceroids internally similar to the Armenoceratidæ, but characterized by the flat shells, in which dorsal and ventral surfaces are separated by sharp lateral angles. It contains *Gonioceras* Hall and *Lambeoceras* Foerste.

Family Sactoceratidæ Troedsson. Actinoceroids with relatively small siphuncles. *Sactoceras* Hyatt and *Ormoceras* Stokes may not be generically distinct. *Deiroceras* Foerste and *Troedssonoceras* Foerste belong here. It is doubtful whether the Silurian *Cyrtactinoceras* Hyatt is properly an actinoceroid. I include here, however, *Treptoceras* Flower. The point of separation of the Sactoceratidæ from the Actinoceroidæ and Armenoceratidæ is exceedingly difficult, and rests more on the size of the siphuncle than any other feature. On the basis of range, I include the large Mississippian *Rayonnoceras* here rather than in the Actinoceratidæ. The Sactoceratidæ develop radial canals which branch straight from the central canal to the connecting ring, instead of being arched or curved as in the Actinoceratidæ and most Armenoceratidæ. *Metarmenoceras* Flower may belong here, as suggested by its canal system, rather than in the Armenoceratidæ, as suggested by the size of the siphuncle.

There has been much discussion in recent years as to the relationship existing between the Actinoceroidea and other cephalopods. Teichert (1933) suggested that they were probably more closely related to the endoceroids than to other cephalopods. Schindewolf (1935) rejected this view on the supposed similarity between the apical end of *Carbactinoceras*, a subgenus of *Rayonnoceras*, and orthochoanitic orthoceracones. Kobayashi (1937) reported the early stages of Ordovician actinoceroids, which were quite different from Schindewolf's Mississippian form, but, rather strangely, came to conclusions concerning the relationship which were quite similar to the views of Schindewolf. Flower (1940) described the early stages of *Actinoceras* and discussed the earlier papers, pointing out that a horizontal section such as exhibited by Schindewolf might pass through the wall of the first camera obliquely, completely missing the true initial chamber, which lies well ventrad of the center of the siphuncle. On this basis, Schindewolf's specimen was not a reliable guide to the condition of the early stages. Kobayashi saw as significant the fact that the siphuncle of the actinoceroid was central in the early stages, and on this basis placed the actinoceroids with the ellipochoanitic cephalopods as opposed to the endoceroids. The writer, however, pointed out that the position of the siphuncle need not be of primary importance, and that it might be more important that the siphuncle appears to be open into the whole of the space between the shell wall and the initial septum in both the endoceroid and the actinoceroid, while the tip is confined in an apical cæcum in most other cephalopods.

Since then, the problem of the significance of the apical ends of the siphuncles has become more complex in the light of new information on the early stages of some of the older cephalopods. Neither the apically ventral siphuncles of Kobayashi nor the distinction between siphuncles, which are open into the apical chamber on one hand and closed by a cæcum on the other, appear to hold. Ventral siphuncles occur in some but not all of the Tarphyceratidæ and Trocholitidæ, as shown in part by Hyatt (1894), by Ulrich, Foerste, Miller, and Furnish (1942) and by unpublished sections made by the writer. The validity of the apical cæcum as a criterion of the stenosiphonate line is impaired by the apparent presence of such a cæcum in "*Cameroceras*" *annuliferum* Flower (1941) of the Canadian of eastern New York. On the basis of these discoveries, the early stages seem too variable to serve as guides to phylogeny, or else their significance has so far not been understood.

On the basis of adult features, it has been possible to show a plausible way in which the endoceroid, in the old broad sense in which the term was formerly used, could have given rise to the actinoceroid. This has been traced by the writer (Flower, 1941) beginning with *Ellesmeroceras* and passing through *Bathmoceras* and the primitive actinoceroid, *Polydesmia*. This hypothesis requires further study of *Bathmoceras,* particularly in regard to the fine structure of the connecting ring, the deposits derived from the connecting ring, and a search for possible vascular structures. Unfortunately, suitable material of this genus has not been available; indeed Holm's earlier study of the genus was based upon the only specimen thus far found well enough preserved to be studied by sections. However, the similarities between this genus and *Polydesmia* are quite striking, and suggest an evolutionary progression involving the expansion of the siphuncle within the cameræ coupled with a differentiation of the thickening of the connecting ring which projects far into the cavity of the siphuncle into annulosiphonate deposits.

Kobayashi, however, (1935, p. 750; 1936, p. 234; 1937) has proposed that the actinoceroids and the Stereoplasmoceratidæ were both derived from orthochoanitic orthoceracones. This is possible from the point of view of the outline of the siphuncle. However, it does not explain the sudden appearance of highly specialized deposits within the siphuncle, the annuli, the vascular system, the perispatial deposits, nor is it particularly consistent with the large blunt apical ends of the actinoceroids which present a sharp contrast to the minute apices of known orthochoanitic orthoceracones.

THE ACTINOCEROIDEA OF THE CINCINNATIAN

The Cincinnatian Actinoceroidea, only a part of which are included in the present work, include representatives of three families, the Armenoceratidæ, represented by several specimens of *Armenoceras,* the Gonioceratidæ, represented by a single species of *Lambeoceras,*and the Sactoceratidæ,represented by *Troedssonoceras,* which is confined to the Cathys and Cynthiana of the Trenton and the Maysville of the Covington but which does not persist into higher strata. The species of *Troedssonoceras* are included in the present volume. *Treptoceras* Flower, also of the Sactoceratidæ, reaches its fullest expression in the Cincinnatian. To this genus belong the smooth orthoceracones which are the commonest of the Cincinnati cephalopods. This genus has its inception in the Trenton and persists throughout the entire section at Cincinnati. It is also represented in the Lorraine of New York, in the Cincinnatian of Ontario, but is unknown in Anticosti or in any of the boreal associations. The magnitude of the problem of identification of the several thousand specimens of this genus available for the present study and the problem of identifying the previously described species of "*Orthoceras*" of the Cincinnatian, nearly all of which belong in this genus, but are so inadequately described that they are for the most part unrecognizable, have made it necessary to delay the description and discussion of these species for the second part of the work.

Family ARMENOCERATIDÆ

Genus ARMENOCERAS Foerste

Genotype.—*Actinoceras hearsti* Parks.

Armenoceras Foerste, 1924, Univ. Michigan, Mus. of Geol., Contrib., vol. 2, p. 32; Foerste, 1924, Canada, Geol. Surv., Mem. 145, p. 73; Troedsson, 1926, Meddelelser om Grœnland, vol. 71, p. 60; Foerste and Savage, 1927, Denison Univ. Bull., Sci. Lab., Jour., vol. 22, p. 63; Foerste, 1929, *ibid.*, vol. 24, p. 202; Foerste and Teichert, 1930, Denison Univ. Bull., Sci. Lab., Jour., vol. 25, p. 269; Foerste, 1933, *ibid.*, vol. 28, p. 17.

Armenoceras is differentiated from *Actinoceras* by the segments of the siphuncle, which are more abruptly expanded, so that the brim is well developed and the neck very short. The brim is sometimes free and sometimes recumbent, that is, so recurved as to lie in contact with the free part of the septum of which it is a modified continuation, and all gradations between the two conditions exist. The segments are expanded within the cameræ, rounded, and generally the adapical end of the connecting ring is adnate to the septum. Annulosiphonate deposits are typical of the actinoceroids. The course of the radial canals varies somewhat within the genus, but consists typically of two series of arclike canals which are possibly efferent and afferent vessels, as in *Nybyoceras*. Teichert (1933) has discussed this type of structure most adequately. However, some species of the genus appear to have simpler canals, and Flower (1941) has suggested that perhaps these forms are more closely allied to the Sactoceratidæ. It is possible that *Armenoceras* and *Ormoceras* may be united by Middle Ordovician species which have been assigned to both genera, typified by *Armenoceras allumettense*, in which the segments of the siphuncle are narrow, subspherical, the septal foramen truncating the spheroidal outline only slightly, but in which the brims are generally extensive, the necks short in species assigned to *Armenoceras*, while forms showing longer necks and shorter brims have been placed in *Ormoceras*. *Treptoceras* Flower, typically developed in the Upper Ordovician, is closely allied to this line.

It is believed that *Armenoceras* arose from such older Armenoceratidæ as *Nybyoceras* and *Cyrtonybyoceras*, which appear in the Chazyan, and are characterized by a series of double arcs forming the radial canals of the siphonal vascular system. This condition is believed to be more primitive than the single series of arcs in each segment developed in the Actinoceratidæ, and the horizontal radial canals of the Sactoceratidæ, a feature which appears in some species,otherwise typical *Armenoceras* on the basis of the outline of the siphuncle alone. Such *Armenoceras* species survive into the Silurian, and give rise to the Devonian *Metarmenoceras* Flower (1941) in which the canal system becomes even more specialized. In general, the younger species of *Armenoceras* develop narrow and small siphuncles, closer to those of *Ormoceras*, and resemble that genus in the simple horizontal radial canals. A few exceptions are found in Silurian species of Anticosti, notably in *A. excentrale* and *A. chicottense*, which appear closer to the Ordovician types.

At the present time some 36 named species and varieties of *Armenoceras* are known in North America. Additional forms are known from Europe, mainly in the Scandinavian area, and also from the Ordovician of Manchuria and Korea. Attempts to subdivide this overly unwieldly genus have thus far been rather unsuccessful. Shimizu and Obata have attempted to subdivide it on the basis of differences in the form of the segments of the siphuncle, but these differences cannot be widely applied and do not seem to include species which are similar on the basis of other features. Part of the difficulty lies in the fact that most species are known from portions of phragmocones not always enough for accurate comparison, while another group is known largely from isolated siphuncles. Further, some species have not been studied closely enough to permit close subdivision on the basis of details of the outline of the siphuncle. The radial canal system is regarded by the writer as a potential aid in clarifying the relationships of these species, but information on the structures involved is lacking for a good many of the described species, particularly those of the American Arctic region.

Cincinnati species.—Three species of *Armenoceras* are known from the Cincinnati region. All three belong to the group of forms characterized by short broad siphuncles which have the septal foramen nearly normal to the axis of the shell, and in which the connecting ring is broadly adnate at its adapical end. In contrast, another group of species including the genotype, shows a poor area of adnation, the septa are oblique where they join the siphuncle, and the general pattern of the segments tends to be faintly heart-shaped, suggesting that these species may be related to the forerunners of *Huroniella,* which appears in the Red River but is better developed in the Silurian.

The first of the Cincinnati forms is *A. vaupeli,* characterized by very shallow cameræ. The siphuncle is relatively small, lies close to the venter, and is made up of very short segments. *A. brevicameratum* Foerste and Teichert (1930) of the equivalent Cathys limestone of Tennessee is probably the only form which is very closely related to this one.

The two remaining species occur in the Richmond and have larger siphuncles. In *A. richmondense* the siphuncle is found to be definitely moved from the venter, and this species appears to be closely allied to *A. arcticum* var. *angustum* Troedsson. *A. madisonense* resembles *A. richmondense* closely, but has a more ventral siphuncle, and differs in details of the form of the septal necks. It is evidently closer to the Maquoketa species *A. clermontense* and *A. iowaense.* A fragment unworthy of description or illustration indicates the presence of *Armenoceras* in the Leipers beds at Rowena, Kentucky.

Armenoceras vaupeli Flower, n. sp. Plate 43, figs. 2, 4; Plate 47, figs. 4-6

Conch orthoceraconic, slender, very slightly depressed in section, without definite flattening of the venter. The most complete specimen expands from 31 mm. and 33 mm. to 38 mm. and 40 mm. in a length of 70 mm., and consists of 22 cameræ. The sutures appear transverse on the ventral side, but slope orad from venter to dorsum, the obliquity being confined to the dorsal half of the shell, a faintly sinuous pattern resulting. Thirteen cameræ occur in a length equal to the height of the shell of 39 mm., and 12 occur on another specimen in a length equal to an adoral width of 42 mm. The septa are deeply curved at a shell height of 37 mm., the curvature is 14 mm., or nearly equal to the length of three cameræ. The greatest depth of the camera is slightly ventrad of the center but dorsad of the siphuncle.

The siphuncle is scarcely wider than high, relatively small, and close to the venter. Adapically a segment is 3 mm. long, expands from 5 mm. to 10 mm., and at its broadest portion is 5 mm. from the venter. Adorally the segment is 3.5 mm. long, expands from 6 mm. to 12 mm., and is 4 mm. from the venter. In vertical section the adapical end of the connecting ring is almost free dorsally and broadly adnate ventrally. At its adoral end the ring is attached broadly to the septum on the dorsum but not on the venter. The septal necks are short and apparently recumbent, but whether narrowly free or actually in contact with their septa, is uncertain. Annulosiphonate deposits are well developed and typical.

The species is known only from phragmocones which range from a width of 33 mm. and a height of 31 mm. to an adoral shell width of 55 mm.

Discussion.—This species is represented in our material by four specimens, three of which are badly weathered and fail to retain the dorsum. The fourth, here used as the holotype, represents a portion of a phragmocone complete for a length of 70 mm.

Only one form is closely allied to this species, *A. brevicameratum* Foerste and Teichert of the Cathys limestone. Both species have short septa, sutures somewhat inclined orad on the dorsum, and a small ventral siphuncle. *A. vaupeli* is distinguished from *A. brevicameratum* in the stronger curvature of the septa, which are also slightly more inclined orad on the dorsum, but mainly in that the siphuncle is considerably smaller in proportion to the diameter of the conch, and is considerably closer to the venter in *A. vaupeli.* It is evident, although *A. vaupeli* is known from portions slightly smaller than *A. brevicameratum,* which seems to be known from the single holotype only, that its siphuncle tends to become more eccentric rather than less, with increase in growth, and consequently the adoral parts of the shell are less like those of *A. brevicameratum,* than are its earlier parts which are more remote from *A. brevicameratum* in actual dimensions. Consequently the two species appear to be quite distinct.

Both forms exhibit the broad adnation of the siphuncle on the adoral end on the dorsum, and on the adapical end on the venter, a condition characteristic of *Nybyoceras.* It is uncertain whether this represents a real relationship inasmuch as the condition is found more or less well developed in all species in which the siphuncle lies well ventrad of the point of greatest depth of the septum.

Other species of *Armenoceras* are not closely allied, typical forms having both deeper cameræ and larger siphuncles.

Types.—Holotype, Shideler Collection; paratypes, Univ. of Cincinnati Museum, Nos. 23901, 23903.

Occurrence.—From the Cynthiana limestone, Cynthiana, Kentucky. All forms are from the Greendale member of the Cynthiana.

Armenoceras richmondense Flower, n. sp. Plate 44, figs. 1, 2

This form is represented by shells usually fragmentary and flattened but which show that this species had a phragmocone rather similar to that of *A. madisonense* but differing in the more central position of the siphuncle. The holotype, selected as the least distorted although not the most complete specimen, is a portion of a phragmocone 55 mm. in length, increasing in width from 40 mm. to 50 mm. in a length of 45 mm. The shell height, decreased partly by weathering and partly by slight pressure, is 38 mm. adorally, and was probably nearly as great basally. At the adoral end of the shell the siphuncle is 14 mm. high and 21 mm. wide at the septal foramen, is 7 mm. from the ventral wall and about 18 mm. from the dorsum. At a shell width of 50 mm. the septa are equal in curvature to one and one-half cameræ. Seven and a half cameræ occur in a length equal to the adoral shell width.

The siphuncle is always much wider than high, strongly depressed in section. The segments in section show a remarkably small septal foramen, actually 9 mm. in width where it is apparently 14 mm. in width, for the septal necks are recumbent and broadly adnate to both ends of the connecting ring, extending far within the apparent minimum diameter of the siphuncle, where they are obscured by the recrystallized annulosiphonate deposits. The apparent expansion of the segments in the cameræ is slight, one increasing from 18 mm. to 23 mm., where the length of the segment is 7 mm.

In section, the siphuncle shows that the septa continue far within the apparent septal foramen, so that where the apparent minimum width of the segment is 18 mm., the septal foramen was actually only 9 mm. wide. The condition of the necks and brims is obscured in most cases by recrystallization of the calcite surrounding and composing them, but at several points the sections show that the brim is strongly recurved, but actually does not become recumbent, and fails to touch the free part of the septum. Also, the adoral portion of the connecting ring remains free from the septum, although adapically a broad area of adnation is developed. The radial canals are nearly normal to the central canal, but their arrangement cannot be made out clearly. The cameræ bear only very thin hyposeptal and episeptal deposits which are unusually thin throughout, even where the segments of the siphuncle contain mature annulosiphonate deposits.

Discussion.—This form resembles *A. madisonense* Foerste and Teichert (1930, page 272) but may be distinguished in complete phragmocones by the position of the siphuncle which is not in contact with the venter in this form. Further, the almost straight course of the septa from the shell wall centrad and apicad to the siphuncle in the adapical part of the phragmocone seems to be characteristic of this species. Recognition on the basis of the isolated siphuncles is more difficult, but is possible if good sections can be made, for in *A. madisonense* the tip of the septal neck touches the free part of the septum, which is not true of *A. richmondense.*

In other regions, among the many described species of *Armenoceras*, there are several other comparable forms. *A. clermontense* Foerste is based upon a weatherd shell which superficially might represent an adoral portion of *A. richmondense*. It shows the same short segments. The curvature of the septa is not dissimilar from that of the adoral but not the adapical end of *A. richmondense*, but the siphuncle is closer to the venter in *A. clermontense*, there seems to be more pronounced flattening of the ventral side of the shell, and the segments of the siphuncle are considerably broader in proportion to their length than would be those of *A. richmondense*. *A. richmondense* fails to show an adoral increase in the width of the segments of the siphuncle such as would produce the wide segments of *A. clermontense* when projected onto a commensurate portion of a phragmocone. *A. iowaense* Foerste, also of the Maquoketa shale, shows segments of a siphuncle which expand less rapidly orad, but differ from those of *A. richmondense* in being in contact with the ventral wall.

More similar to *A. richmondense* are two forms from the Cape Calhoun beds of Greenland, *A. arcticum* Troedsson (1926) and *A. arcticum* var. *angustum* Troedsson (1926). The former is easily distinguished by its broader siphuncle, in which it seems to be very closely allied to *A. clermontense*. *A. arcticum* var. *angustum* in the narrower siphuncle is closer to the Richmond species but has a more poorly developed area of adnation at the adapical end of the connecting ring. This form is probably more closely allied to *A. richmondense* than any other species.

Other comparable forms have been discussed under the generic discussion.

Types.—Holotype, Univ. of Cincinnati Museum, No. 23916. Paratypes, Univ. of Cincinnati Museum, No. 24472, and two specimens in the collection of Dr. W. H. Shideler.

Occurrence—This species ranges from the Blanchester apparently to the top of the Liberty beds. The holotype is from the Liberty, in a road cut about three miles south of Milan, Indiana, on Indiana Route 1. The figured paratype (Shideler Collection) is from the Blanchester beds of the Waynesville, Addison's Creek, near Oxford, Ohio. Two loose siphuncles are from the Liberty, one at Madison, Indiana, the other from the coral reefs of the Liberty at Bardstown, Kentucky.

Armenoceras madisonense Foerste and Teichert Plate 47, fig. 7

Armenoceras madisonense Foerste and Teichert, 1930, Denison Univ. Bull., Sci. Lab., Jour., vol. 25, p. 272, pl. 45, fig. 1A-C; pl. 58, fig. 1.

Original description.—Specimen 155 mm. long, enlarging at an approximate angle of 5 degrees. At its base the lateral diameter is estimated at 35 mm., and at a point 90 mm. farther up it equals 43 mm. The number of cameræ in a length equal to a lateral diameter of the conch varies from 6 along the lower part of the specimen to 7 near its top. The concavity of the septa is about 8 mm. The sutures of the septa are not exposed. The siphuncle is in flattened contact with the ventral wall of the conch at the lower end of the specimen, but is 1.5 mm. distant at the upper end. The diameter of the siphuncle enlarges from 18 mm. at the base of the specimen to 20 mm. at the top. The septal necks are extremely short, and hardly twice as long as the thickness of one septum. The septa curve backward very sharply at the septal foramen and form a rather short brim. Along its inner part the brim is separated for a very short distance from the lower side of the overlying septum, but comes in contact with this septum along its outer half.

Occurrence.—Madison, Indiana, from some unknown horizon, but apparently from the Saluda member of the Richmond. Holotype, No. 15493, U. S. National Museum.

Discussion.—This species is evidently rare and appears to be known only from the holotype. Examination of other Richmond *Armenoceras* has shown in the case of every specimen examined that the septal necks are longer and the brim and the adoral end of the connecting ring are free, which is not the case in *A. madisonense*. These specimens are assigned to the new species *A. richmondense*, which is known to range from the upper Waynesville to the Liberty but has not been found higher in the section. This species differs further in having a siphuncle which is much farther from the ventral wall of the shell than is that of *A. madisonense*.

Foerste and Teichert are somewhat doubtful concerning the age of *A. madisonense*, but the writer has followed them in assigning it tentatively to the Saluda. This seems probably safe in view of the usually characteristic lithology of the Saluda, and Foerste's intimate knowledge of the entire Cincinnatian, but even in the Saluda lithology may play strange tricks, and further verification is eminently to be desired. The writer can say only that none of the Liberty or Waynesville species of *Armenoceras* which have come to his attention are conspecific with the species under discussion. However, it must be admitted that had one of these forms not been collected in place, it might have been considered of Saluda age on the basis of lithology and weathering. Unfortunately the holotype of *A. madisonense* could not be re-examined for the present study with these matters in mind, as at the time of writing, it is, with other of the U. S. National Museum types, in storage for the duration of the war. Happily, the species was studied by Foerste and Teichert with their customary thoroughness and was amply illustrated.

Family GONIOCERATIDÆ

Genus LAMBEOCERAS Foerste

Genotype.—*Gonioceras lambei* Whiteaves.

Lambeoceras Foerste, 1917, Cincinnati Soc. Nat. Hist., Jour., vol. 22, p. 45; Foerste, 1926, Denison Univ. Bull., Sci. Lab., Jour., vol. 21, p. 312; Troedsson, 1926, Meddelelser om Grœnland, vol. 71, p. 44; Foerste, 1929, Denison Univ. Bull., Sci. Lab., Jour., vol. 24, p. 213; Foerste, 1929, *ibid.*, vol. 24, p. 320; Foerste and Teichert, 1930, *ibid.*, vol. 25, pp. 207, 213, 214; Foerste, 1933, *ibid.*, vol. 28, p. 41; Foerste, 1935, *ibid.*, vol. 30, p. 51; Teichert, 1935, Amer. Jour. Sci., vol. 29, p. 22; Teichert, 1934, Meddelelser om Grœnland, vol. 92, pp. 32-36; Leith, 1942, Jour. Paleont., vol. 16, pp. 130-132.

Shell straight, very strongly depressed, with the dorsum and venter somewhat convex but strongly separated by sharp lateral angles. The sutures form broad rounded lobes, generally very deep, over dorsum and venter separated by angular lateral saddles. Generally the suture describes a lobe on the venter somewhat more strongly curved and narrower than that of the dorsum. The sutures show only a very slight reversal of curvature toward the sides, not present in all species. The septa are strongly curved laterally but nearly flat vertically. The siphuncle is located ventrad of the center of the shell, is large, and is typical of the Actinoceroidea in its construction and deposits. Owing to the extreme flatness of the shell the siphuncle differs markedly in appearance depending upon the direction of the section from which it is studied. A horizontal section shows broadly expanded segments. The septa appear to approach each other where they make up part of the siphuncle and are adnate to the next adoral connecting ring but are turned slightly farther apicad than is normal. The true brim cannot usually be seen in opaque sections as it is very short and is usually complicated by the development of the circulus; the whole being frequently obscured by recrystallization. The true structure has, however, been demonstrated by Teichert. The connecting ring is nearly free at its adoral end but broadly adnate adapically. In vertical section the septa bend abruptly apicad and appear to be orthochoanitic. They do, however, have short recumbent septal necks. The connecting ring expands rapidly, forming an inflated segment and is broadly adnate to the next septum at its adapical end. The structure is faintly suggestive of that of *Huronia*. The usual annulosiphonate deposits are developed with radial and central canals remaining.

The surface features (Leith, 1942) are known for only the genotype. They consist of transverse bands which form a slight crest on the dorsum and a low broad sinus over the entire venter. Shells of this genus may attain immense size, rivaling the larger endoceroids.

Discussion.—This genus is widespread in strata of the later Ordovician Arctic embayment, being known from Cape Calhoun to the Big Horns. Although present in the Richmond of Ohio, it is not known from the Maquoketa shale of the Mississippi Valley, though present there in the underlying Stewartville beds. It is not known from the eastern equivalent formations, either from the Whitehead of Gaspé or from the Ordovician of Anticosti. The range of the known species is summarized below:

L. acutilaterale Foerste (1935). Lander sandstone, Big Horns.

L. arcticum Teichert (1937). Ordovician, Igluiik Island.

L. boreum Troedsson (1926). Cape Calhoun series, Greenland.

L. confertum Foerste (1932). Stewartville formation, Minnesota and Illinois.

L. cf. confertum Foerste (1935). Lander sandstone, Big Horns.

L. cultratum Miller (1932). Lander sandstone, Big Horns.

L. cf. cultratum Miller, (Foerste, 1935). Stewartville of Illinois.

L. lambei (Whiteaves, 1891), (see Foerste, 1926). Selkirk formation, Red River, Manitoba.

L. cf. lambei Foerste, (Teichert, 1937). Mt. Nautilus, Cockburn land.

L. landerense Foerste (1935). Lander sandstone, Big Horns.

L. magnum Troedsson (1926). Cape Calhoun formation, Greenland.

L. nudum Troedsson (1926). Cape Calhoun formation, Greenland.

L. cf. nudum (Teichert, 1937). Ordovician, Iglulik Island.

L. cf. nudum Foerste (1932-33). Ordovician, southern Baffin Land.

L. peculiare Miller (1932). Lander sandstone, Big Horns.

L. princeps Troedsson (1926). Cape Calhoun formation, Greenland.

L. cf. princeps Troedsson (Foerste, 1929). Dog Head, Red River, Manitoba.

L. richmondense (Foerste) (1917). Whitewater, Richmond, Indiana.

L. (?), sp. Miller (1932). Lander sandstone, Big Horns.

One other species, *L. leveannulatum* (Troedsson, 1926), has been made the genotype of *Rasmussenoceras* Foerste (1933). Internal molds of this genus resemble those of *Lambeoceras* but the siphuncle is very slender. That genus is discussed elsewhere in the present work.

Lambeoceras has been placed by Foerste and Teichert (1936) in the family Gonioceratidæ of the Actinoceroidea, and subsequent morphological investigations of Teichert (1934) have tended to confirm this assignment as have those of Leith (1942) who confirmed the presence of typical actinoceroid type of deposits in the genotype.

Gonioceras may readily be distinguished by the course of the sutures. In that genus the broad rounded lobe of the center on both dorsum and venter reverses its curvature at the sides, so that there are rounded saddles flanking the central lobe and at the edges of the two flat surfaces sharp lateral lobes are formed. Although the sutures may tend to flatten out laterally in *Lambeoceras* they never form true lateral lobes, and these genera although apparently closely related, do not intergrade.

Species which in the past have been placed in *Tripteroceras* agree with *Lambeoceras* in form, but have a small siphuncle, so small and weak that it is usually not preserved at all. Although some such species have been placed in *Tripteroceras*, it has seemed wisest to remove them to *Rasmussenoceras*, with which they agree in all known morphological features, inasmuch as they differ from typical *Tripteroceras* in that the section is not subtriangular, while the dorsal keel is lacking.

Only one species, and that a somewhat variable one, of *Lambeoceras* is recognized in the Richmond of the Cincinnati area. This may be distinguished from *Rasmussenoceras* by the characters of the siphuncle, and also by the somewhat larger size attained by the species. The two are, however, so very similar in aspect, so much so that I have often been in doubt as to which certain poorly preserved fragments, failing to show the siphuncle and septa clearly, should be placed.

The apical end of *Lambeoceras* has not been noted. One specimen of *L. richmondense* figured here fails to retain the extreme apex but indicates by the form of the external mold at the base of the shell that the apex was very rapidly expanding as in simpler genera of the Actinoceroidea. Somewhat analogous conditions are inferred from specimens of *Gonioceras* which approach but do not quite attain the apex of the shell.

Lambeoceras richmondense (Foerste)
Plate 44, figs. 3, 4; Plate 45, figs. 1, 4; Plate 46, figs. 1-4

Tripteroceras (*Lambeoceras*) *richmondensis* Foerste 1917, Cincinnati Soc. Nat. Hist., Jour., vol. 22, pp. 44-46, pl. 1, fig. 3A-D; pl. 3, fig. 2.

Conch straight, strongly depressed in section, with the venter slightly more flattened centrally than the dorsum. The rate of expansion of the shell varies among the different growth stages, being rapid at first, and later more gradual until the adoral part of the shell scarcely expands laterally. The earliest stage observed shows a lateral expansion of 16 mm. to 32 mm. in 40 mm., while an external mold of a more apical portion of the same specimen indicates that this rapid expansion began at or very near a blunt apex. At a region between a width of 34 mm. and a width of 40 mm. the rate of expansion decreases, and the shell expands from 34 mm. to 47 mm. in a length of 80 mm. The larger specimens show a still more slender form in adoral parts of the conch

One specimen (Shideler Collection, Pl. 45, fig. 4) increases from 54 mm. to 59 mm. in the 40 mm. of the phragmocone and to 65 mm. in the 75 mm. of the living chamber. A second large specimen (Earlham Collection, No. 6422, Pl. 44, fig. 4) shows an increase of from 60 mm. to 66 mm. in a length of 114. The largest specimen observed increases from a width of 67 mm. to 70 mm. in a lateral length of 134 mm. (Pl. 46, fig. 1.)

The section of the shell is generally uncertain as specimens are often subjected to crushing. However, one small fragment in a good condition of preservation shows a width of 31 mm. and a height of 14 mm. which increases in 31 mm. to 43 mm. and 16 mm. Flattening is more marked in more mature portions of the shell but may be augmented by distortion. The height is 20 mm. at a width of 58 mm. near the base of one of our larger specimens where the shell does not appear to be distorted.

The septa are strongly curved laterally but nearly flat vertically. In the central portion the septum is slightly oblique in undistorted specimens sloping slightly orad from venter to dorsum. The sutures in early ephebic stages of growth show lobes on the venter and dorsum which are slightly different. On the venter the median lobe is deep and sharp, though rounded at its center, the appearance of sharpness being augmented by the way the suture is curved laterally, so that it becomes convex orad upon approaching the lateral saddle. A broad rounded lobe, broader and slightly shallower occupies the entire dorsum, as shown in Plate 46, figure 3. Adorally the difference between the dorsal and ventral sutures becomes less marked, the broad adoral convexity of the lateral part of the suture is lost, though in the extreme adoral portion of the phragmocone the extreme lateral part of the sutures of the venter again becomes slightly curved apicad. This is shown clearly on our largest specimen which represents a definitely gerontic condition.

The cameræ increase in depth from 4 mm. near the apex at a width of 16 mm., to 5 mm. at a width of 40 mm. Adorally the cameræ tend to become shorter. The largest specimen shows cameræ 5 mm. deep at the center of the specimen, but only 3 mm. deep over a broad area near the base of the living chamber. Another specimen shows cameræ 4 mm. deep at a width of 54 mm., and a third (Earlham Collection, No. 6422) has cameræ 3 mm. in depth at a width of 62 mm. In general, the depth of the lobe of the suture is equal to or slightly less than the depth of two cameræ in the early part of the shell, but adorally the cameræ are shortened and at a width of 60 mm. seven cameræ occur in the linear interval of one ventral lobe, and are still more closely spaced in the extreme gerontic portion.

The siphuncle lies ventrad of the center of the shell. The segments are broadly nummuloidal, as can be seen in several weathered specimens. The form of the segments is shown clearly in the enlarged sections. Horizontal sections are typical of *Lambeoceras* as known from the genotype and the Cape Calhoun forms studied by Troedsson and by Teichert. In vertical section, however, the necks are more evenly recurved and do not extend apicad for any considerable distance along the siphuncle but are more similar to the septal necks of *Armenoceras*. Also, the expanded part of the segment is nearly equal to its length as a result of the reduction of the length of the septal necks.

The surface features have not been observed on this species. The living chambers are essentially complete on two known individuals, one of which has a maximum length of 90 mm. in the median portion, 73 mm. laterally, and expands in this length from a width of 56 mm. to 60 mm. The second living chamber has a maximum median length of 95 mm., a lateral length of 80 mm., and increases in width from 60 mm. to 63 mm.

Discussion.—Typical specimens of this species, which are internal molds, are readily confused with *Rasmussenoceras mutabile* and can be best distinguished by the characters of the siphuncle, for while *Lambeoceras* always has a rather large nummuloidal siphuncle which leaves conspicuous traces on the septa, the Cincinnatian *Rasmussenoceras* fails to show more than the faintest indication of the septal foramen, and the structure of the siphuncle is poorly known. *L. richmondense* may further be recognized by the greater size, the more flattened venter, but the sutures and the rate of expansion in both species are very similar.

L. richmondense differs from the genotype of *Lambeoceras* and the Cape Calhoun species, in short, from all of the species which have thus far been studied from vertical sections in that the septal necks do not extend straight apicad along the siphuncle for any considerable distance. *L. lambei*, the genotype, is a gigantic species of the Red River formation, and the convexity of the sutures as they approach the lateral margins of the shells is confined to a very late stage of growth. *L. princeps* Troedsson is also a very large species which can be readily distinguished by the deeper cameræ and also by the cross section in which the venter is as convex as the dorsum. It also has a considerably larger siphuncle in proportion to the size of the conch. *L. nudum* Troedsson is more similar in aspect to *L. richmondense*, but the venter is more convex in cross section, and in horizontal section the siphuncle is less expanded in the cameræ. *L. magnum* Troedsson is a much larger species in which the septal necks are parallel to the axis of the shell in vertical section, and in which they are nearly parallel to the shell axis in a horizontal section. Commensurate parts of this species are not known for comparison with *L. richmondense*, but the extant portions show a greater adapical curvature of the sutures upon approaching the lateral margins of the shell, though this is confined to the extreme marginal portion of the shell. *L. boreum* Troedsson, is distinguished from *L. richmondense* by the broader siphuncle as seen in horizontal section. In spacing of cameræ this species is perhaps closer to *L. richmondense* than the others thus far mentioned.

Comparison with the Bighorn species is more difficult, inasmuch as many of these species are known only from fragments, and differences which appear to be real on the basis of the known portions of these species may become less marked when the entire shells are known. *L. cultratum* Miller is very similar in aspect, differing mainly in that the cameræ are slightly shorter. The sutures are less steeply inclined laterally than in commensurate portions of *L. richmondense*. *L. peculiare* Miller is readily distinguished by the very shallow cameræ and the very broad section. *L.*, sp. Miller (1932, pl. 27, figs. 1, 2) is distinctive in the strongly transverse condition of the central part of the dorsal suture. *L. confertum* Foerste of the Stewartville dolomite is reported as having a more slender siphuncle than other species, a condition which is partly due to the narrow appearance of the siphuncle as incompletely exposed on the venter by weathering in the type specimens. The cameræ are much deeper than in commensurate parts of *L. richmondense,* the ventral lobe deeper and more narrow, and the faint recurvature of the lateral part of the suture appears relatively early in life. *L. landerense* is a form readily distinguished by very shallow cameræ. *L. acutilaterale* is distinct in the combination of rapid expansion and cameræ which increase rapidly in depth orad. Although the type is probably an immature shell, no comparable species are known.

In general the ontogenetic progression of *Lambeoceras* seems to begin with a flattened shell in which lateral expansion is rapid and dorsal and ventral lobes are simple. This is followed by a region in which the rate of lateral expansion is markedly decreased and in which a clear differentiation appears between a broad dorsal lobe and a narrower steeper ventral lobe. Still farther orad the sutures tend to curve toward the horizontal upon approaching the sides, sometimes faintly suggestive of *Gonioceras.* In such a stage the conch frequently becomes even more slender, the rate of lateral expansion becoming negligible.

L. richmondense is represented by a number of specimens among our material, all consisting of internal molds. One is of particular interest for the grouping of a large number of orbiculoid brachiopods in the living chamber. From their position, these were fastened to the inside of the shell.

Types.—The location of the syntypes, which include apparently four specimens, is unknown. The hypotypes upon which this description is based are from the W. H. Shideler Collection, Miami University, the University of Cincinnati Collection, and the collection of Earlham College.

Occurrence.—From the Whitewater formations and the Saluda, from various localities in Ohio. One specimen is recorded as from the Liberty of McDill's Mills, near Oxford, but may actually be from the basal Whitewater. The species appears to be present in both the lower and upper Whitewater, from the vicinity of Oxford, Ohio, and Richmond, Indiana.

Family SACTOCERATIDÆ

Genus TROEDSSONOCERAS Foerste

Genotype.—*Orthoceras turbidum* Hall and Whitfield.

Troedssonoceras Foerste, 1928, Denison Univ. Bull., Sci. Lab. Jour., vol. 23, pp. 40-41; Foerste and Teichert, 1930, Denison Univ. Bull., Sci. Lab., Jour., vol. 25, pp. 209, 214; Teichert, 1934, Meddelelser om Grœnland, Bd. 22, nr. 10, pp. 40-43; Flower, 1939, Jour. Paleont., vol. 13, pp. 481-484.

Conch straight, circular or very slightly depressed in section, with sutures which are straight and transverse or only very slightly oblique. The siphuncle is usually eccentric and is composed of segments which vary from subglobular ones, rather broad at the septal foramen, to more elongate slender segments such as are characteristic of *Deiroceras*. The brim is not greater than the neck and no areas of adnation are developed. Annulosiphonate deposits are of the type which characterize Actinoceroidea and may fill the siphuncle except for a rather large central canal, the radial canals and the perispatium. The radial canals are few, simple, roughly normal to the axis of the central canal, and may depart from the central canal at different levels in the segment. Cross sections and longitudinal sections show that the dorsal and ventral canals leave the central canal at markedly different levels, the dorsal canal occurring apicad of the ventral one. Canals at the right and left sides may leave the central canal at the same point. Cameral deposits are often not clearly shown but when present are episeptal and hyposeptal. Their development is apparently greatly delayed, and they have been observed only in cameræ adjacent to segments of the siphuncle in which the siphonal deposits have reached their complete development.

The surface of the shell is fluted into low and numerous longitudinal ridges which can be observed on the interior as well as on the exterior. In addition, the surface bears numerous fine longitudinal striæ and liræ.

Discussion.—As pointed out before (Flower, 1939) the genus approaches and sometimes attains the shape and general proportions of a *Dieroceras*, from which it may be differentiated only by the ridges and longitudinal ornament of the shell wall. This presents something of a problem in generic identification, for it is by no means certain that all of the species which have been placed in *Dieroceras* lack such surface features, for often the internal molds by which species of this genus are known, are poorly preserved. Such species are not definitely known to lack the fluted shells which characterize *Troedssonoceras*. Inasmuch as it is not even certain that *Deiroceras python*, the genotype, lacks such longitudinal markings, it is not certain even that *Troedssonoceras* and *Deiroceras* are really distinct genera. However, inasmuch as there clearly is a group of smooth-shelled species which may be separated from the fluted actinoceroids, the name *Deiroceras* is tentatively retained for these forms, while only those definitely known to possess longitudinal surface features are placed in *Troedssonoceras*.

The Greenland species upon the basis of which Teichert studied the genus and from which he concluded that it was not a true actinoceroid, have siphonal deposits of a peculiar type, which are parietal rather than pendant. These species are not congeneric with *Troedssonoceras*, since a restudy of the genotype showed that it had the internal structure of a typical actinoceroid. Therefore the generic name *Striatoceras* Shimizu and Obata had to be revived for the reception of the Greenland species, which are of uncertain relationship but are not actinoceroids.

Troedssonoceras, as understood at present, is known only from the Cynthiana-Cathys formations and the closely allied Leipers and Maysville, all of supposedly austral affinities in their faunas. The writer (Flower, 1939A) has previously refigured and redescribed the genotype, distinguishing it from the associated *T. multiliratum* and also described *T. baileyi* from the Trenton of Nashville, Tennessee. The horizon, originally unspecified, is now believed to be the Cathys limestone. Subsequent material has added somewhat to the knowledge of the range and structure of these species and has supplied the basis for two additional forms, *T.* (?) *obscuroliratum* of the Cynthiana limestone and *T. rowenæ* of the Leipers formation. *Sactoceras lineatum* Troedsson and *S. striatum* Troedsson (1926) were placed in *Troedssonoceras* by Foerste. These species show a type of siphonal deposit very different from that of the Actinoceroidea, and the writer, therefore, placed both in the genus *Striatoceras* Shimizu and Obata. *Orthoceras* (*Kionoceras*?), sp. Holtedahl (1918) of the Ordovician of Bear Island may belong either in *Striatoceras* or *Troedssonoceras,* since the character of the siphonal deposits cannot be ascertained from the published data.

The range of the described species is as follows:

T. baileyi Flower. Trenton, Cathys limestone, Nashville, Tennessee.

T. (?) *obscuroliratum* Flower, n. sp., Cynthiana limestone, Kentucky.

T. rowenæ Flower, n. sp. Leipers formation, Kentucky.

T. turbidum (Hall and Whitfield). Fairview group, Cincinnati.

T. multiliratum Flower. Mt. Hope, possibly Fairmount, Cincinnati.

T. cf. multiliratum Flower. Bellevue, Cincinnati.

In addition a small fragment, not good enough to merit illustration or description, indicates the presence of an additional species in the Cathys of Tennessee which is superficially similar to *T. multiliratum* in surface features. The genus is not common at Cincinnati. Only in the Leipers formation of Rowena, Kentucky, is the genus at all abundant.

Troedssonoceras turbidum (Hall and Whitfield) Plate 49, figs. 5, 6

Orthoceras turbidum Hall and Whitfield, 1875, Ohio Geol. Surv., vol. 2, pt. 2, Paleontology, p. 100, pl. 3, fig. 1; James, 1889, Cincinnati Soc. Nat. Hist., Jour., vol. 8, p. 240; Ulrich, 1880, Cat. Foss. Cincinnati Group, Cincinnati, p. 21; Harper and Bassler, 1896, Cat. Foss. Trenton and Cincinnati Periods, Cincinnati, p. 28; Nickles, 1902, Cincinnati Soc. Nat. Hist., Jour., vol. 20, p. 81.

Troedssonoceras turbidum Foerste, 1928, Denison Univ. Bull., Sci. Lab., Jour., vol. 23, p. 40. (Not pp. 41-42, or pls. 6 or 23.); Flower, 1939, Jour. Pal., vol. 13, p. 483, pl. 50, figs. 3-4.

Original description.—Shell of moderate size and very gradually tapering; septa not very closely arranged, four, or a little less than four of them occupying the space of an inch where the diameter of the shell is one and a quarter inches; on the specimen used for description. which has been somewhat flattened accidentally, giving a slightly increased width. Septa moderately concave; siphuncle unknown.

Surface marked by low, rounded, longitudinal ridges, about four and a half to five of which occur in the space of a half inch.

The fragment from which this description was taken, and which is, so far, the only specimen known, is somewhat compressed, so that the spaces representing the chambers are slightly displaced and otherwise distorted, so that the entire characters of the species cannot be determined. But the surface features of the shell are so distinctive and so unlike any others from this horizon, that it cannot be readily confounded with them.

Formation and locality.—In the shales of the Hudson River group, at Cincinnati. Collection of U. P. James, Esq.

Revised description.—Conch orthoconic, very slender, probably originally circular in section or very nearly so. Rate of expansion between 2 mm. and 3 mm. in a length of 60 mm. Known portion of conch ranging from 24 mm. to 42 mm. in width but probably actually much less, as all known specimens are somewhat flattened. The sutures show a slight lobe on the ventral side which may or may not be original. On the dorsal side they are straight and transverse. The cameræ occur three in a length equal to the adoral width in a slightly flattened specimen. The septum is gently curved, its depth of curvature about half the depth of a camera. The siphuncle is clearly eccentric in the adapical half of the holotype, where it is about halfway between the center of the shell and the venter. At the adoral end it appears to be more central in position. It is impossible to say whether a real change in position occurs, or whether the apparent change is the result of distortion. The segments of the siphuncle are convex but longer than broad and essentially similar in outline and internal structure to those of *Deiroceras*. At a shell width of 25 mm. the segment is 10 mm. long and increases from 4.5 mm. to 9 mm. in diameter. Necks are conspicuous, but short, and with the brim considerably less than half the neck. The deposits within the siphuncle are typical of the Actinoceroidea. A wide central canal remains, with short nearly straight radial canals. The cameræ of the hypotype are filled with calcite, but no cameral deposits can be made out with certainty. The exterior of the specimen is an internal mold, which shows faint longitudinal ridges, spaced so that three to four ridges occupy a width of 10 mm., and four to five occur in a half inch.

Discussion.—This is a rare and little known species, formerly confused with two others, *T. multiliratum* Flower (1939) with which *T. turbidum* is associated at Cincinnati, and the form described below as *T. rowenæ*. The original material of *T. turbidum* is from Cincinnati. The original description was based upon a somewhat distorted specimen, and the figure which accompanies it can be applied about equally well to the two Cincinnati species. However, the description yields a clue by which, even in the absence of the original specimen, it is possible to identify the species. This is found in the spacing of the longitudinal markings of the shell, which remain nearly constant throughout the growth stages, and which is not affected, as is the spacing of the cameræ, by flattening of the shell.

This species may be distinguished from *T. multiliratum* by the more widely spaced ridges of the surface of the shell The siphuncle is made up of more slender segments, and the cameræ are somewhat deeper. *T. baileyi* and *T. rowenæ* both have more closely spaced ridges on the shell surface. *T. rowenæ* approaches *T. turbidum* very closely in internal proportions, by *T. baileyi* has a more eccentric and a much smaller siphuncle.

Types.—Holotype.—Location unknown. Hypotype (originally catalogued as a topotype of this species), Univ. of Cincinnati, No. 3308.

Occurrence.—This species is listed by practically all of those who have tried to present the range of the Cincinnati fossils as Fairmount. The species is known to me in the field only from a fragment consisting of three or four segments of an isolated siphuncle, from the middle of the Fairmount, Mt. Airy Forest, Cincinnati.

Troedssonoceras baileyi Flower Plate 50, figs. 3-5

Troedssonoceras baileyi Flower, 1939, Jour. Paleont., vol. 13, p. 483, pl. 50, figs. 1, 2, 7.

Conch orthoceraconic, circular or very slightly depressed in section. Rate of expansion very gradual, increasing from 24 mm. to 28 mm. in 60 mm. Sutures straight, inclined faintly orad from venter to dorsum. Septal curvature 4 mm. in depth where the diameter of the shell is 26 mm. Four cameræ occur in a length equal to the adoral diameter of the shell throughout the known portion. At a shell height of 24 mm. the siphuncle is 2 mm. in diameter at the foramen and 4 mm. from the venter. Segments are fusiform, relatively slender as in *Deiroceras*. A segment 6 mm. long increases from 3 mm. to 4.5 mm. within the camera. Radial canals diverge at different points in the length of the segments toward the wall on different sides. Annulosiphonate deposits are typical of the genus.

Surface with closely spaced longitudinal ridges, six to seven in a width of 10 mm. in the holotype. The interspaces have fine longitudinal liræ, eight to twelve in an interspace. The middle liræ may be strengthened forming secondary weak ridges between the primary strong ridges.

The holotype has a length of 146 mm. and increases from 24 mm. to 30 mm. The sectioned portion is the apical half of the specimen.

Discussion.—No new information is available for this species. It is included here inasmuch as it is needed for comparison with the forms already known from the Cincinnati region, particularly in regard to the surface markings. No exact data were available for the stratigraphic position of the holotype; but it is presumably Cathys. Strangely, no similar form has been recognized in the equivalent and closely allied Cynthiana fauna of Kentucky. There the only *Troedssonoceras* is the dubious *T.* (?) *obscurolineatum* which has fewer longitudinal ridges, all of which are extremely faint on the internal molds, so faint that this species seems to bridge the gap between *Troedssonoceras* and *Deiroceras*. *T. baileyi* is probably the ancestor of *T. rowenæ* which resembles it externally but differs considerably in having a siphuncle more like that of *T. turbidum*. *T. multiliratum*, also somewhat similar, has less closely spaced ridges, but differs mainly in the more rounded and broader segments of the siphuncle.

Type.—Holotype. U. S. National Museum.

Occurrence.—From the Trenton of Nashville, Tennessee, probably from the Cathys limestone.

Troedssonoceras (?) obscurolineatum Flower, n. sp. Plate 47, figs. 2, 3

Conch straight, probably originally circular in section, the holotype slightly compressed, clearly as a result of slight lateral pressure. The internal mold expands from 20 mm. and 21 mm. to 24 mm. and 22 mm. in a length of 55 mm. The sutures are straight and tranverse, the septa shallow, 4 mm. deep at a shell height of 24 mm., or about two-thirds the length of a camera.

The cameræ occur three and a half in length equal to the shell height adapically, from a height of 20 mm. to 23 mm., and occur about three and a third in a similar length at a height of 24 mm. The siphuncle lies close to the venter. Adapically it is 4 mm. from the venter, 13 mm. from the dorsum, and 3 mm. across at the septal foramen. Adorally it is 4 mm. from the venter, 16 mm. from the dorsum and 4 mm. across. A segment at a shell height of 24 mm. is 8 mm. long and increases from 4 mm. to 6 mm. in diameter. The septal neck is slightly recurved, and the segments have no area of adnation at either end of the connecting ring. Annular deposits in the siphuncle have not been observed in a mature condition. Episeptal deposits and vestigial hyposeptal deposits have been noted in the cameræ, but the mural part of the camera is essentially free from deposits.

The surface of the shell is unknown. The surface of the internal mold, though poorly preserved, retains traces of longitudinal ridges which are low, fairly sharp, separated by broader shallow interspaces, five ridges occurring in a width of 10 mm. adapically.

Discussion.—The ridges of the shell wall are so very faintly preserved that I place this species in *Troedssonoceras* with doubt. The siphuncle is typical of *Troedssonoceras*, but also of *Dieroceras*, in the form of its segments, and similar segments may even be found in the later stages of growth of some species assigned to *Treptoceras*. The faint longitudinal ridges on the surface of the type are imperfectly duplicated by molds of cameral deposits in some related Sactoceratidæ, but the ridges are never so clear, and the interspaces always show some trace of transverse marking and pitting. Further, the ridges lack the bilaterally symmetrical arrangement of organic deposits in actinoceroids, the concentration on the venter, and further, small areas of the surface do show molds of incipient cameral deposits which are confined to the region of the sutures and fail to extend any appreciable distance along the mural part of the camera.

This species differs from *T. baileyi* of the Cathys limestone in the larger and more ventral siphuncle as well as in the more distant longitudinal ridges of the shell. Comparable species from the Cincinnati have more central siphuncles, and *T. turbidum*, which is most similar in the spacing of the ridges and in the outline of the segments of the siphuncle, has a much less eccentric siphuncle and considerably deeper cameræ.

The species is evidently rare. Aside from the holotype, only one other specimen is known to me which can be placed in the species, and this only with doubt, as it is a very poorly preserved internal mold which upon sectioning, revealed a siphuncle similar to that of the holotype.

Type.—Holotype, collection of Dr. W. H. Shideler, Miami University.

Occurrence.—The holotype is from the Millersburg phase of the Cynthiana limestone between Sutherland Mill and Chapman, near Bardstown, Ky.

Troedssonoceras rowenæ Flower, n. sp. Plate 49, figs. 4, 7; Plate 50, fig. 6

Troedssonoceras turbidum Foerste (*pars*), 1928, Denison Univ. Bull., Sci. Lab., Jour., vol. 23, pp. 41-43, pl. 6, fig. 2; pl. 23, fig. 9.

Shell faintly depressed in section, straight, expanding at about 1 mm. in 10 mm. The holotype increases from 18 mm. to 27 mm. in the basal 100 mm. and to 30 mm. in the succeeding 40 mm. suggesting a slight adoral reduction in expansion. The shell attains a large size. One somewhat flattened living chamber has a width of 69 mm., and must have had, when undistorted, a diameter of at least 50 mm.

The sutures are straight and transverse. The cameræ vary markedly in depth among individuals, but in general are rather deep adapically and become shallower at a shell diameter of from 28 mm. to 32 mm. The deepest cameræ occur two and a half in a length equal to the adoral diameter of the shell. These range from 20 mm. to 24 mm. The adoral end of the holotype shows four cameræ in a length equal to a diameter of 28 mm., while a larger fragment shows six cameræ in a length equal to the adoral width of 33 mm., though this shell is incomplete and it is not certain that the width has not been increased by slight flattening. It may, on the other hand, represent an approach to geronticism.

The siphuncle is eccentric. In one section, its center lies 9 mm. from the venter and 14 mm. from the dorsum. Here the segment is 10 mm. long, and expands from 5 mm. to 8 mm. In later stages the siphuncle segments become not only shorter, but apparently narrower. In the adoral end of the holotype, in a section which does not quite attain the center of the siphuncle, at a shell diameter of 28 mm., the segment is 7 mm. long, and expands from 4 mm. to 6 mm.

The deposits within the siphuncle are typical of the genus. Episeptal and hyposeptal deposits are found in the cameræ.

The surface of the shell bears numerous longitudinal ridges, which appear angular but are actually narrow rounded ridges separated by somewhat broader concave interspaces. The ridges are spaced five in 5 mm. at a shell width of 20 mm., but four in that width at a diameter of 30 mm., and they become apparently still more widely spaced in fragments from points farther orad. One portion of the holotype shows longitudinal liræ and striæ on the surface. At least five liræ occur between the crests of two adjacent ridges, but they are very faint, and more may be present.

Discussion.—This species agrees with *T. baileyi* of the Cathys limestone in being relatively rapidly expanding and in having numerous rather closely spaced ridges on the surface of the shell. It differs from that species in that the siphuncle is less eccentric, and also in the widening of the surface ridges in late growth stages. The adoral reduction of the siphuncle and the closer spacing of the cameræ are not known in *T. baileyi,* but a comparable adoral part of that species is not known.

From *T. turbidum* the species may be differentiated by the more rapid expansion and the more numerous longitudinal ridges of the shell. Although the adoral ridges of *T. rowenæ* approach the condition of the two Cincinnati species, both clearly attain widely spaced ridges at a much earlier growth stage. The early portions of *T. rowenæ* suggest, in section, *T. turbidum,* but may be distinguished by the more rapid expansion of the shell. The broad round and subspherical siphuncular segments of *T. multiliratum* are unknown in this species, though adorally the cameræ of *T. rowenæ* approach the proportion attained at an earlier stage in *T. multiliratum,* and one which is continued to the latest known growth stage.

Types.—Holotype and paratypes, Univ. of Cincinnati Museum, Nos. 24465-24469.

Troedssonoceras multiliratum Flower **Plate 49, figs. 1-3**

Troedssonoceras turbidum Foerste, 1928, (*pars*), Denison Univ. Bull.,

Sci. Lab., Jour., vol. 23, pp. 41-3.
Troedssonoceras multiliratum Flower, 1939, Jour. Pal., vol. 13, p. 483, pl. 50, figs. 5, 6.

Conch straight, very slender, usually flattened, but probably originally circular or only very slightly depressed in section. Rate of expansion, very gradual. Our longest specimen, which is considerably flattened (Univ. of Cincinnati, No. 22648,) increases in a length of 90 mm. from 34 mm. to 40 mm. Sutures essentially straight and transverse. Four and a half to five cameræ occur in a length equal to the width of the shell. The septum is curved 4 mm. deep at a width of 30 mm., so that in section the curvature of the septum is about equal to the depth of a camera. The siphuncle is subcentral in the later growth stages, but may be eccentric in the young, as suggested by the holotype. The segments are broader and shorter than those of *T. turbidum*, resembling *Ormoceras* more than *Deiroceras*. At a shell width of 30 mm., a segment of the siphuncle is 6 mm. long and expands from 6 mm. to 8 mm. within the camera. Annulosiphonate deposits are typical of the actinoceroids but have not been observed in advanced stages of development.

The internal mold shows on the surface subangular longitudinal ridges with broader concave interspaces. No surface markings are shown on our specimens. Foerste (1928) among a series of specimens most or all of which apply to this species, which he considered at *T. turbidum*, described longitudinal surface markings on the surface of the shell. He reports faint alternating ribs and very fine alternating striæ and liræ, 9 to 11 in a width of 1 mm.

Discussion.—This species is differentiated from *T. turbidum* by the broader segments of the siphuncle, shorter cameræ, and more numerous longitudinal ridges or corrugations of the shell surface. Three specimens of this form are among our material. The holotype is of uncertain horizon and locality and was labeled "Maysville, Cincinnati." Of the two remaining specimens, one is from the Mount Hope of Rice Street, Cincinnati, and the other was collected by the writer from a layer about a foot above the Mount Hope graptolite bed, which lies some distance below the *Strophomena* bed which marks the base of the Fairmount. This specimen is from Stone Lick Creek.

Types.—Holotype, Univ. of Cincinnati, No. 22456. Hypotype, No. 22648.

Occurrence.—Mount Hope beds, from Cincinnati, at Rice Street and Stone Lick Creek. An isolated siphuncle indicates the presence of this species in the Fairmount of Cincinnati. The specimen described below suggests that the species may persist into the Bellevue.

Troedssonoceras cf. multiliratum Flower Plate 50, figs. 1, 2

Under this name is described one specimen represented only by an external mold. This represents a portion of a shell 140 mm. long expanding from a width of 37 mm. to one of 52 mm., and is possibly somewhat widened as the result of distortion. No features of the phragmocone are preserved. However, the surface is preserved, showing fine details with unusual clarity in some regions.

The ridges are fairly closely spaced, four occurring in a width of 10 mm. near the base of the specimen. Adorally where the surface is clearest, four ridges occupy a width of 14 mm., but between them secondary narrower and slightly weaker ridges have developed. This part of the shell evidently represents gerontic ornamentation. The entire surface of the shell, the surface of the ridges as well as the interspaces, is marked with fine closely spaced longitudinal liræ and striæ. Near the adoral end of the shell rather obscure lines of growth are also evident.

Discussion.—This specimen shows adapically the type of spacing of the ridges characteristic of *T. multiliratum*, known formerly only from internal molds representing parts of phragmocones. The features in which it differs from *T. multiliratum* are probably not significant. Unfortunately no specimens which have been placed in *T. multiliratum* can be compared closely because they fail to show a late growth stage of the shell, and also because they are internal molds which fail to preserve the fine longitudinal liræ of the surface. This specimen fails also to show the proportions of the cameræ and of the siphuncle, by which *T. multiliratum* can be separated very readily from other species of *Troedssonoceras*, for in this species alone the segments of the siphuncle are short, broad and rounded.

As in the present state of our knowledge this specimen may represent only a part of the shell and a phase of preservation of *T. multiliratum* not previously observed, I have referred it to that species tentatively. However, until other and more complete specimens are found in the same horizon, which are more comparable to typical *T. multiliratum*, the specific identity of this form must remain in doubt.

Type.—Holotype, Univ. of Cincinnati Museum, No. 24463.

Occurrence.—Bellevue strata, English Homes, Western Boulevard, Cincinnati. Collected by Dr. K. E. Caster.

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PLATES

Except where otherwise indicated, figures are natural size.

PLATE 1 (3)

EXPLANATION OF PLATE 1 (3)

(Annulated Orthoceracones)

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1.	**Gorbyoceras duncanæ** Flower, n. sp. Paratype, transverse longitudinal section; ×1. Lower Whitewater, Little Four Mile Creek, Oxford quad., Ohio. Shideler Coll.	156
2, 3.	**Gorbyoceras hammelli** (Foerste) Hypotypes. 2. Vertical section; ×1. Saluda beds, probably Hitz layer, Madison, Ind. Univ. of Cincinnati, No. 24166. 3. Early stage; ×2. Hitz layer, Madison, Ind. Univ. of Cincinnati, No. 24164.	151
4, 5.	**Gorbyoceras, sp. aff. calvini** (Foerste) 4. Exterior; ×1. 5. Enlargement showing division of primary longitudinal liræ. Univ. of Cincinnati, No. 24090. Lower Whitewater horizon, McDill's Mills, Oxford quad., Ohio. Shideler Coll.	158
6.	**Gorbyoceras duncanæ** Flower, n. sp. Paratype, Univ. of Cincinnati, No. 24087. Vertical section; dorsum incomplete. Lower Whitewater horizon or possibly upper Liberty, railroad cuts, Weisburg, Ind.	156
7.	**Gorbyoceras crossi** Flower, n. sp. Section of adapical portion of holotype; ×1. Univ. of Cincinnati, No. 23084. Saluda beds, Versailles, Ind.	149
8.	**Gorbyoceras simile** Flower, n. sp. Holotype; ×1. Lower Whitewater beds, Little Four Mile Creek, Oxford quad., Ohio. Shideler Coll.	160
9.	**Gorbyoceras hammelli** (Foerste) Hypotype; ×1. Shideler Coll. Saluda beds, Big Sains Creek. Laurel, Ind.	151
10.	**Anaspyroceras williamsæ** Flower, n. sp. Paratype, Shideler Coll. Lower Whitewater horizon, Little Four Mile Creek, Oxford quad., Ohio.	141

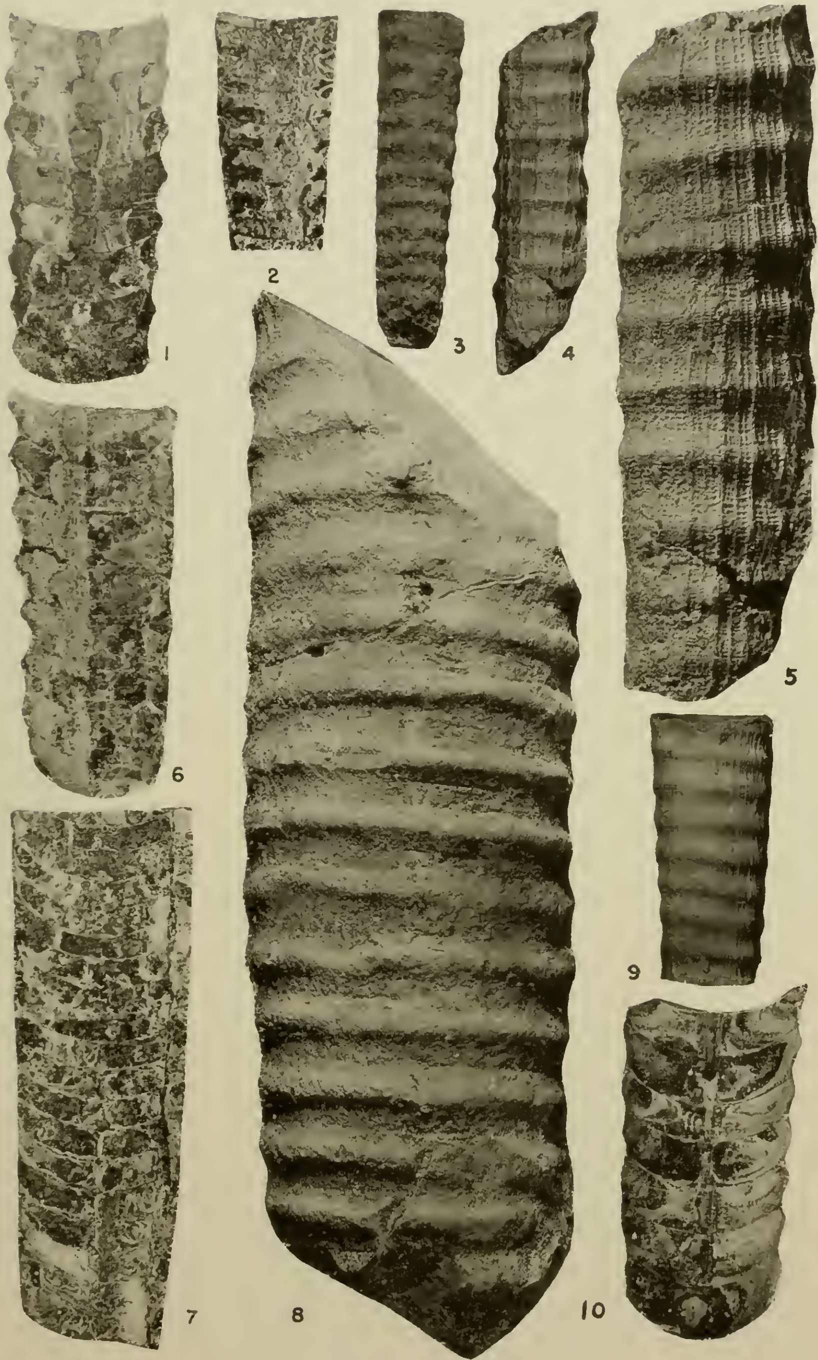
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PLATE 2 (4)

EXPLANATION OF PLATE 2 (4)

(Annulated Orthoceracones)

Figure Page

1, 9, 10. **Gorbyoceras gorbyi** (Miller) 145
Hypotype, Shideler Coll., basal Whitewater horizon, Little Four Mile Creek, Oxford, Ohio; ×1. Section from apical end of specimen. 9. Lateral view. 10. Concave side of same specimen.

2, 3. **"Spyroceras" bilineatum-frankfortense** Foerste 137
Holotype. 2. Enlarged. 3. Natural size. Beds of Curdsville age, Crow distillery, south of Frankfort, Ky. (After Foerste.)

4. **Gorbyoceras crossi** Flower, n. sp. 149
Paratype, Shideler Coll. Portion of surface from near aperture of specimen shown on Pl. 3, fig. 6. Gerontic ornament.

5. **Gorbyoceras hammelli** (Foerste) 151
Siphuncle, early stage; ×1. Shideler Coll. Saluda beds, Madison, Ind.

6. **"Spyroceras,"** sp. 139
Only specimen known from the Fulton. From Twelve Mile Creek, Cincinnati. Univ. of Cincinnati, No. 23907.

7. **Gorbyoceras crossi** Flower, n. sp. 149
Holotype; ×1. Same specimen as Pl. 1, fig. 7. Saluda, Versailles, Ind. Univ. of Cincinnati, No. 24083.

8. **Anaspyroceras williamsæ** Flower, n. sp. 141
Holotype; ×1; ventral (?) aspect. Lower Whitewater beds, Flat Fork Creek, Univ. of Cincinnati, No. 24089.

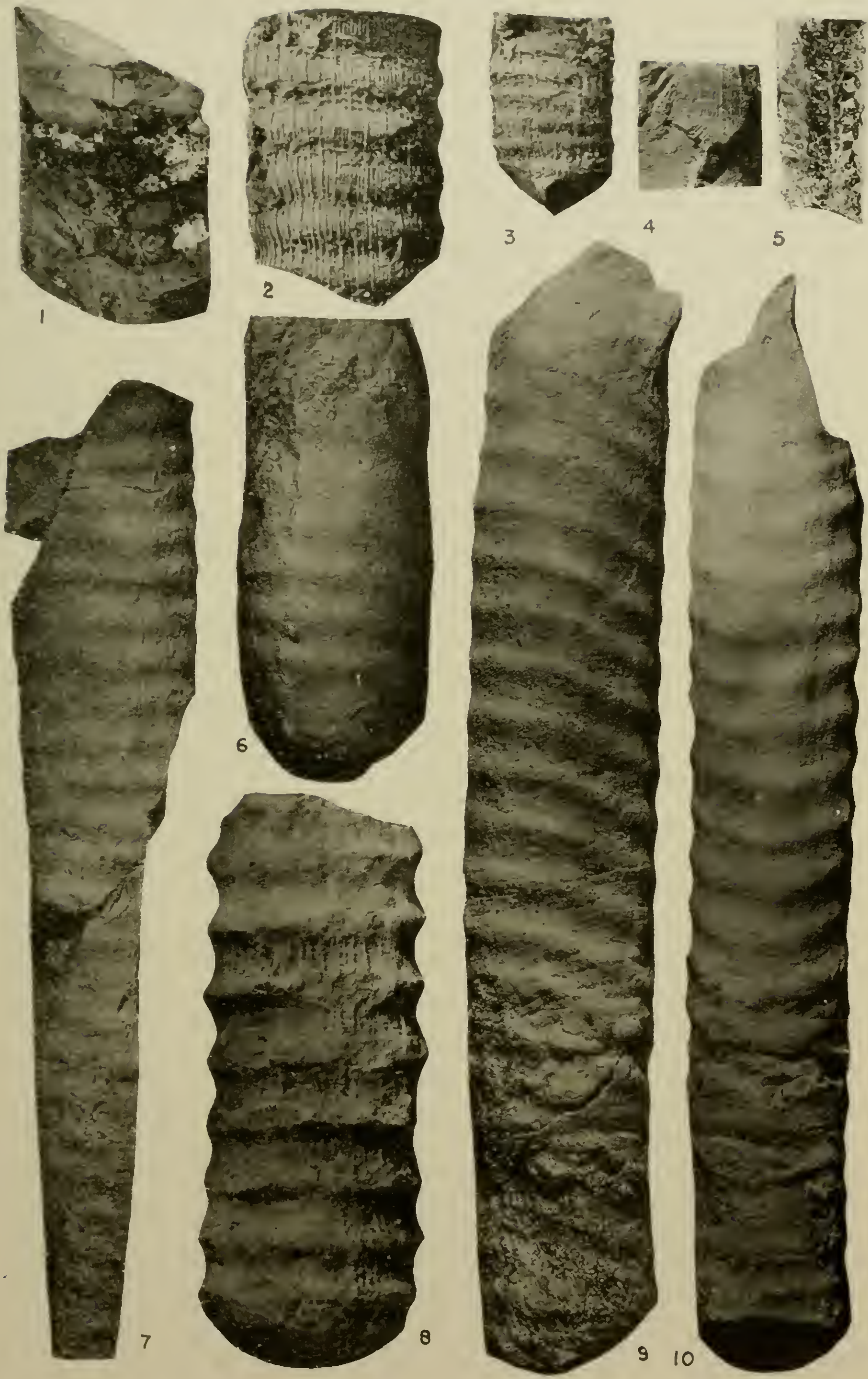
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PLATE 3 (5)

EXPLANATION OF PLATE 3 (5)

(Annulated Orthoceracones)

Figure | Page

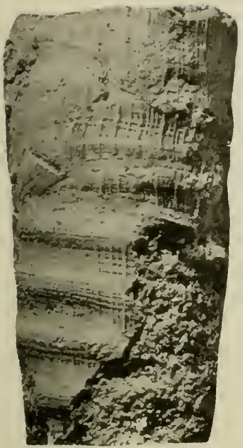
1. **Gorbyoceras hammelli (Foerste)** 151
   Hypotype, Univ. of Cincinnati, No. 24166. Surface markings, ×2, showing exceptional development of transverse markings and surface irregularities. Same specimen as Pl. 1, fig. 2.

2, 3. **Anaspyroceras williamsæ Flower, n. sp.** 141
   Holotype, Univ. of Cincinnati, No. 24089. Lower Whitewater, Flat Fork Creek. 2. Enlargement of one interspace showing ornament. 3. Lateral aspect, natural size.

4. **Gorbyoceras hammelli (Foerste)** 151
   Hypotype, Univ. of Cincinnati, No. 24165, Saluda of Canaan, Ind.; showing typical ornament of a relatively large shell; ×2.

5. **Gorbyoceras crossi Flower, n. sp.** 149
   Paratype, Shideler Coll., Hitz layer, Saluda, Madison, Ind.

6. **Gorbyoceras crossi Flower, n. sp.** 149
   Largest specimen observed, a living chamber with a faint adoral contraction. Slightly reduced. Shideler Coll. Saluda beds, 3 miles west of Cross Plains, Ind.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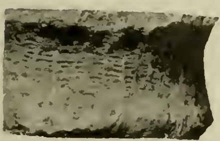
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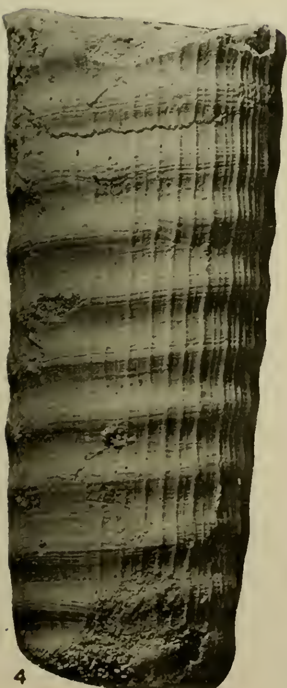
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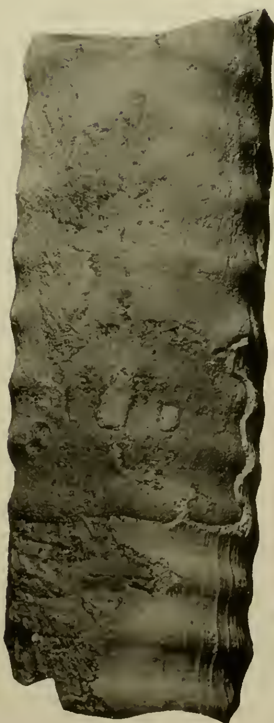
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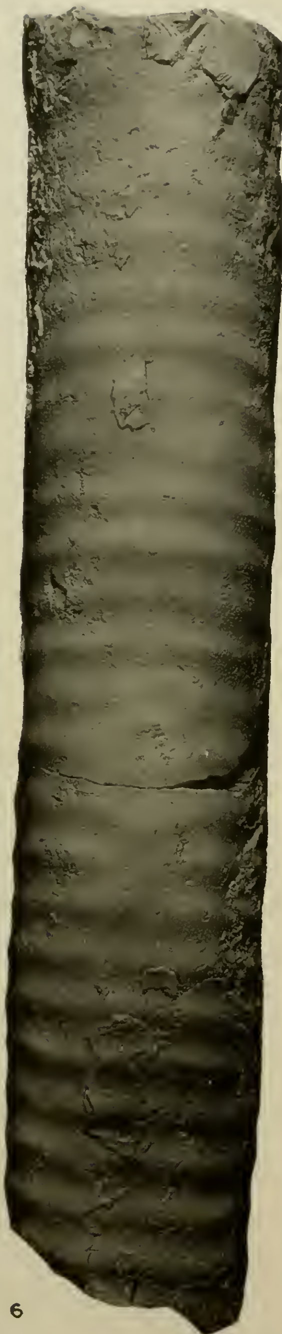
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PLATE 4 (6)

EXPLANATION OF PLATE 4 (6)

(Annulated Orthoceracones)

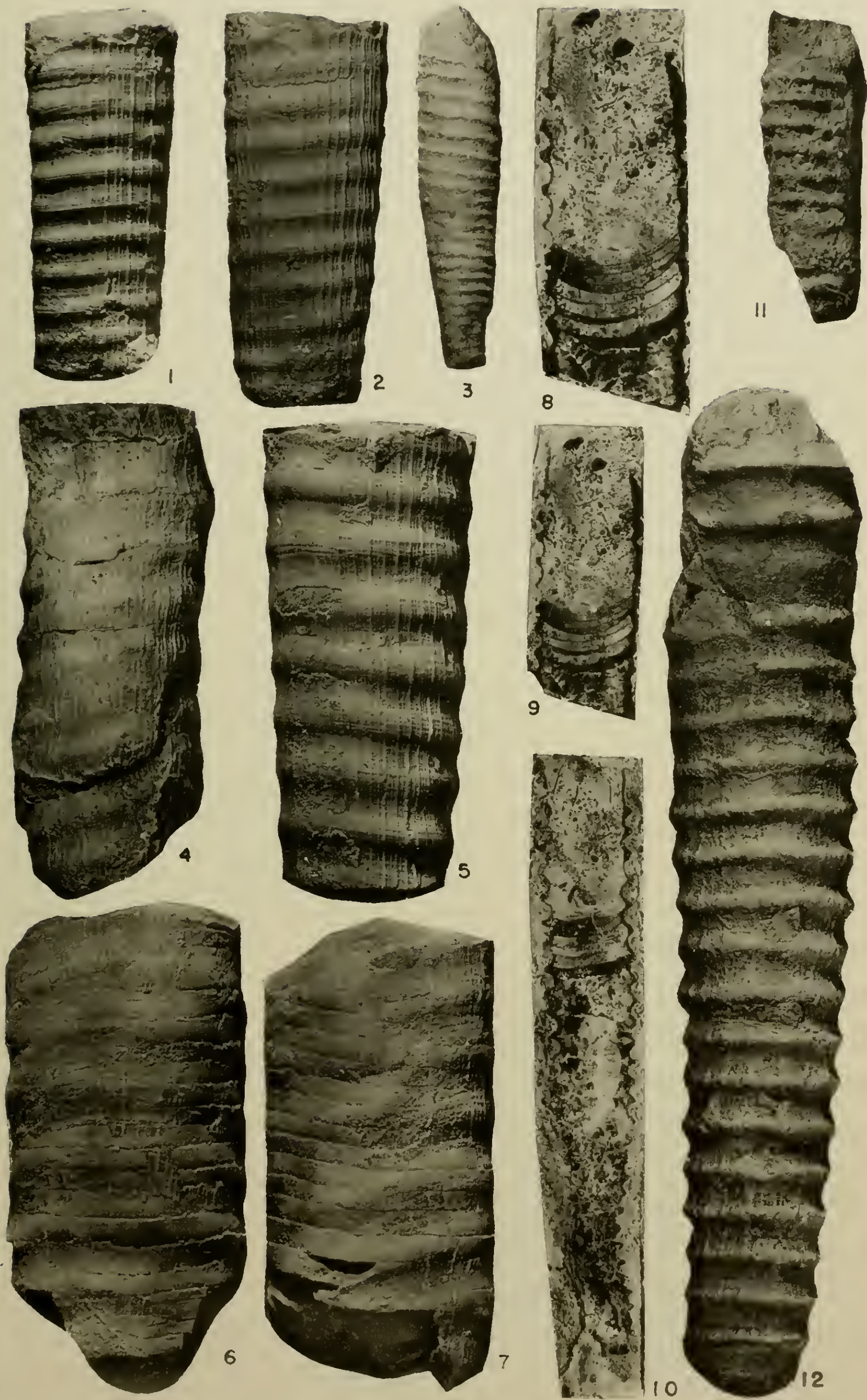
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PLATE 5 (7)

Explanation of Plate 5 (7)

(Annulated Orthoceracones; Mixochoanites)

Figure | Page

1. **Schuchertoceras distinctum** Flower, n. sp. 200
   Holotype, Shideler Coll., lateral aspect; ×1. Saluda beds, near Oxford, Ohio.

2, 3. **Gorbyoceras curvatum** Flower, n. sp. 159
   Holotype: 2. Lateral aspect; ×1. 3. Vertical section from base of type, enlarged. Univ. of Cincinnati, No. 24088. Fort Ancient member, Waynesville, near Clarkesville, Ohio.

4, 9. **Gorbyoceras hammelli** (Foerste) 151
   4. Most complete mature portion known; ×1. Univ. of Cincinnati. Saluda beds, Canaan, Ind. 9. Original figure of holotype (after Foerste) Hitz layer, Hanover, Ind.

5. "**Spyroceras**" **mcfarlani** Foerste 138
   Perryville formation, south of Frankfort, Ky. Holotype, U. S. National Museum, No. 87115. (After Foerste.)

6-8. **Ecdyceras foerstei** Flower, n. sp. 190
   Holotype, Shideler Coll. 6. Ventral view. 7. Lateral view. 8. Dorsal view. Arnheim formation, Lebanon, Ky.

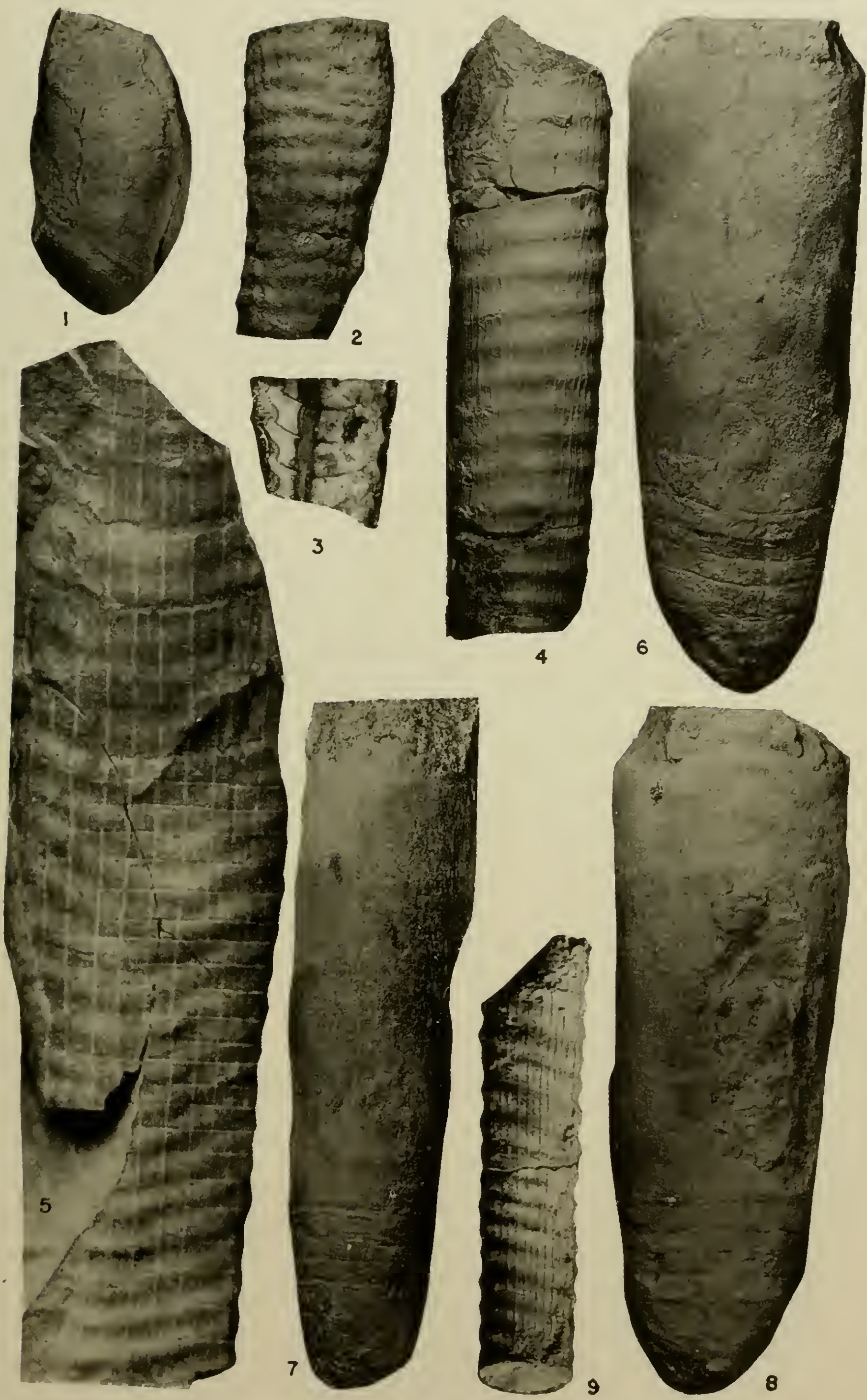
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PLATE 6 (8)

EXPLANATION OF PLATE 6 (8)

(Mixochoanites)

Figure		Page
1-3.	**Schuchertoceras discretum var. minor** Flower, n. var. Holotype; ×1, Shideler Coll. 1. Vertical section, dorsum on left. 2. Exterior, dorsum on left. 3. Dorsal view. Lower Whitewater horizon, Little Four Mile Creek, near Oxford, Ohio.	205
4, 5.	**Schuchertoceras obscurum** Flower, n. sp. Holotype, Shideler Coll.; ×1. 4. Lateral aspect, dorsum on right. 5. Ventral aspect. Dry fork of Elk Creek, Jacksonburg, Ohio. In the lower part of the Blanchester division of the Waynesville.	202
6.	**Probillingsites lebanonensis** Flower, n. sp. Dorsal aspect of the larger of the two specimens; referred to this species with doubt. Arnheim, from Lebanon, Ky.	193
7, 8.	**Probillingsites oxfordensis** Flower, n. sp. Holotype, Shideler Coll.; ×1. 6. Lateral aspect, dorsum at left. 7. Dorsal aspect. Lower Whitewater horizon, Little Four Mile Creek, near Oxford, Ohio.	196
9.	**Schuchertoceras cf. prolongatum** (Foerste) Univ. of Cincinnati, No. 24209. Lateral aspect; ×1. Shera farm, near Oxford, Ohio, Saluda beds.	207
10, 11.	**Schuchertoceras prolongatum** (Foerste) Holotype, Shideler Coll. 10. Lateral aspect, dorsum on left. 11. Dorsal aspect. Upper Elkhorn, near Hamburg, Ind.	207

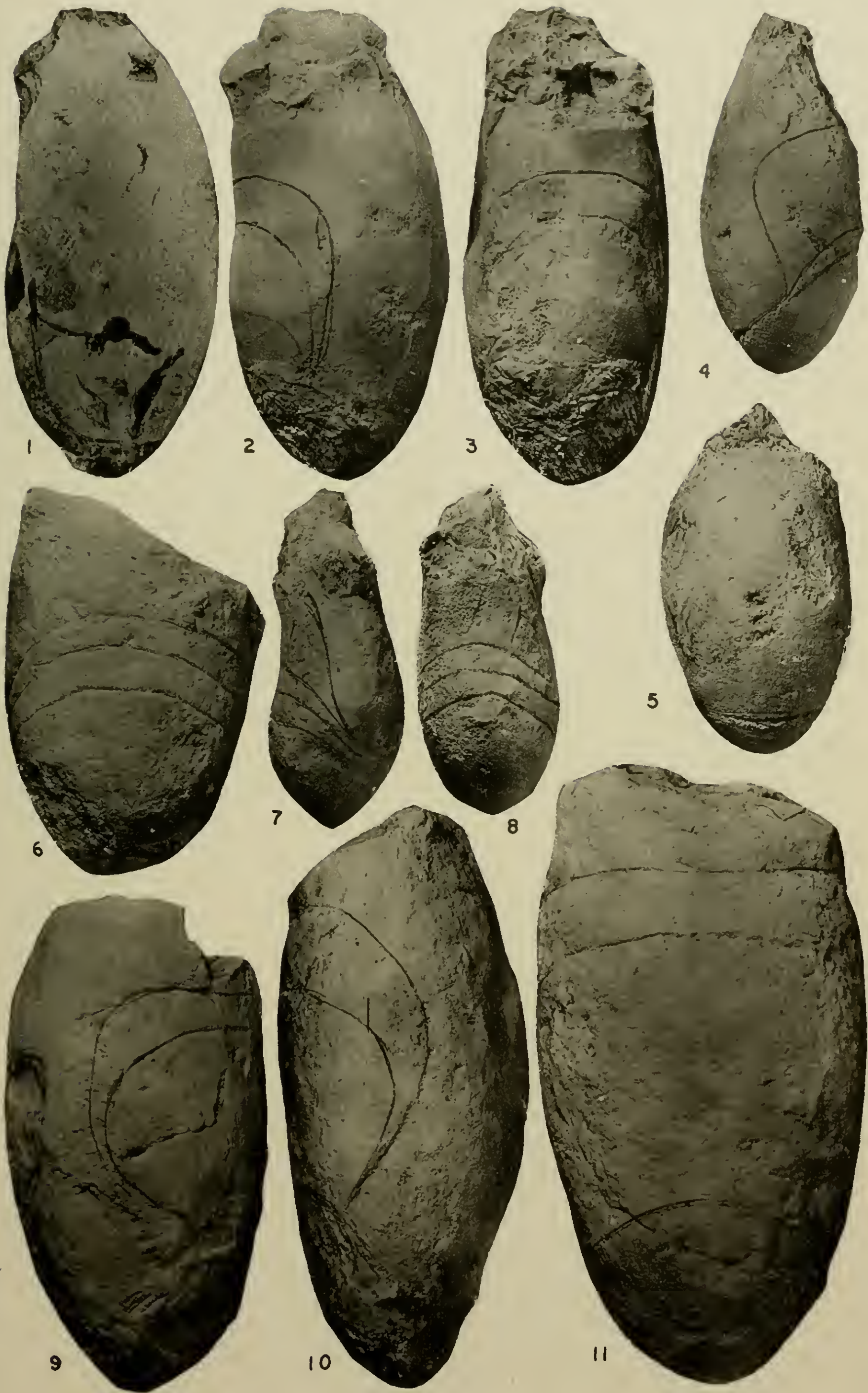
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PLATE 7 (9)

EXPLANATION OF PLATE 7 (9)

(Mixochoanites)

Figure | Page

1, 2. **Schuchertoceras rotundum** Flower, n. sp. 210
Holotype; ×1. 1. Dorsal aspect. 2. Lateral aspect, venter on right. Shideler Coll. Upper Whitewater, McDill's Mills, Little Four Mile Creek, Oxford quad., Ohio.

3, 4. **Schuchertoceras geniculatum** Flower, n. sp. 209
Holotype, Shideler Coll.; ×1. 3. Ventral aspect. 4. Lateral aspect, dorsum on left. Upper Whitewater horizon, Beasley Creek, near Camden, Ohio.

5-7. **Probillingsites oxfordensis** Flower, n. sp. 196
Paratype, Shideler Coll.; ×1. 5. Ventral view. 6. Lateral view, dorsum on left. 7. Dorsal view. Blanchester member of Waynesville, Stony Hollow, Clarkesville, Ohio.

8, 9. **Probillingsites faberi** Flower, n. sp. 197
Holotype, Univ. of Cincinnati, No. 24208. 8. Lateral aspect, venter on left. 9. Dorsal aspect. Lower Whitewater horizon, Little Four Mile Creek, near Oxford, Ohio.

10, 11. **Schuchertoceras discretum** (Foerste) 204
Holotype, Shideler Coll.; ×1, 10. Lateral view, dorsum on left. 11. Dorsal aspect. Lower Whitewater horizon, Little Four Mile Creek, near Oxford, Ohio.

12-14. **Probillingsites lebanonensis** Flower, n. sp. 193
Holotype; ×1, Shideler Coll. 12. Ventral view. 13. Lateral aspect, dorsum on left. 14. Dorsal aspect. Arnheim formation, near Lebanon, Ky.

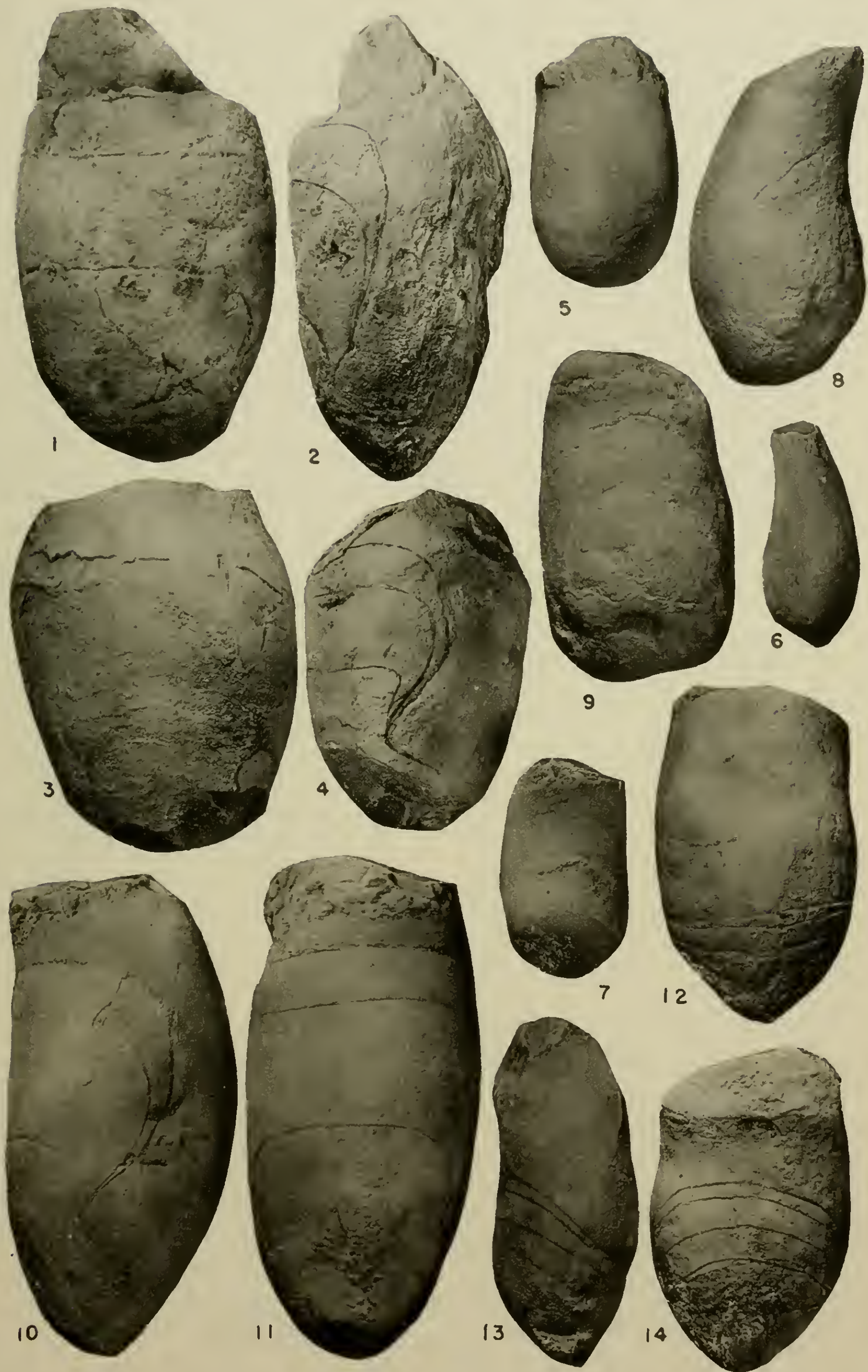
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PLATE 8 (10)

EXPLANATION OF PLATE 8 (10)

(Covington Cyrtoconic Cephalopods)

Figure	Page
1. **Faberoceras multicinctum** Flower, n. sp. Holotype, vertical section; ×1. Univ. of Cincinnati, No. 24210. Leipers formation, Cumberland River near Belk I., Ky. Shows ontogenetic change in form of siphuncle segments, also traces of endocones at base of section.	468
2. **Faberoceras saffordi** Paratype, ventral aspect; ×1. Shideler Coll. Cathys limestone, Williamsport, Tenn. See Pl. 17, fig. 15. for ventral view.	459
3. **Danoceras crater** Flower, n. sp. Section of siphuncle, ground from ventral side, about ×2, Holotype, Univ. Cincinnati, No. 24225. Leipers formation, Rowena, Ky.	421
4. **Faberoceras percostatum** Flower, n. sp. Vertical section from base of holotype, Univ. of Cincinnati, No. 24214; ×1. Leipers formation, Rowena, Ky.	463
5. **Faberoceras saffordi** Foerste, n. sp. Paratype, vertical section; ×1, U. S. National Museum. Cathys limestone, east of Franklin, Tenn.	459


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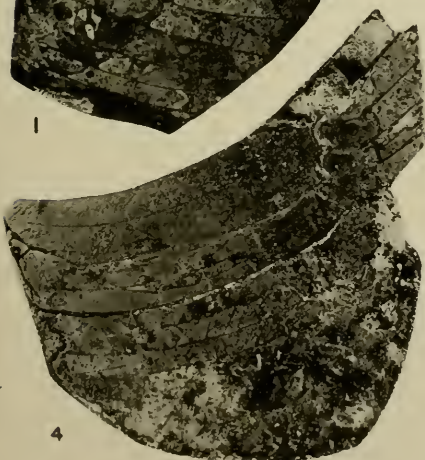
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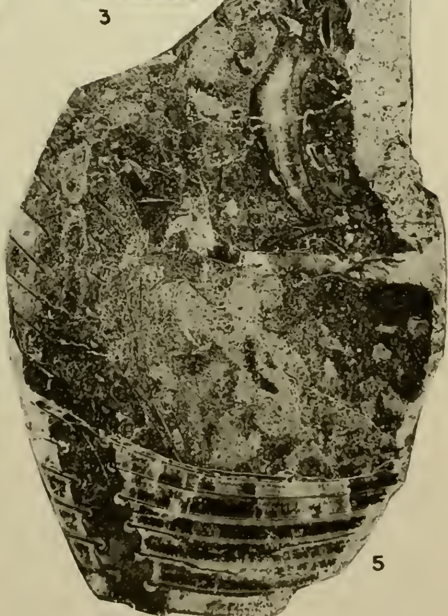
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PLATE 9 (11)

EXPLANATION OF PLATE 9 (11)

(Covington Cyrtoconic Cephalopods)

Figure | Page

1. **Westonoceras ventricosum** (Miller) 441
Paratype, Univ. of Cincinnati, No. 105. Adapical view of septum. Southgate member, Eden; Columbia Ave., Cincinnati. (See Pl. 14.)

2. **Faberoceras multicinctum** Flower, n. sp. 468
Paratype; ×1, Univ. of Cincinnati, No. 24211. Leipers formation, Cumberland River, near head of Belk I., Ky.

3-5. **Vaupelia russelli** Flower, n. sp. 480
Holotype, No. 24226, Univ. of Cincinnati. 3. Ventral view. 4. Lateral view. 5. Dorsal view. Fairmount beds, Bald Knob, Cincinnati, Ohio.

6, 7. **Vaupelia seiberti** Flower, n. sp. 482
Holotype, Univ. of Cincinnati, No. 24227. 6. Ventral view. 7. Lateral view. Mount Hope beds, Rapid Run, Cincinnati, Ohio.

8. **Diestoceras bettinæ** Flower, n. sp. 414
Holotype, Univ. of Cincinnati, No. 24230. Fairmount beds, Cincinnati, Ohio.

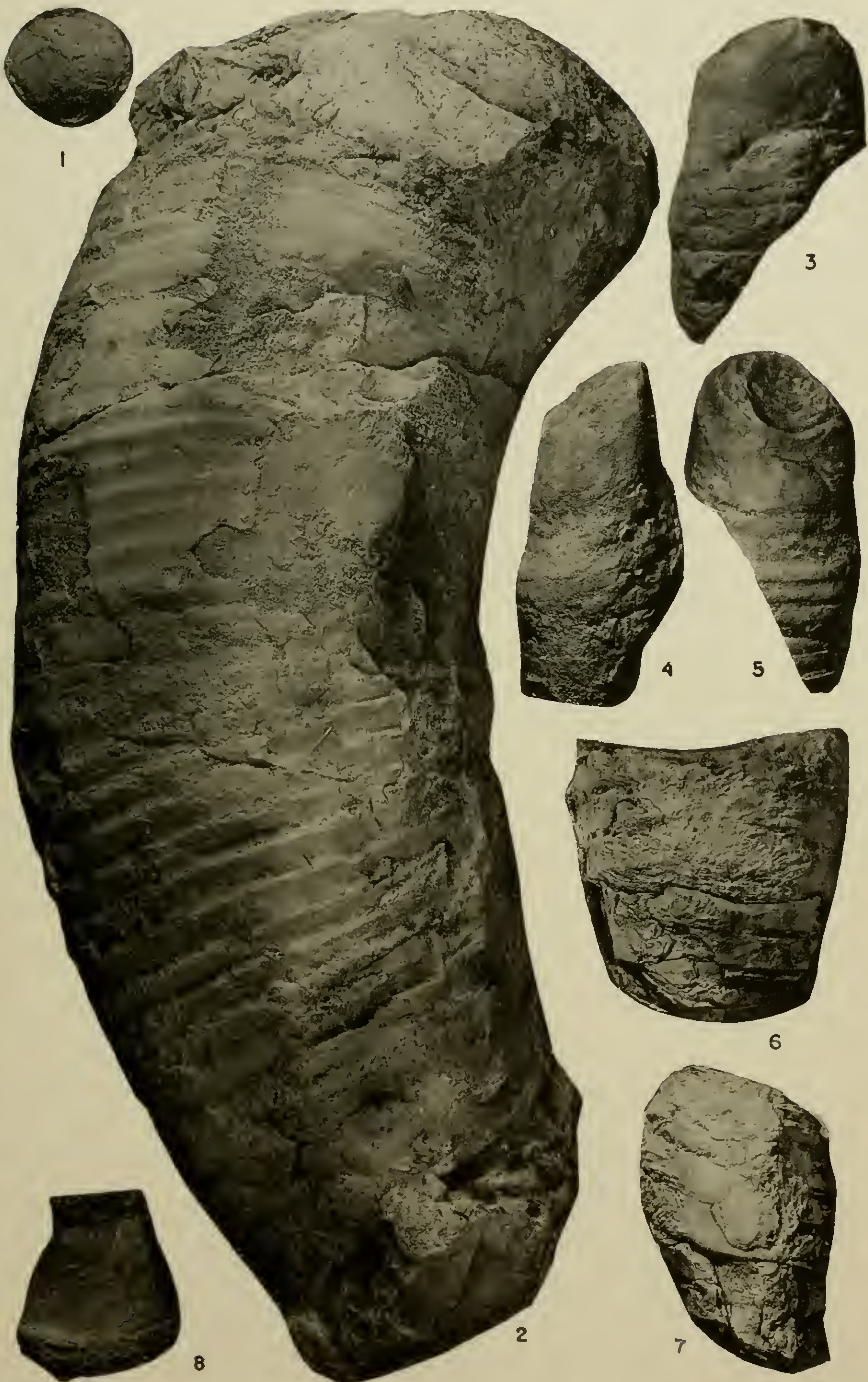

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PLATE 10 (12)

EXPLANATION OF PLATE 10 (12)

(Leipers Cyrtocones)


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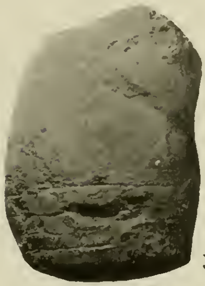
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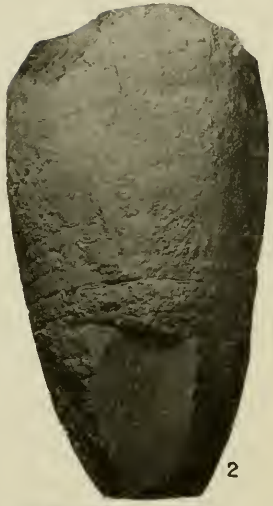
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PLATE 11 (13)

EXPLANATION OF PLATE 11 (13)

(Westonoceratidæ and Oncoceratidæ)


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PLATE 12 (14)

EXPLANATION OF PLATE 12 (14)

(Faberoceras)

Figure | Page

1, 4. **Faberoceras elegans** Flower, n. sp. 472
Holotype, Univ. of Cincinnati, No. 22860. 1. Vertical section, slightly greater than ×1. 4. Exterior, lateral aspect; ×1. Corryville beds, Cincinnati, Ohio.

2. **Faberoceras saffordi** 459
Paraytpe, vertical section (see Pl. 8, fig. 5) of siphuncle, about ×2.2. Cathys formation, east of Franklin, Tenn.

3. **Faberoceras multicinctum** Flower, n. sp. 468
Paratype, Shideler Coll. Leipers formation, Cumberland River, 2 miles above Wolf Creek, Ky.

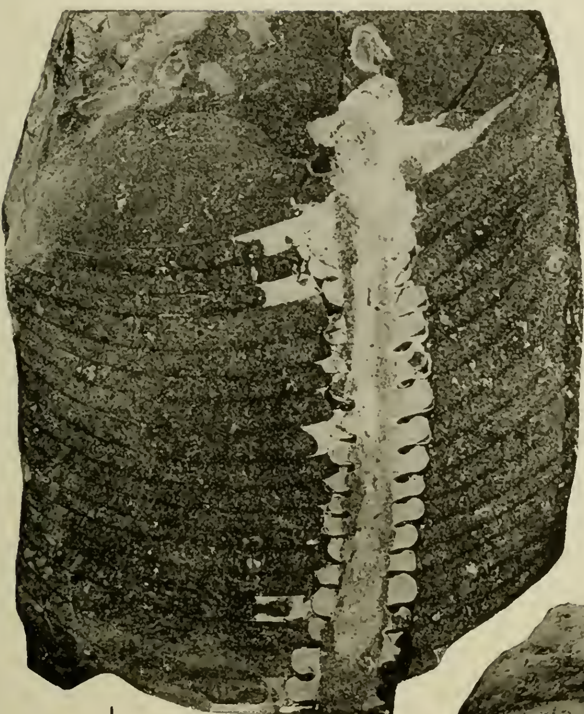

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PLATE 13 (15)

EXPLANATION OF PLATE 13 (15)

(Faberoceras Oonoceras)

Figure Page

1. **Oonoceras curviseptatum** Flower, n. sp. 305
Holotype, Univ. of Cincinnati, No. 23972. Cynthiana limestone, probably from Ohio River near Cincinnati.

2. **Faberoceras percostatum** Flower, n. sp. 463
Holotype, Univ. of Cincinnati, No. 24214. Ventral aspect; ×1. Leipers formation, Rowena, Ky. (See Pl. 14, fig. 6.)

3. **Faberoceras magister** (Miller) 461
Holotype, lateral aspect, ×1, Univ. of Cincinnati, No. 300. Southgate, Eden, from Columbia Ave., Cincinnati, Ohio.

4, 5. **Faberoceras sonnenbergi** Flower, n. sp. 455
4. Ventral view. 5. Lateral aspect. Paratype. Cynthiana limestone, Cynthiana, Ky.


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PLATE 14 (16)

EXPLANATION OF PLATE 14 (16)

(Covington Cyrtocones)

Figure Page

1, 2. **Danoceras cynthianense** Flower, n. sp. 420
Holotype, Shideler Coll. 1. Lateral view. 2. Ventral view. Cynthiana limestone, Cynthiana, Ky.

3, 4. **Westonoceras ventricosum** (Miller) 441
3. Ventral aspect of a crushed paratype, Univ. of Cincinnati, No. 105. Southgate, Eden, Columbia Ave. 4. Vertical section of same specimen, ×2½.

5. **Faberoceras magister** (Miller) 361
Siphuncle, from holotype, Univ. of Cincinnati, No. 300. From opposite side of specimen shown in Pl. 13, fig. 3.

6-8. **Kindleoceras kentuckiense** Flower, n. sp. 364
Holotype, Univ. of Cincinnati, No. 24077. 6. Adapical view. 7. Ventral view. 8. Lateral view, venter on right. Cynthiana limestone. Cynthiana, Ky.

9. **Faberoceras percostatum** Flower, n. sp. 463
Holotype, lateral aspect. Univ. of Cincinnati, No. 24214. Leipers formation. Rowena, Ky. (See Pls. 8, 11, 13.).


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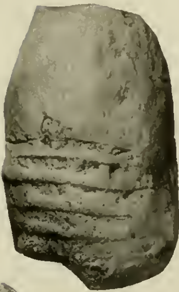
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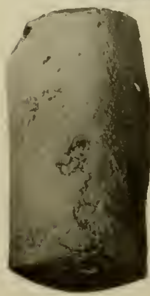
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PLATE 15 (17)

EXPLANATION OF PLATE 15 (17)

(Cynthiana and Covington Cyrtocones)


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PLATE 16 (18)

EXPLANATION OF PLATE 16 (18)

(Cynthiana and Covington Cyrtocones)

Figure Page

1. **Faberoceras shideleri** Foerste, n. sp. 471
   Paratype, Shideler Coll., vertical section. Leipers formation, Cumberland River, near Rowena, Ky.
2. **Oncoceras foerstei** Flower, n. sp. 253
   Vertical section, ×1, of phragmocone of holotype, showing three segments of the siphuncle. The phragmocone is crushed dorsally and encrusted with algæ. Univ. of Cincinnati, No. 24229. Leipers formation, Cumberland River at Rowena, Ky.
3. **Vaupelia seiberti** Flower, n. sp. 482
   Vertical section of holotype, venter on right. Univ. of Cincinnati, No. 24227. Mount Hope beds, Rapid Run, Cincinnati, Ohio.

4-6. **Reedsoceras mcfarlani** Flower, n. sp. 489
   Holotype. 4. Lateral aspect. 5. Ventral aspect. 6. Dorsal aspect. Univ. of Cincinnati, No. 23911. Cynthiana limestone, probably from the Ohio River near Cincinnati.

7. **Faberoceras sonnenbergi** Flower, n. sp. 455
   Enlargement, ×2½, of oblique section through siphuncle of paratype, Univ. of Cincinnati, No. 23908, showing annular phase of deposits within siphuncle. Cynthiana limestone, Cynthiana, Ky.

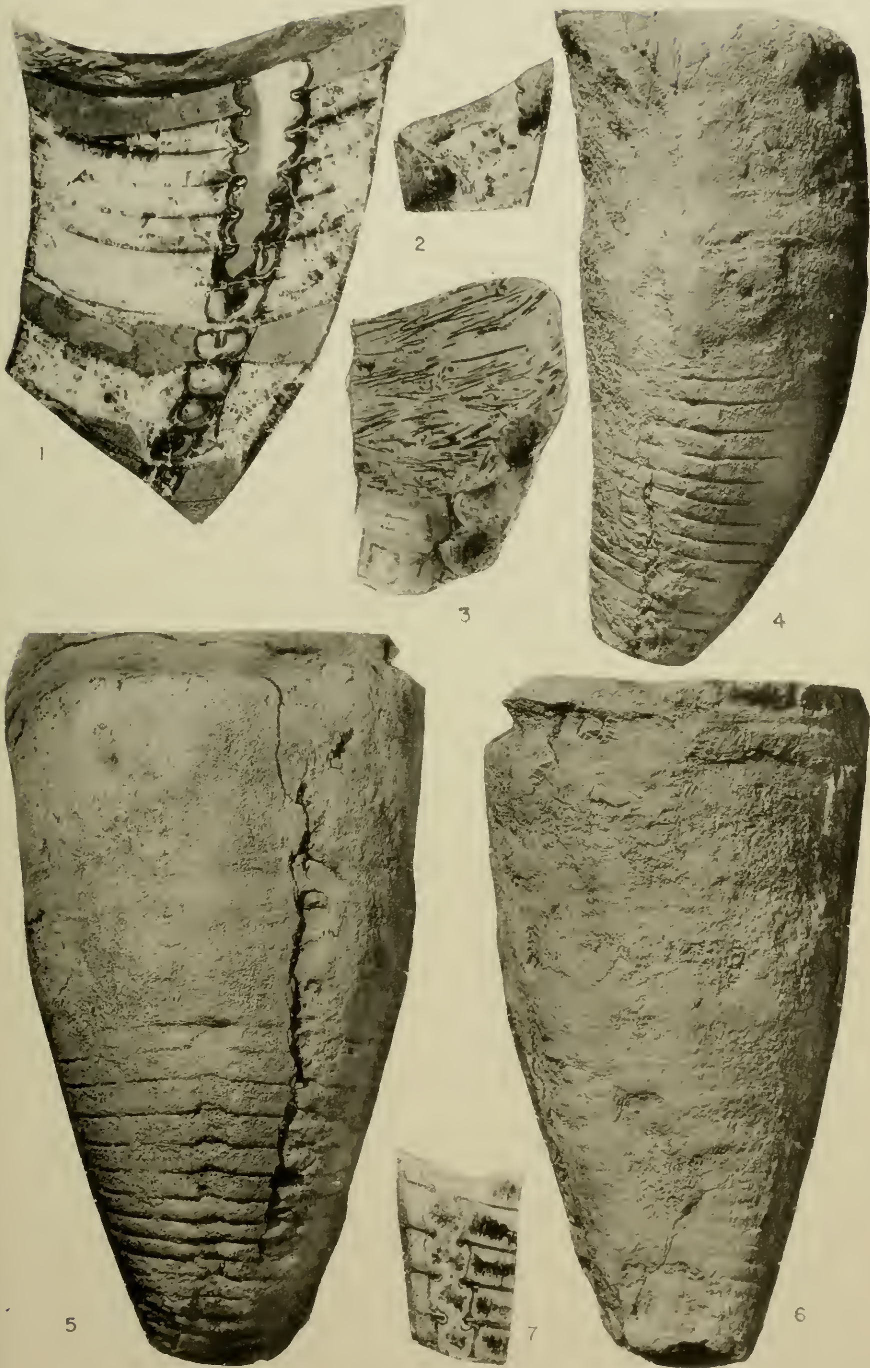
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PLATE 17 (19)

Explanation of Plate 17 (19)

(Bickmorites and Covington Cyrtoceracones)

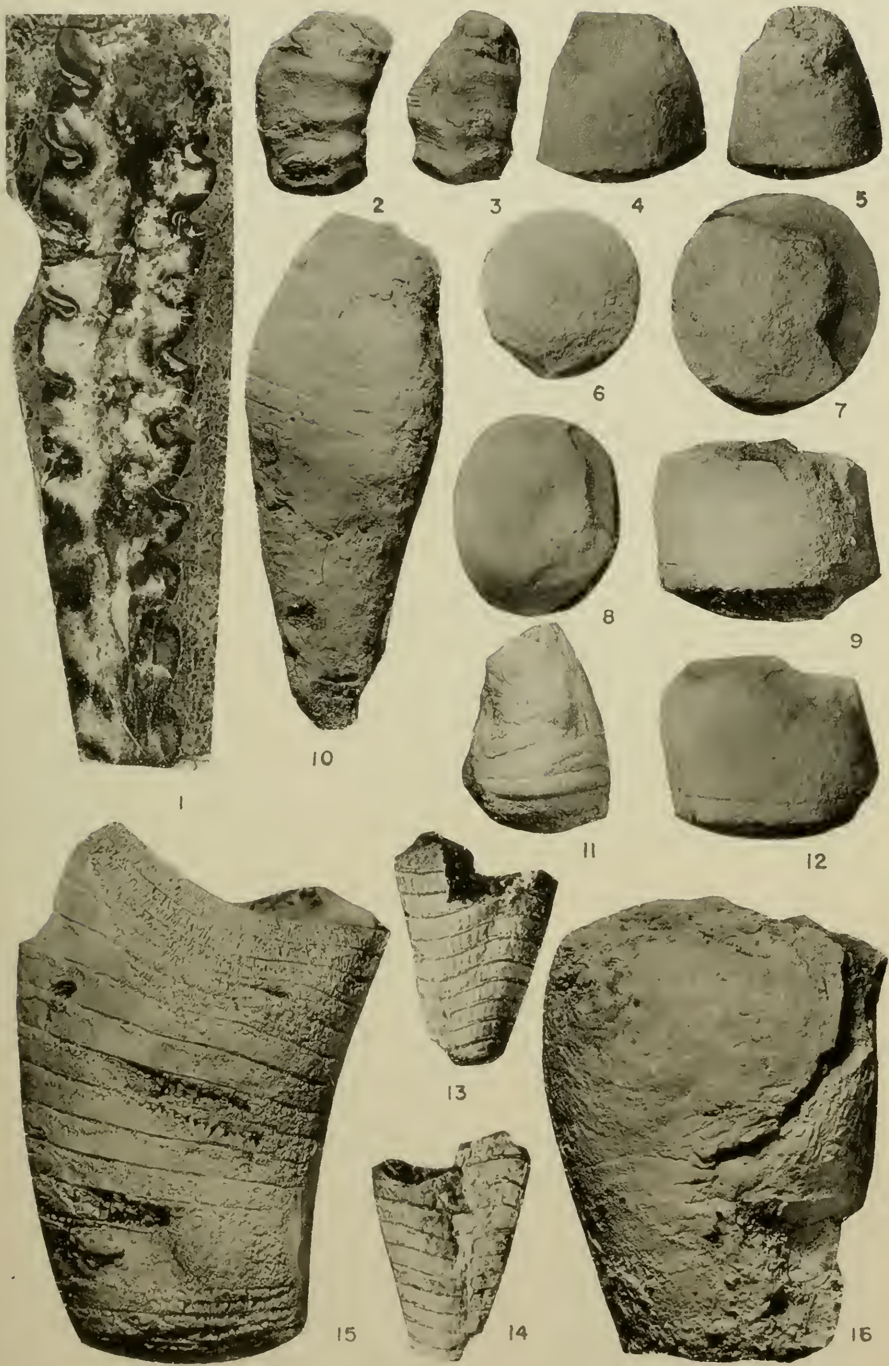
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PLATE 18 (20)

EXPLANATION OF PLATE 18 (20)

(Augustoceras)

Figure | Page

1-10. **Augustoceras shideleri** Flower, n. sp. 350
1. Paratype, lateral aspect (see also Pl. 19, fig. 14), Univ. of Cincinnati, No. 24291. 2. Dorsal aspect. 3. Lateral aspect. 4. Ventral aspect. Holotype, Univ. of Cincinnati, No. 24290. 5. Septum, from lower fourth of figs. 7-9. 6. Septum, from adoral end of same specimen. 7. Dorsal view. 8. Lateral view. 9. Ventral view. Paratype, Univ. of Cincinnati, No. 24292. Leipers formation, Rowena, Ky. 10. Paratype, thin section, vertical, through center of siphuncle showing actinosiphonate deposits. Univ. of Cincinnati. ×6.

11-13. **Augustoceras commune** Flower, n. sp. 353
Holotype, Shideler Coll. 11. Dorsal view. 12. Lateral view. 13. Ventral view. Leipers formation, Cumberland River, from exposures on the south side of the river near Belk I.

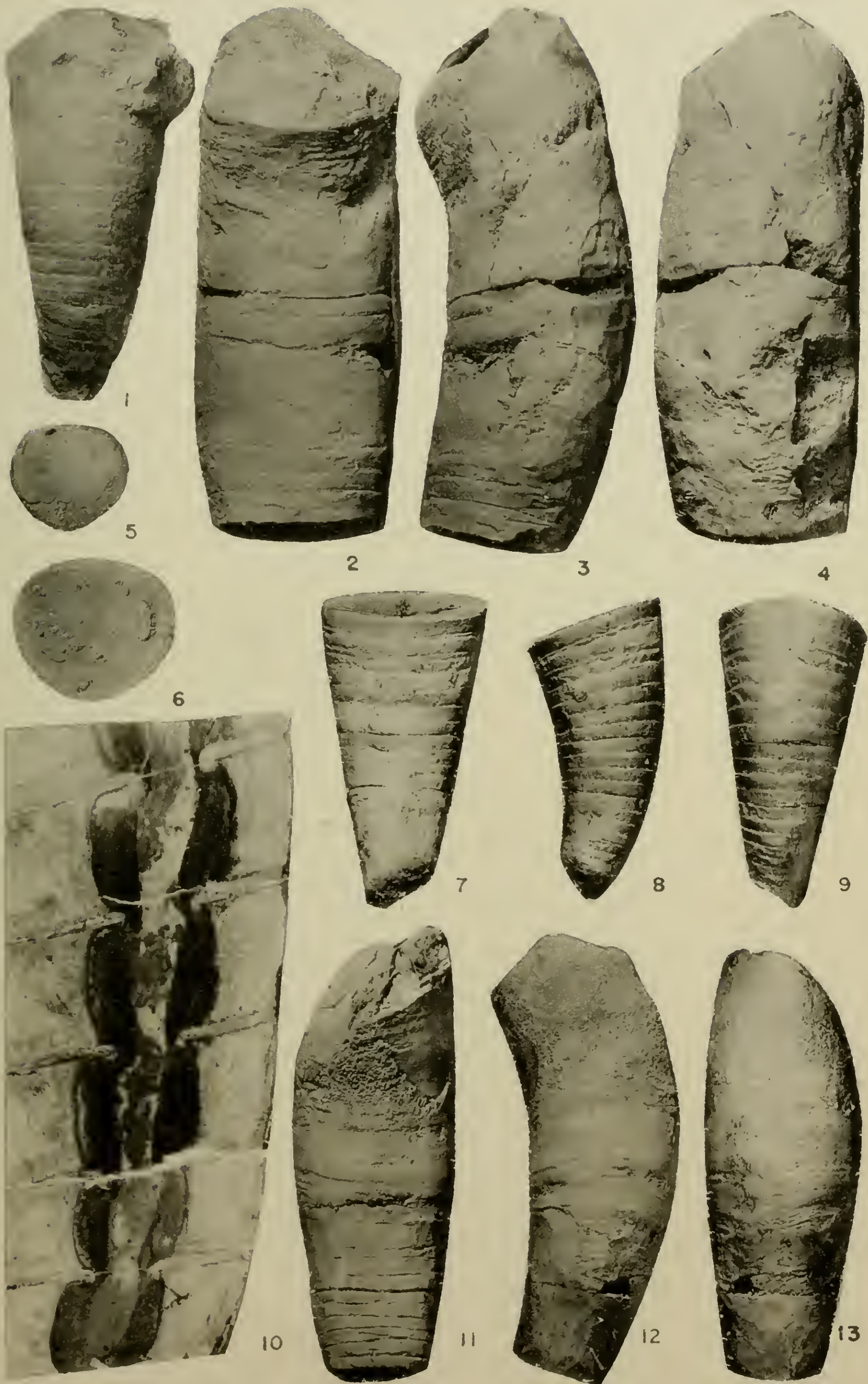
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PLATE 19 (21)

Explanation of Plate 19 (21)

(Augustoceras)

Figure | Page

1-4. **Augustoceras commune** Flower, n. sp. 353
1. Ventral view. 2. Lateral view. Paratype. Univ. of Cincinnati, No. 24284. 3. Paratype, lateral aspect of a portion of a phragmocone retaining portions of the surface of the shell, Univ. Cincinnati, No. 24285. 4. Paratype, lateral aspect of a typical specimen retaining the basal part of the living chamber, Univ. Cincinnati, No. 24283. All are from the Leipers formation, Rowena, Ky.

5-6. **Augustoceras minor** Flower, n. sp. 354
Holotype, a nearly complete but badly weathered individual. 5. Lateral aspect. 6. Ventral aspect. Univ. of Cincinnati, No. 24287. Leipers formation, Rowena, Ky.

7-9. **Rizoceras bellulum** Flower, n. sp. 321
7. Holotype, lateral aspect, venter on left, Shideler Coll. 8. Paratype, dorsal aspect, Univ. of Cincinnati, No. 24330. 9. Paratype, Shideler Coll., dorsal aspect. Lower Whitewater beds, Dodge's Creek, near Oxford, Ohio.

10. **Augustoceras shideleri** Flower, n. sp. 350
Vertical section through phragmocone. Paratype, Univ. of Cincinnati. Leipers formation, Rowena Ky. About ×3. (See also Pl. 20, fig. 6.)

11-13. **Augustoceras medium** Flower, n. sp. 352
Holotype. 11. Dorsal aspect. 12. Ventral aspect. 13. Lateral aspect. Univ. of Cincinnati, No. 24284. The middle of the phragmocone has been slightly restored. Leipers formation, Rowena, Ky.

14. **Augustoceras shideleri** Flower, n. sp. 350
Paratype, lateral aspect, Univ. of Cincinnati, No. 24291. Leipers formation, Rowena, Ky.


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PLATE 20 (22)

EXPLANATION OF PLATE 20 (22)

(Thin Sections of Siphuncles)

Figure		Page
1-7.	**Angustoceras shideleri** Flower, n. sp.	350

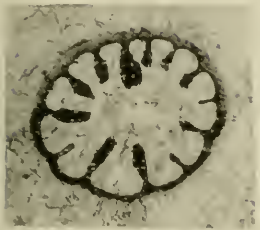
1-4. Selected cross sections. 1. Typical cross section. 2. Section showing differentiation of layers in the deposit. 3. Section taken close to the septal foramen, slightly oblique so that the lower side of the picture shows the section passing obliquely into the expanded part of the segment. 4. A section taken through the adoral part of the phragmocone in which the siphuncle is surrounded with and filled by matrix. This section shows an unusually irregular development of the rays. About ×14.

5. Longitudinal section showing the increase in prominence of the actinosiphonate deposits when traced orad. The section cuts all rays obliquely. About ×12.

6. Section passing close to the center of the siphuncle adorally, but near the edge adapically; ×6.

7. Longitudinal section passing nearly straight through the center of the siphuncle and cutting the rays on both the dorsum and venter throughout; ×12.

All sections are from the Leipers of Rowena, Ky. and are deposited in the University of Cincinnati Museum.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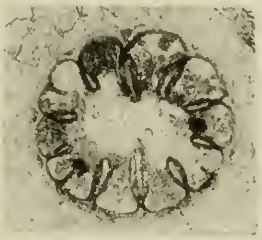
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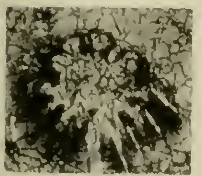
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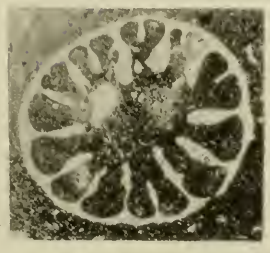
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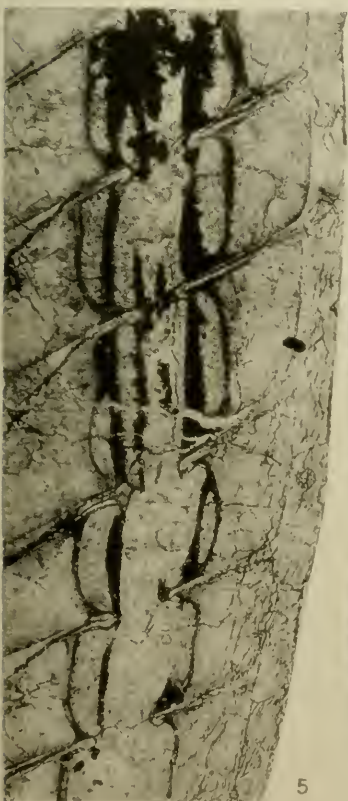
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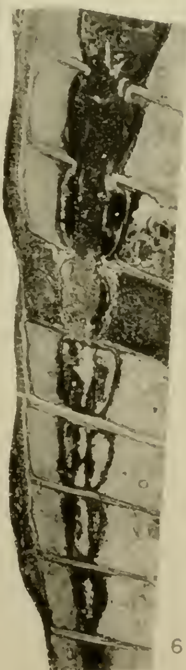
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PLATE 21 (23)

EXPLANATION OF PLATE 21 (23)

(Manitoulinoceras)

Figure Page

1-3. **Manitoulinoceras moderatum** Flower, n. sp. 380
Paratype, Shideler Coll. early portion of phragmocone. 1. Dorsal view. 2. Lateral view. 3. Ventral view. Saluda beds, Dodge's Creek, Oxford, Ohio.

4, 5, 10. **Manitoulinoceras erraticum** Flower, n. sp. 383
Holotype, Shideler Coll. 4. Lateral view, dorsum on left. 5. Dorsal view. 10. Ventral view. Upper Whitewater beds, Dodge's Creek, Oxford, Ohio.

6-8. **Manitoulinoceras ultimum** Flower, n. sp. 386
Holotype, Shideler Coll. 6. Lateral view. 7. Dorsal view. 8. Ventral view. Elkhorn formation, two miles west of Hamburg, Ind.

9, 15. **Manitoulinoceras moderatum** Flower, n. sp. 380
9. Section, ground from venter, of a distorted specimen referred to the species with doubt. Elkhorn beds, creek south of College Corners. Shideler Coll. 15. Section ground from venter of holotype; ×2. See Pl. 22.

11. **Manitoulinoceras tenuiseptum** (Faber) 376
Cross section from middle of paratype, Pl. 22, figs. 9-11. Waynesville beds, Clarkesville, Ohio.

12-14. **Manitoulinoceras gyroforme** Flower, n. sp. 382
Holotype, Shideler Coll. 12. Ventral view. 13. Lateral view. 14. Dorsal view. Saluda beds, small tributary of Indian Creek, near Oxford, Ohio.


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PLATE 22 (24)

EXPLANATION OF PLATE 22 (24)

(Manitoulinoceras)


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PLATE 23 (25)

EXPLANATION OF PLATE 23 (25)

(Manitoulinoceras)


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PLATE 24 (26)

EXPLANATION OF PLATE 24 (26)

(Kindleoceras and Staufferoceras)

Figure		Page
1-4.	**Kindleoceras cumingsi** Flower, n. sp. Holotype, Shideler Coll. 1. Ventral view. 2. Lateral view. 3. Dorsal view. Paratype. 4. Ventral view, a portion of a living chamber showing growth lines and traces of the hyponomic sinus. Shideler Coll. Both are from the upper part of the Saluda, at Cooper's Falls, 5 miles south of Versailles, Ind.	366
5-7.	**Staufferoceras subtriangulare** Foerste, n. sp. Holotype. Shideler Coll. 5. Ventral view. 6. Lateral view. 7. Dorsal view. Lower Whitewater beds, Little Four Mile Creek, near Oxford, Ohio.	390
8, 9.	**Kindleoceras equilaterale** Foerste, n. sp. Holotype, Shideler Coll. 8. Lateral view. 9. Dorsal view. Saluda beds, 3/4 mi. north of Mixerville, Ind.	367
10, 11.	**Kindleoceras rotundum** Flower, n. sp. Holotype, Shideler Coll. 10. Lateral aspect. 11. Ventral aspect. Saluda beds above the *Tetradium* zone, Big Sains Creek, 2½ mi. southwest of Laurel, Ind.	365


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PLATE 25 (27)

EXPLANATION OF PLATE 25 (27)

(Wetherbyoceras, Augustoceras, and Shideleroceras)

Figure | Page

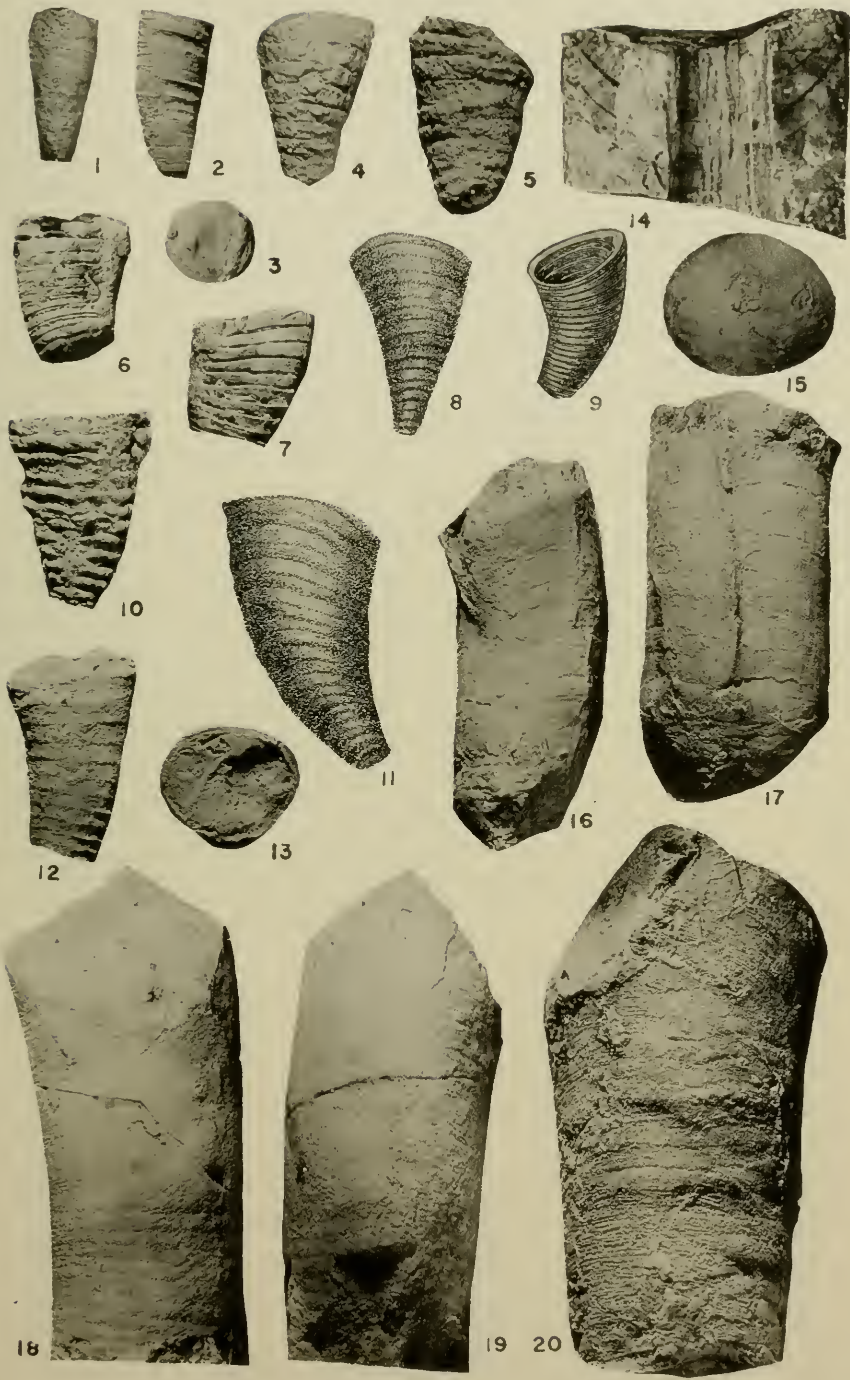
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PLATE 26 (28)

EXPLANATION OF PLATE 26 (28)

(Zitteloceras and Shideleroceras)


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PLATE 27 (29)

EXPLANATION OF PLATE 27 (29)

(Zitteloceras, Charactocerina and Shideleroceras)

Figure		Page
1-3.	**Zitteloceras russelli** Flower, n. sp. 1. Dorsal view. 2. Lateral view. 3. Ventral view. Holotype. Univ. of Cincinnati, No. 24272. Trilobite shales of lower Waynesville (upper Fort Ancient), Stony Run, south of Fort Ancient, Ohio.	328
4, 5.	**Charactocerina** (?) **faberi** (James) Holotype. 4. Vertical section. 5. Lateral view, from opposite side. Whitewater beds, probably upper Whitewater, Richmond, Ind. Univ. of Cincinnati, No. 102.	494
6-8.	**Shideleroceras sinuatum** Foerste, n. sp. Paratype. 6. Ventral view. 7. Lateral view. 8. Dorsal view. Lower Whitewater beds, Little Four Mile Creek, Oxford, Ohio. Shideler Coll.	510


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PLATE 28 (30)

EXPLANATION OF PLATE 28 (30)

(Cyrtocerina and Michelinoceras)

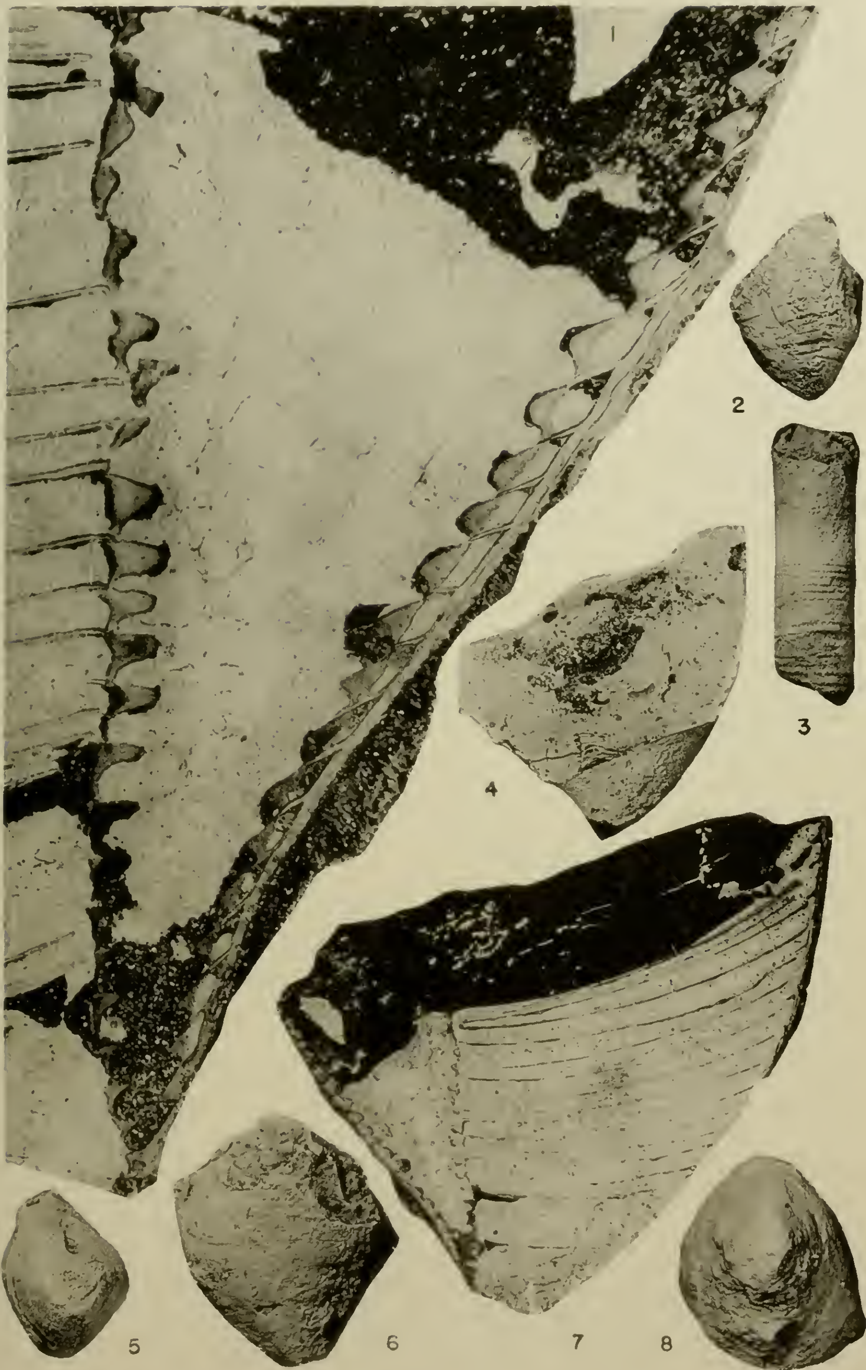
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PLATE 29 (31)

EXPLANATION OF PLATE 29 (31)

(Cyrtocerina, Diestoceras, and Faberoceras)

Figure | Page

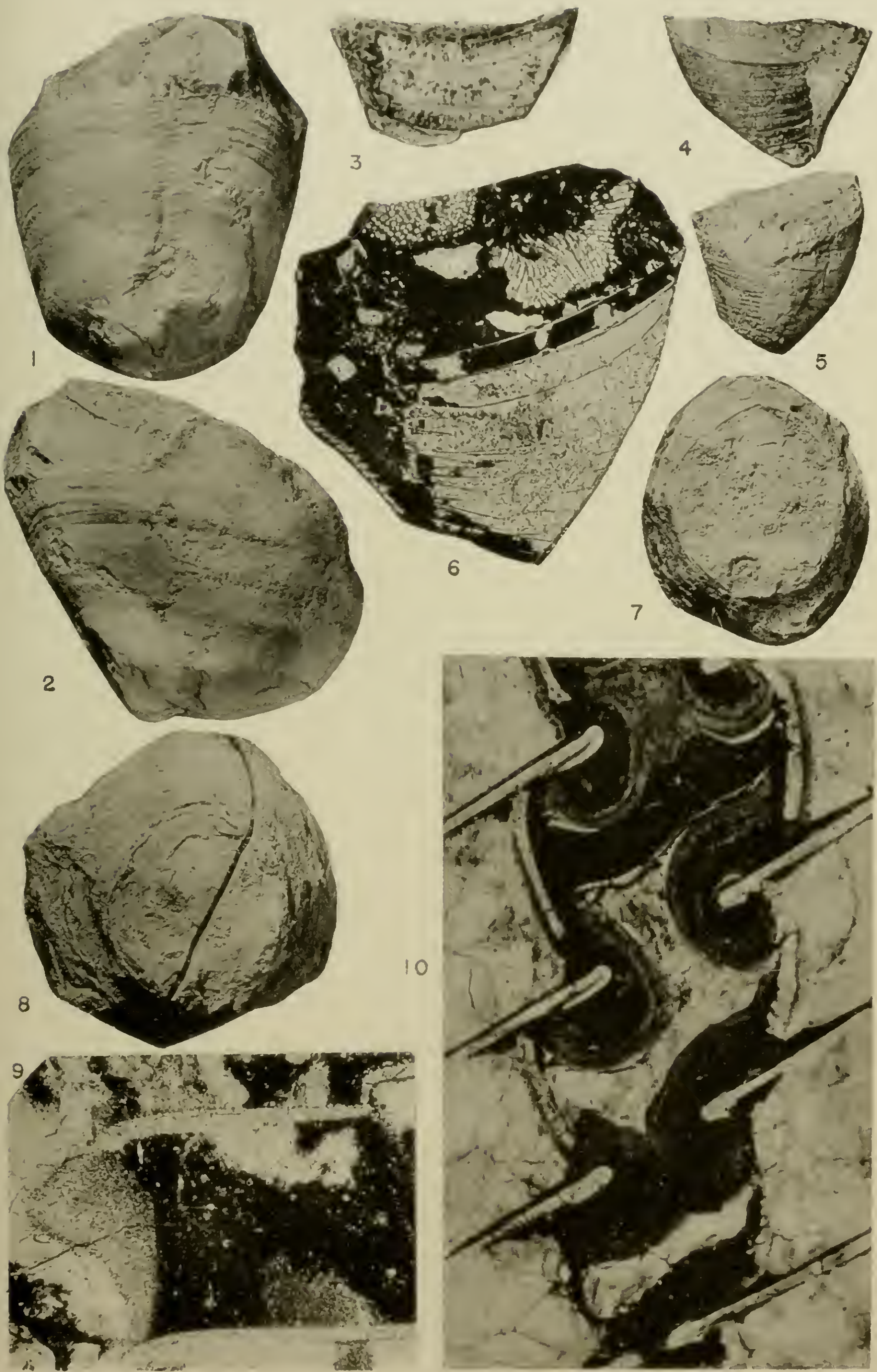
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PLATE 30 (32)

EXPLANATION OF PLATE 30 (32)

(Faberoceras and Cyrtocerina)

Figure | Page

1. **Faberoceras cf. percostatum Flower** 431, 463
   Thin section of siphuncle, about ×4, showing growth relationship of deposits. A vestige of the endocones is present at the base, elsewhere only annulosiphonate deposits and thickened connecting rings are visible. Venter on right. Leipers formation, Rowena, Ky.
2. **Cyrtocerina madisonensis (Miller)** 505
   Enlargement of small part of ventral wall of siphuncle, showing also wall of shell and encrusting Bryozoa, on left. Note gradation in texture of connecting rings. About ×26.
3. **Cyrtocerina madisonensis (Miller)** 505
   Enlargement of the dorsal part of a series of siphuncular segments from the middle of the sectioned hypotype showing variation in mode of preservation of the necks and connecting rings. About ×18.

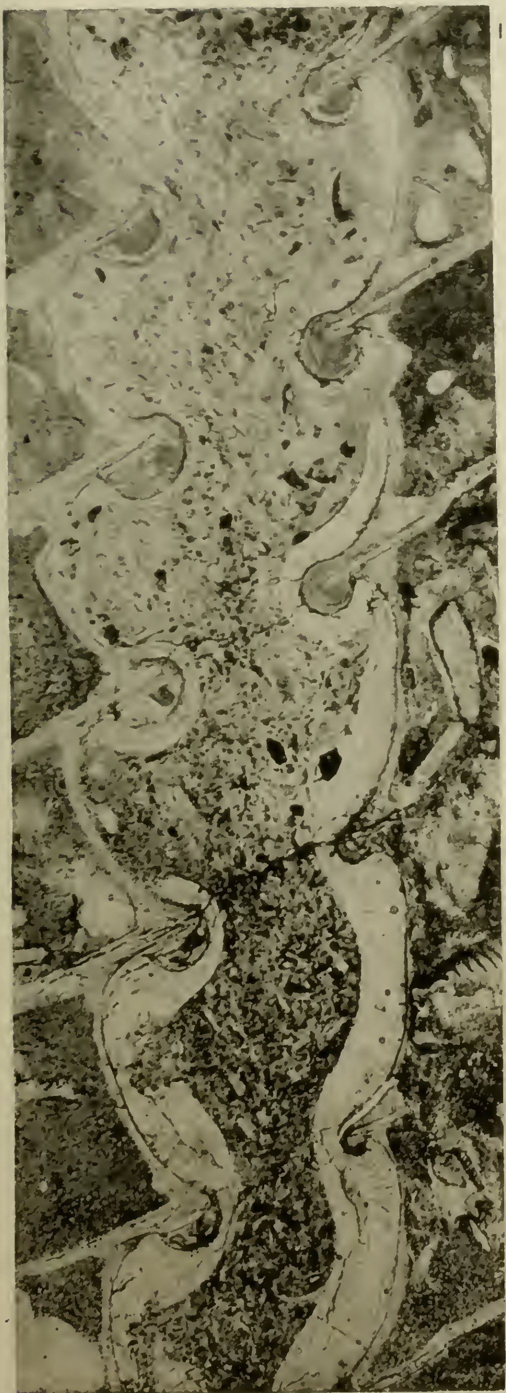
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PLATE 31 (33)

EXPLANATION OF PLATE 31 (33)

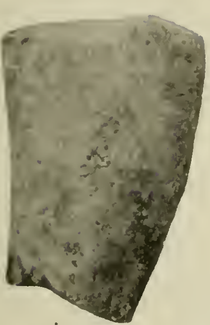
(Charactoceras, Fayettoceras, and Oncoceras)

Figure Page

1, 2. Fayettoceras thompsoni (Miller) ... 486
Holotype. 1. Lateral view, venter on right. 2. Dorsal view. U. S. Nat. Mus., No. 64334. (After Foerste, 1932.) Upper Richmond (Whitewater?), Longwood, Fayette Co., Ind.

3-5. Oncoceras elkhornense Flower, n. sp. ... 265
3. Paratype, lateral view, venter on right. 4. Holotype, ventral view. 5. Holotype, lateral view, venter on left. Shideler Coll Middle Elkhorn, from a creek south of College Corners, Ohio.

6-8. Charactoceras baeri (Meek and Worthen) ... 489
6. Hypotype, lateral aspect, an individual showing the clearest preservation of fasciculate ornament. Shideler Coll., lower Whitewater beds, Little Four Mile Creek. 7. Hypotype, Univ. of Cincinnati, No. 24527, showing earliest stage observed. Hitz layer, Madison, Ind. 8. A relatively complete individual; $\times 2/3$. Lower Whitewater, Little Four Mile Creek. Univ. of Cincinnati, No. 24526.



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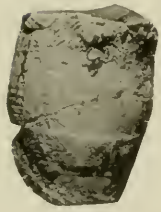

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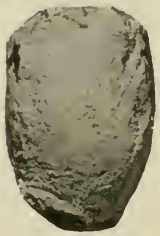

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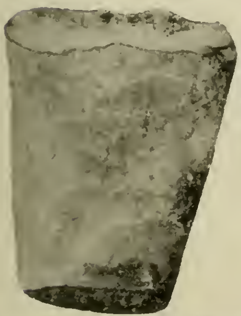

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PLATE 32 (34)

EXPLANATION OF PLATE 32 (34)

(Oncoceratidæ)

Figure Page

1-8. Oncoceras delicatulum Flower, n. sp. 259
1. Holotype, lateral aspect, Univ. of Cincinnati, No. 24410. 2. Lateral view. 3. Apical view. 4. Ventral view. Paratype, Univ. of Cincinnati, No. 24411. 5. Oblique section of paratype ×2, Univ. of Cincinnati, No. 24412. 6. Paratype, lateral aspect, Univ. of Cincinnati, No. 24413. 7 and 8. Opposite views of a paratype, a badly crushed but relatively complete individual. Carrie Williams Coll. All specimens are from the *duseri* beds of the lower Waynesville, from Clarkesville, Ohio.

9-11. Beloitoceras chapparsi Flower, n. sp. 284
9. Lateral view. 10. Ventral view. 11. Apical view. Holotype, Univ. of Cincinnati, No. 24419. Upper Whitewater beds. Shera farm, near Oxford, Ohio.

12. Beloitoceras transiens Flower, n. sp. 284
Holotype, lateral aspect, Shideler Coll. Upper Whitewater beds, Oxford, Ohio.

13-14. Oncoceras exile Flower, n. sp. 263
Paratype. 13. Lateral view. 14. Ventral view. Saluda beds, Hitz fauna, Canaan, Ind.

15. Beloitoceras amoenum (Miller) 272
Hypotype, lateral aspect, Earlham College, No. 14953. Whitewater beds, Richmond, Ind.

16. Beloitoceras ohioense Flower 279
Paratype, Shideler Coll., lower Whitewater, Dodge's Creek, Oxford, Ohio.

17. Beloitoceras amoenum (Miller) 272
Holotype, Univ. of Cincinnati, No. 106. Whitewater beds, Richmond, Ind.

PLATE 33 (35)

EXPLANATION OF PLATE 33 (35)

(Oncoceratidæ)

Figure Page

1, 2. **Oonoceras fennemani** Flower, n. sp. 308
1. Ventral aspect. 2. Lateral aspect. Holotype, Shideler Coll. Saluda-Whitewater transition, from a small tributary of Indian Creek, 5 mi. west of Oxford, Ohio.

3, 4. **Beloitoceras geniculatum** Flower, n. sp. 281
3. Lateral view. 4. Ventral view. Holotype, Shideler Coll. lower Whitewater beds, Little Four Mile Creek, Oxford, Ohio.

5, 6. **Beloitoceras protractum** Flower, n. sp. 282
Holotype, Shideler Coll. 5. Dorsal view. 6. Lateral view. Lower Whitewater beds, Little Four Mile Creek, near Oxford, Ohio.

7. **Oonoceras shideleri** Flower, n. sp. 309
Holotype, Shideler Coll., lateral view. Upper Whitewater beds, left fork of Beasley Creek, north of Camden, Ohio.

8-11. **Oonoceras rejuvenatum** Flower, n. sp. 311
8. Holotype, a slightly crushed shell showing the ventral siphuncle at the extreme left. Paratype: 9. Ventral view. 10. Septal view. 11. Lateral view. Both specimens are in the Shideler Coll. and are from the upper Whitewater beds of Dodge's Creek, Oxford, Ohio.


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PLATE 34 (36)

EXPLANATION OF PLATE 34 (36)

(Oncoceratidæ and Diestoceratidæ)

Figure Page

1. **Diestoceras eos** (Hall and Whitfield) 403
   A slightly flattened specimen showing the lines of growth with remarkable clarity. Very slightly reduced. Actual length 87 mm. Shideler Coll. Lower Whitewater beds, Little Four Mile Creek, Oxford, Ohio.
2. **Beloitoceras cumingsi** Flower, n. sp. 277
   Holotype, lateral aspect, Shideler Coll. Lower Whitewater beds, Little Four Mile Creek, Oxford, Ohio.
3. **Beloitoceras ohioense** Flower, n. sp. 279
   Holotype, lateral aspect, Shideler Coll. Upper Whitewater beds, Harper's Branch, Olderburg, Ind.

4, 5. **Beloitoceras amoenum** (Miller) 272
   4. Lateral aspect. 5. Ventral aspect. Hypotype, Univ. of Cincinnati, No. 24417. Upper Whitewater beds, Dodge's Creek, Oxford, Ohio.

6. **Diestoceras eos** (Hall and Whitefield) 403
   Hypotype, lateral aspect, venter at right. Same specimen figured by Foerste (1924, pl. 26, fig. 1A-B). Shideler Coll. Lower Whitewater beds, Little Four Mile Creek, near Oxford, Ohio.

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PLATE 35 (37)

EXPLANATION OF PLATE 35 (37)

(Oncoceratidæ and Diestoceratidæ)

Figure Page

1. **Beloitoceras ulrichi** Flower, n. sp. 285
Holotype, lateral view, U. S. Nat. Mus. Elkhorn beds, Versailles, Ind.

2, 3. **Oncoceras cincinnatiense** (Miller) 257
2. Flattened specimen, lateral aspect. U. S. National Museum, No. 48356. Lorraine beds (Corryville ?), Cincinnati, Ohio. 3. Lateral aspect of a plastotype of the holotype. U. S. Nat. Mus., No. 67449.

4. **Oncoceras** (?), sp. 259
Lateral aspect. Lorraine group, Cincinnati. U. S. Nat. Mus., No. 48396. Probably from the Corryville.

5. **Oncoceras fossatum** Flower, n. sp. 247
Holotype, lateral aspect. U. S. National Museum, No. 59481. Cynthiana limestone, Eddyville, Ky.

6. **Beloitoceras cumingsi** Flower, n. sp. 277
Hypotype, lateral aspect, showing a specimen with an extremely rapidly expanding phragmocone. Univ. of Cincinnati, No. 24414. Whitewater beds, Oxford, Ohio.

7. **Oncoceras faberi** (Miller) 255
Lateral aspect of plastotype, U. S. Nat. Mus., No. 67448. Maysville (Corryville ?), Cincinnati, Ohio.

8. **Beloitoceras cumingsi** Flower, n. sp. 277
Paratype, lateral view, upper Whitewater beds, McDill's Mills, Oxford, Ohio. Shideler Coll.

9. **Diestoceras eos** (Hall and Whitfield) 403
One side of the flattened holotype, Ohio State Univ., No. 38082. Whitewater beds, near Dayton, Ohio.

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PLATE 36 (38)

EXPLANATION OF PLATE 36 (38)

(Oncoceratidæ and Diestoceratidæ)

Figure Page

1, 2. **Diestoceras indianense** (Miller and Faber) 400
1. Exterior, lateral view. 2. Vertical section. Hypotype, Univ. of Cincinnati, No. 24479. Lower Whitewater beds, Little Four Mile Creek, near Oxford, Ohio.

3. **Diestoceras indianense** (Miller and Faber) 400
Lateral aspect of hypotype, Univ. of Cincinnati, No. 24480. Lower Whitewater beds, Little Four Mile Creek, near Oxford, Ohio.

4. **Oncoceras duncanæ** Flower, n. sp. 262
Holotype, lateral aspect, venter on left. Univ. of Cincinnati, 24481. Upper Saluda beds, Canaan, Ind. (See Pl. 37, fig. 4.)

5. **Oonoceras insuetum** Flower, n. sp. 314
Lateral aspect of holotype, Univ. of Cincinnati, No. 24482. Saluda beds, Versailles, Ind. (See Pl. 37, fig. 8.)

6, 7. **Oncoceras covingtonense** Flower, n. sp. 248
6. Ventral view. 7. Lateral view. Holotype, U. S. Nat. Mus., No. 48391. Upper beds of the Trenton (Bromley shale phase of the Cynthiana limestone), West Covington, Ky.


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PLATE 37 (39)

EXPLANATION OF PLATE 37 (39)

(Oncoceratidæ and Diestoceratidæ)

Figure | Page

1. **Diestoceras** (?) **vasiforme** Flower, n. sp. 416
   One side of the slightly flattened holotype. Orientation uncertain. Earlham College, No. 7948. Precise horizon and locality uncertain. Probably from the Saluda near Richmond, Ind.

2, 3. **Beloitoceras**, sp. 280
   2. Lateral view. 3. Ventral view. Living chamber, Univ. of Cincinnati, No. 24804. Lower Whitewater beds, Oxford, Ohio.

4. **Oncoceras duncanæ** Flower, n. sp. 262
   Ventral view of holotype. See Pl. 36. Univ. of Cincinnati, No. 24481. Hitz fauna, upper Saluda, Canaan, Ind.

5. **Diestoceras reversum** Flower, n. sp. 415
   Lateral view of holotype, venter on right. Shideler Coll. Saluda beds, Laurel, Ind.

6. **Beloitoceras** cf. **cumingsi** Flower 278
   Lateral view. Shideler Coll. Top of Elkhorn, Harper's Branch, Olderburg, Ind.

7. **Beloitoceras ohioense** Flower, n. sp. 279
   Paratype, lateral aspect, Univ. of Cincinnati, No. 23914. Lower Whitewater beds, Flat Fork Creek, Ohio.

8. **Oonoceras insuetum** Flower, n. sp. 314
   Ventral view of holotype, Univ. of Cincinnati, No. 24482. Saluda beds, Versailles, Ind. (See Pl. 36.)

9. **Beloitoceras amoenum** (Miller) 272
   Hypotype, lateral aspect, Shideler Coll. Upper Whitewater McDill's Mills, near Oxford, Ohio.

10. **Diestoceras eos** (Hall and Whitfield) 403
    Dorsal view of hypotype, slightly widened by vertical flattening, Univ. of Cincinnati, No. 24500.


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PLATE 38 (40)

EXPLANATION OF PLATE 38 (40)

(Diestoceras, Probillingsites and Beloitoceras)

Figure Page

1. **Diestoceras shideleri** Foerste 407
   Hypotype, an essentially unflattened shell incomplete adorally. Shideler Coll. Saluda beds, McDill's Mills, near Oxford, Ohio.

2, 3. **Diestoceras cyrtocerinoides** Flower 410
   Holotype. 2. Portion of sagittal section; ×2. 3. Adoral view of type, Univ. of Cincinnati, No. 23971. Hitz layer, Madison, Ind. (See Pl. 29, fig. 3.)

4, 5. **Probillingsites** (?) **minutum** Flower, n. sp. 195
   4. Lateral view, venter on right. 5. Dorsal view. Holotype, Shideler Coll. Middle Liberty beds, Dodge's Creek, Oxford, Ohio.

6. **Beloitoceras amoenum** (Miller) 272
   Hypotype, a typical internal mold of an isolated living chamber, lateral view. Univ. of Cincinnati, No. 24916. Whitewater beds, Dodge's Creek, Oxford, Ohio.

7. **Diestoceras eos** (Hall and Whitfield) 403
   Portion of sagittal section through siphuncle, about ×1½. Univ. of Cincinnati, No. 24502. Lower Whitewater beds, Little Four Mile Creek, near Oxford, Ohio.

8. **Diestoceras shideleri** Foerste 407
   Lateral view of a somewhat flattened but relatively complete shell. Univ. of Cincinnati, No. 24508. Lower Whitewater beds, Little Four Mile Creek, near Oxford, Ohio.

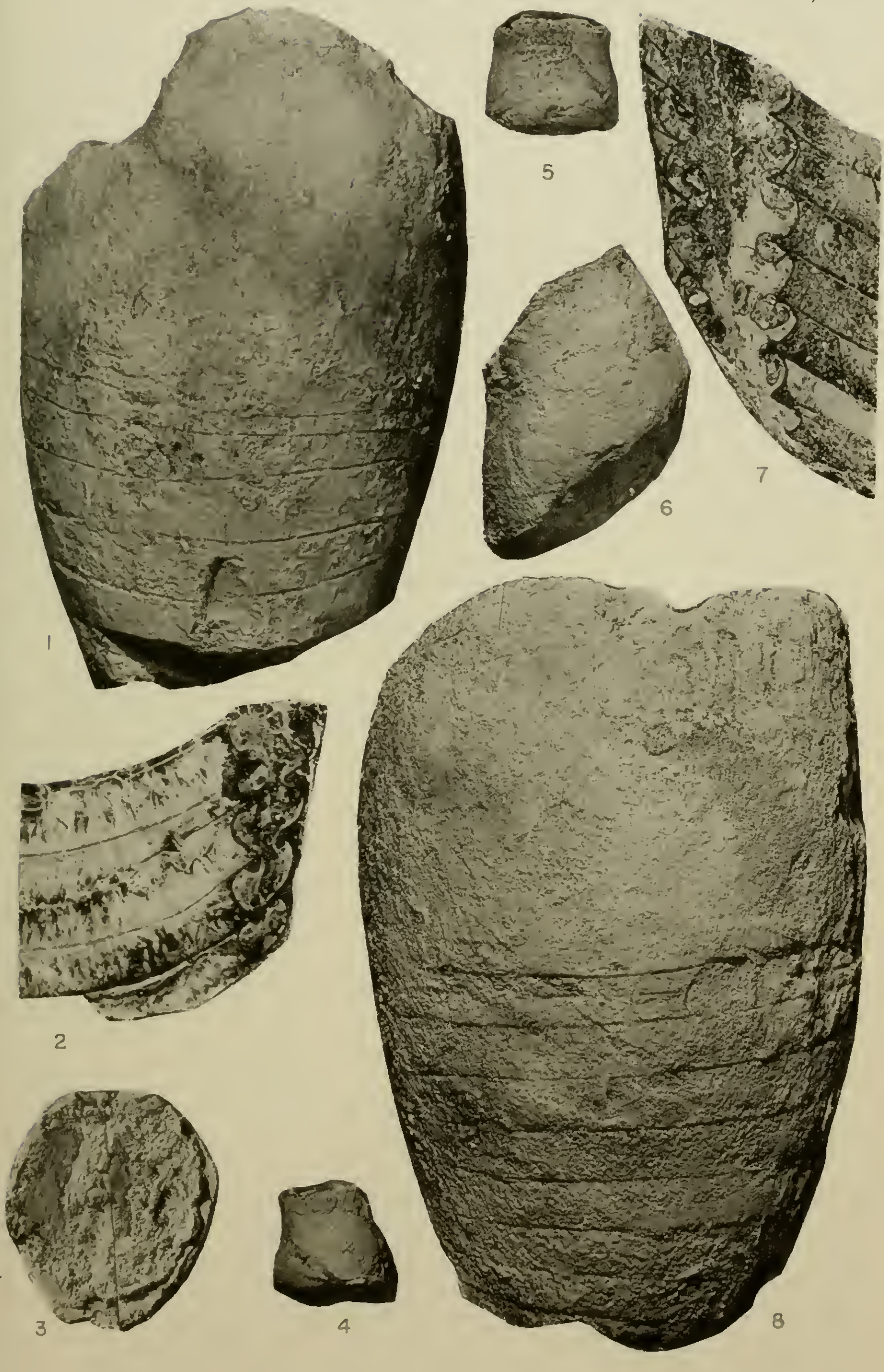
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PLATE 39 (41)

EXPLANATION OF PLATE 39 (41)

(Richmond Oncoceratidæ and Diestoceratidæ)

Figure Page

1, 2. **Oncoceras exile** Flower, n. sp. 263
Paratype, showing form of early part of phragmocone. 1. Ventral aspect. 2. Lateral aspect. U. S. Nat. Mus. Hitz layer, uppermost Saluda, at Madison, Ind.

3. **Diestoceras** cf. **shideleri** Foerste 408
Dorsal aspect, ×2/3, of the only specimen observed in the Elkhorn, a somewhat flattened shell, Shideler Coll. Middle Elkhorn, Seven Mile Creek, Eaton, Ohio.

4, 5. **Oncoceras madisonense** Flower, n. sp. 264
Holotype. 4. Lateral view. 5. Ventral view. Univ. of Cincinnati, No. 24485. Hitz layer, Madison, Ind.

6. **Beloitoceras bucheri** Flower, n. sp. 283
Holotype, lateral aspect. Shideler Coll. Basal Whitewater, Elk Run, near Winchester, Ohio.

7. **Diestoceras attenuatum** Flower, n. sp. 409
Holotype, lateral view, venter on left. Univ. of Cincinnati, No. 24524. Lower Whitewater beds, Little Four Mile Creek, near Oxford, Ohio.

8, 9. **Oncoceras madisonense** Flower, n. sp. 264
Paratype, a shell somewhat smaller than the holotype. 8. Ventral view. 9. Lateral view. U. S. Nat. Mus., Hitz layer, Madison, Ind.

10. **Diestoceras eos** (Hall and Whitfield) 403
Hypotype, showing a dorsal surface retaining the shell, also the concave outline of the early portion. Shideler Coll. Saluda beds, Madison, Ind.


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PLATE 40 (42)

EXPLANATION OF PLATE 40 (42)

(Richmond Cyrtoceracones)

Figure | Page

1-3. **Miamoceras shideleri** Flower, n. sp. 318
Holotype, Shideler Coll. 1. Ventral view, showing siphuncle exposed by sectioning. 2. Lateral view, venter on left. 3. Dorsum. Saluda beds, about 4 mi. west of Oxford, Ohio.

4, 5. **Graciloceras extensum** Flower, n. sp. 173
Holotype. 4. Weathered lateral surface. 5. Opposite side, showing surface of internal mold. Shideler Coll. Lower Whitewater beds, Flat Fork Creek. The pustulose material at the extreme base of fig. 4 is a starfish arm.

6-8. **Oonoceras rectidomum** Flower, n. sp. 313
6. Lateral view, venter on right. 7. Ventral. 8. Lateral, venter on left. Holotype, Univ. of Cincinnati, No. 24484. Lower Whitewater beds, above cephalopod zone, Flat Fork Creek.

9, 10. **Neumatoceras subconicum** Flower, n. sp. 297
9. Ventral view. 10. Lateral view, venter on left. Holotype, Univ. of Cincinnati, No. 24329. Cephalopod beds, lower Whitewater horizon, Little Four Mile Creek, Oxford, Ohio.

11. **Oncoceras**, sp. 249
Lateral view of the only known specimen. Shideler Coll. Cynthiana limestone, quarry 2½ mi. from Winchester, Ruckersville road.


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PLATE 41 (43)

Explanation of Plate 41 (43)

(Richmond Cyrtoceracones)

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PLATE 42 (44)

EXPLANATION OF PLATE 42 (44)

(Richmond Clarkesvillia and Oncoceratidæ)

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PLATE 43 (45)

EXPLANATION OF PLATE 43 (45)

(Clarkesvillia and Armenoceras)

Figure Page

1, 4. **Clarkesvillia halei** Flower, n. sp. 476
Holotype, Univ. of Cincinnati Museum. 1. Lateral aspect before sectioning, showing weathered surface and apparently concavosiphonate siphuncle. 3. Vertical section through the same specimen. From the Waynesville formation in the vicinity of Clarkesville, Ohio. Precise horizon uncertain.

2, 3. **Armenoceras vaupeli** Flower, n. sp. 521
2. Paratype, Univ. of Cincinnati, No. 23901, natural weathered section. 4. Paratype, Univ. of Cincinnati, No. 23903, natural weathered section. Both specimens retain only the ventral part of the original shell. Cynthiana limestone, Cynthiana, Ky.

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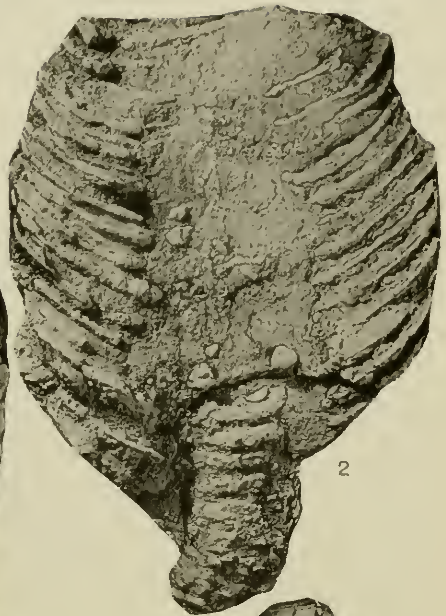

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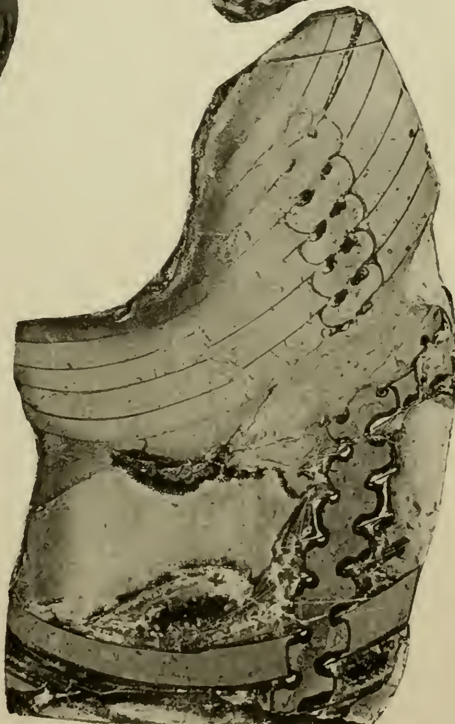

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PLATE 44 (46)

EXPLANATION OF PLATE 44 (46)

(Armenoceras and Lambeoceras)

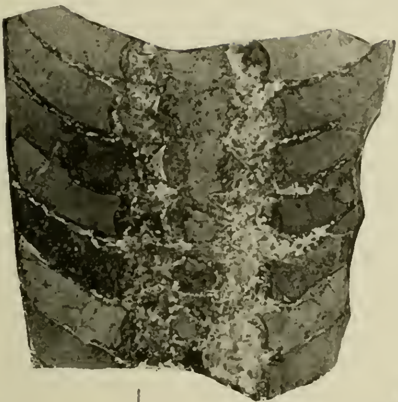
Figure Page

1, 2. Armenoceras richmondense Flower, n. sp. 523

1. Section of holotype. Liberty beds, Route 1, about 4 mi. south of Milan, Ind., Univ. of Cincinnati, No. 23910.
2. Paratype, a naturally weathered and somewhat crushed specimen which is more complete longitudinally. Shideler Coll. Blanchester beds of the Waynesville, Addison's Creek, near Oxford, Ohio.

3, 4. Lambeoceras richmondense (Foerste) 530

3. Lateral longitudinal section, ×1. Shideler Coll. Whitewater beds, Beasley's Creek, Camden, Ohio.
4. Portion of mature individual, with shells of *Crania* originally attached to the inside of the living chamber. Ventral aspect. Earlham College, No. 6422. Probably from the Whitewater beds, Richmond, Ind.



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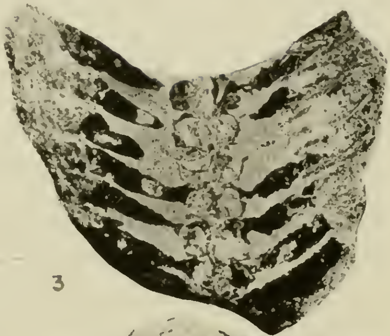

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PLATE 45 (47)

EXPLANATION OF PLATE 45 (47)

(Lambeoceras and Neumatoceras)

Figure		Page
1.	**Lambeoceras richmondense** (Foerste)	530
	Hypotype, most complete specimen observed. The external mold obscurely preserved adapically, indicates that the shell comes to a blunt termination at the extreme base of the portion figured. Earlham College, No. 7955. No data. evidently Whitewater, probably from Richmond, Ind.	
2, 3.	**Neumatoceras chrysalis Flower, n. sp.**	295
	Holotype, Shideler Coll. 2. Lateral view. 3. Ventral view. Lower Whitewater beds, Little Four Mile Creek, near Oxford, Ohio.	
4.	**Lambeoceras richmondense** (Foerste)	530
	Hypotype, ventral view, of a relatively complete living chamber and a portion of a phragmocone. Shideler Coll. Whitewater beds, Beasley's Creek, near Camden, Ohio. Note presence of extensive *Clionolithes* on the living chamber.	

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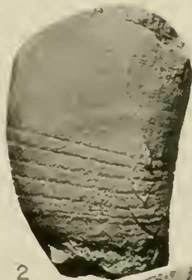

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PLATE 46 (48)

EXPLANATION OF PLATE 46 (48)

(Lambeoceras)

Figure Page

1. **Lambeoceras richmondense** (Foerste) ... 530
   Hypotype, internal mold of the largest phragmocone observed. Shideler Coll. Saluda beds, Harper's Run, northeast of Oxford, Ohio. Note lateral modification of adoral sutures.

2, 3. **Lambeoceras richmondense** (Foerste) ... 530
   Hypotype, ventral (2) and dorsal (3) views, of an exceptionally well-preserved small fragment, showing difference in dorsal and ventral sutures. Shideler Coll. Listed as from the Liberty formation, McDill's Mills, Oxford, Ohio. Possibly lower Whitewater.

4. **Lambeoceras richmondense** (Foerste) ... 530
   Hypotype. Vertical section $\times 2\frac{1}{2}$ showing the form of the segments of the siphuncle, Shideler Coll. Upper Whitewater beds, from valley of Harper's Branch, Ind.

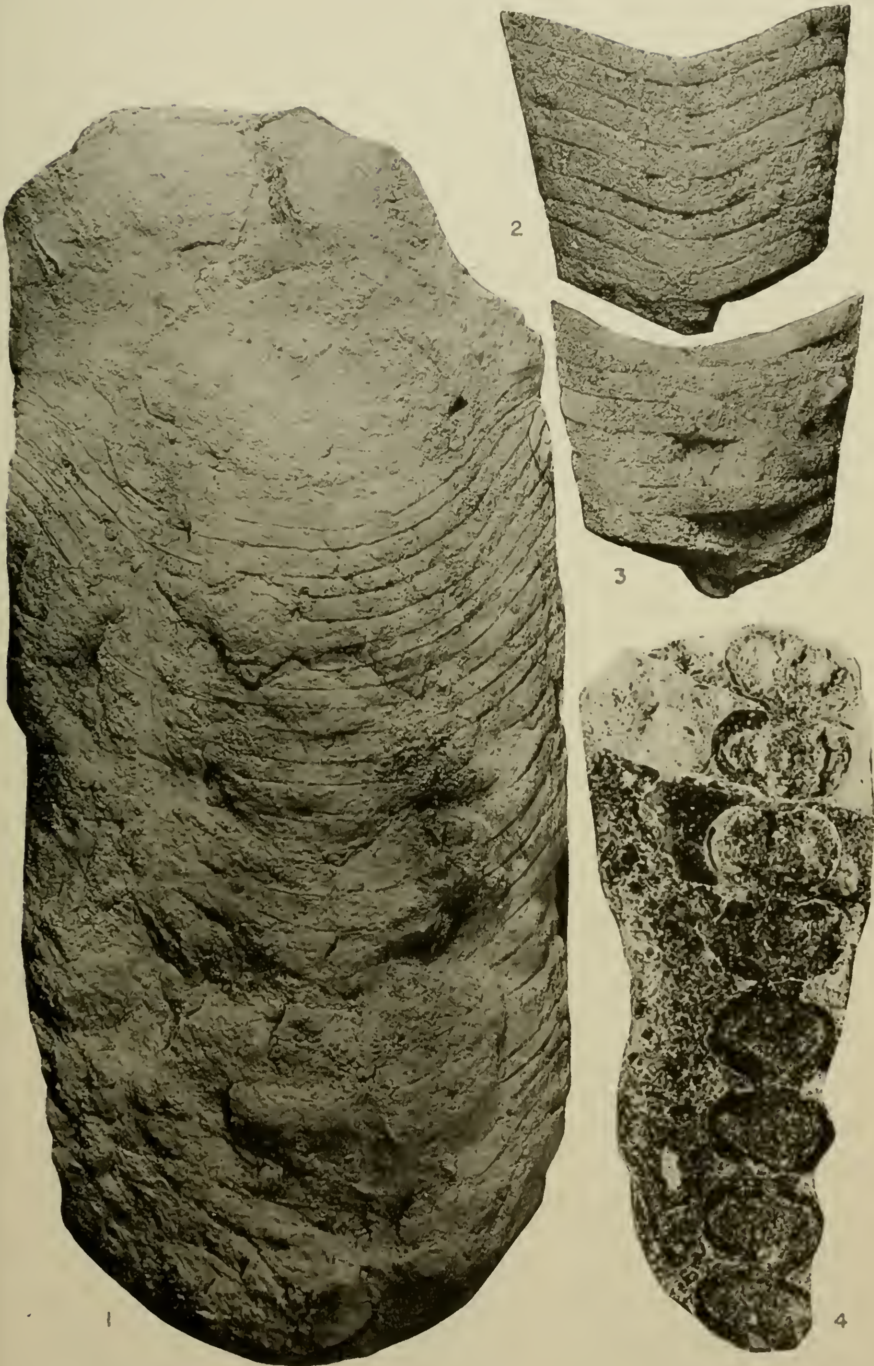
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PLATE 47 (49)

EXPLANATION OF PLATE 47 (49)

(Actinoceroidea)

Figure Page

1. **Treptoceras duseri** (Hall and Whitfield) (Part II)
Lateral view of an abnormal individual with distorted septa. The venter is to the right. Shideler Coll. *Duseri* zone, Fort Ancient member, Waynesville. From Stony Hollow, Clarkesville, Ohio.

2, 3. **Troedssonoceras** (?) **obscuroliratum** Flower, n. sp. 540
Holotype. 2. Exterior section. 3. Vertical section. Holotype, Shideler Coll. Cynthiana limestone, Millersburg phase, between Sutherland Mill and Chapman, near Bardstown, Ky.

4-6. **Armenoceras vaupeli** Flower, n. sp.
Holotype, Shideler Coll. 4. Ventral aspect. 5. Lateral aspect. 6. Vertical section through siphuncle. Cynthiana limestone, Cynthiana, Ky.

7. **Armenoceras madisonense** Foerste 526
Holotype, dorsal view. (After Foerste and Teichert.) U. S. Nat. Mus., No. 15493. Madison, Ind., believed to have come from the Saluda beds.

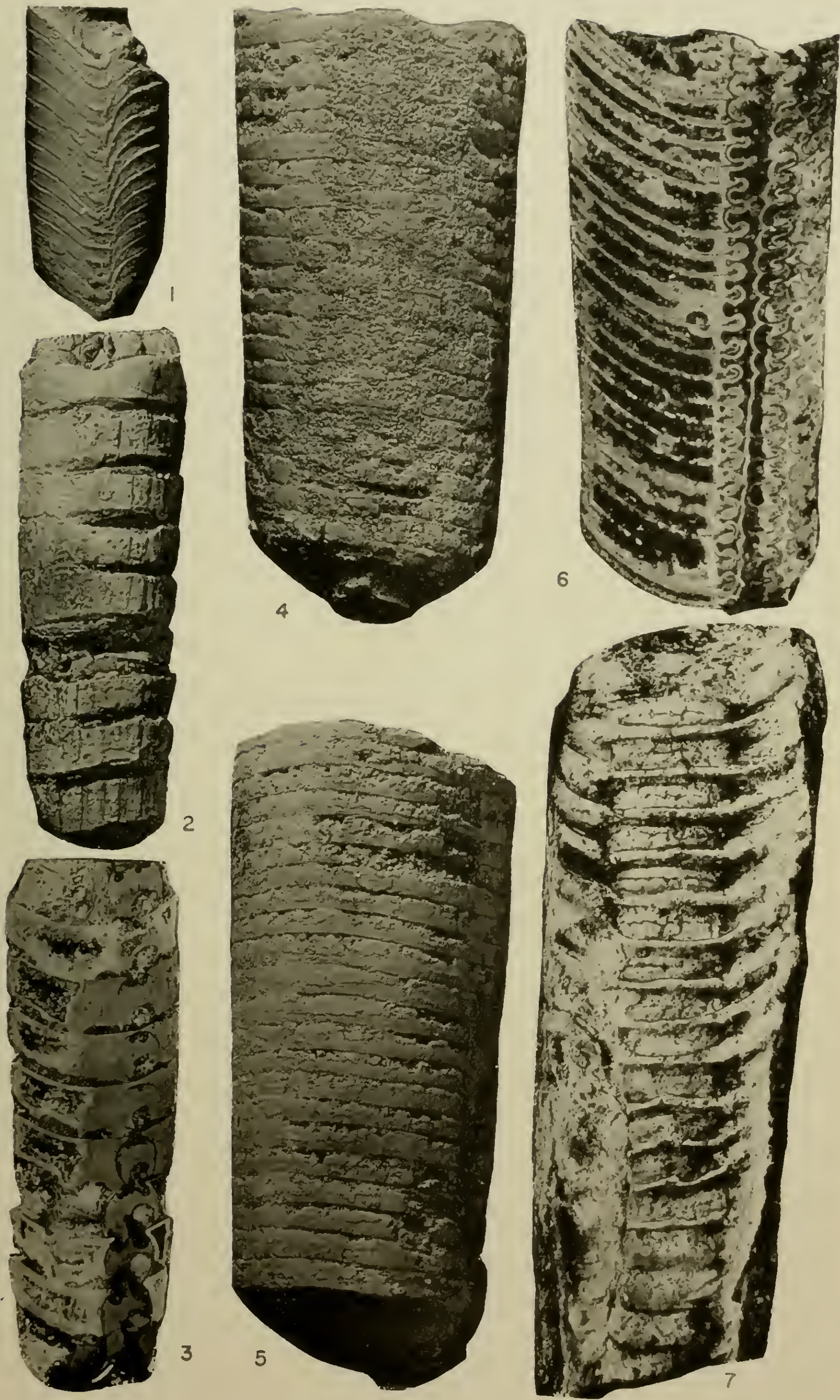
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PLATE 48 (50)

EXPLANATION OF PLATE 48 (50)

(Rasmussenoceras)

Figure | Page

1-8. **Rasmussenoceras variabile** Flower, n, sp. ... 222

1. Syntype, Shideler Coll., one of the most complete mature living chambers observed. Ventral aspect. Basal Whitewater, Flat Fork Creek.

2-3. Ventral and dorsal views of syntype, Earlham Coll. No. 8203, showing difference in dorsal and ventral lobation of sutures. No data. Probably from the Whitewater formation of Richmond, Ind.

4. Dorsal aspect of syntype, the youngest stage represented. Shideler Coll. Basal Whitewater, Flat Fork Creek.

5. Dorsal aspect of a later growth stage showing broadening of the dorsal keel and the adoral decrease in rate of expansion. Shideler Coll. Lower Whitewater beds, Little Four Mile Creek, Oxford, Ohio.

6. Syntype, dorsal view of a typical ephebic living chamber. Shideler Coll. Lower Whitewater beds, Little Four Mile Creek.

7-8. Ventral (7) and dorsal (8) aspects of an immature living chamber showing the characteristic neanic rapid lateral expansion. Lower Whitewater beds, Little Four Mile Creek, Oxford, Ohio.


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PLATE 49 (51)

EXPLANATION OF PLATE 49 (51)

(Troedssonoceras)

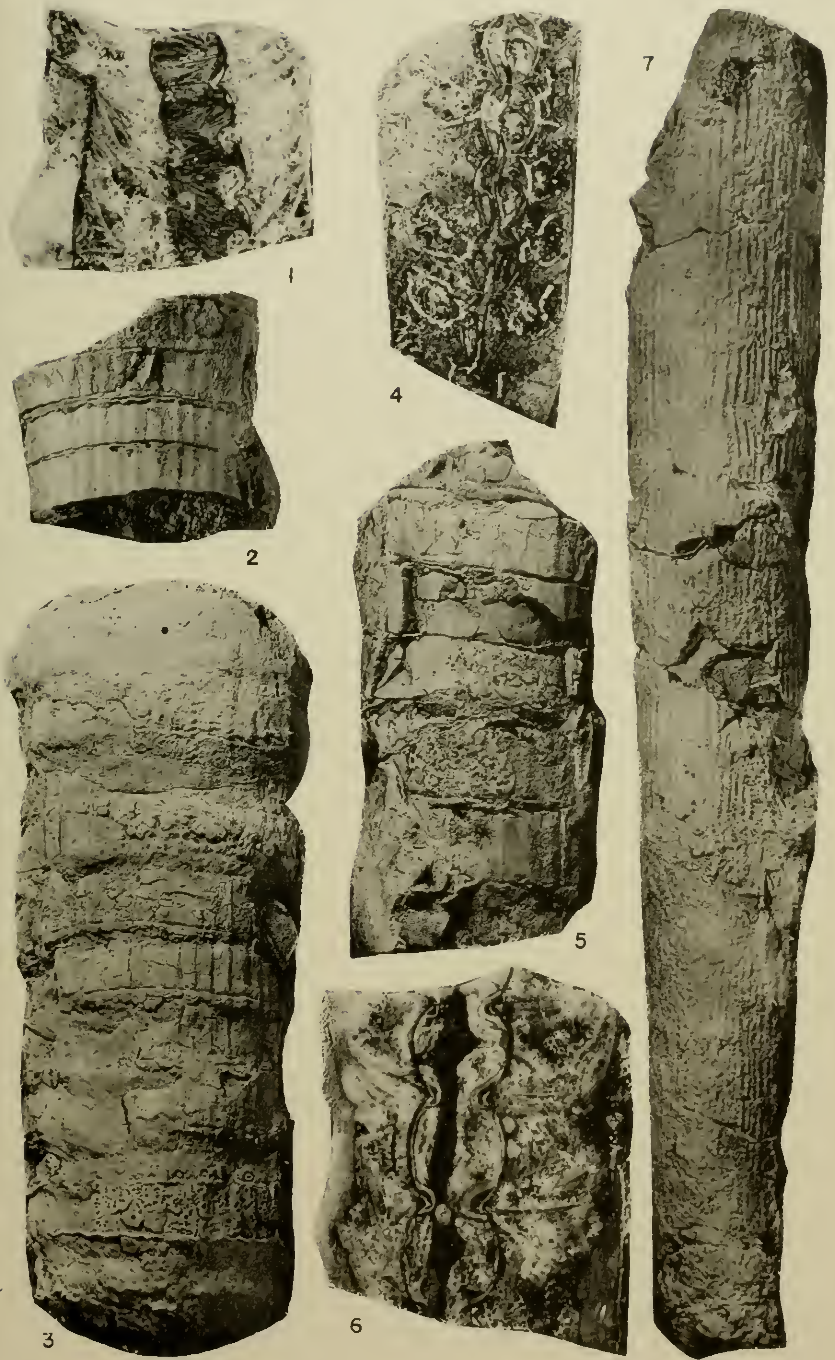


PLATE 50 (52)

EXPLANATION OF PLATE 50 (52)

(Troedssonoceras)

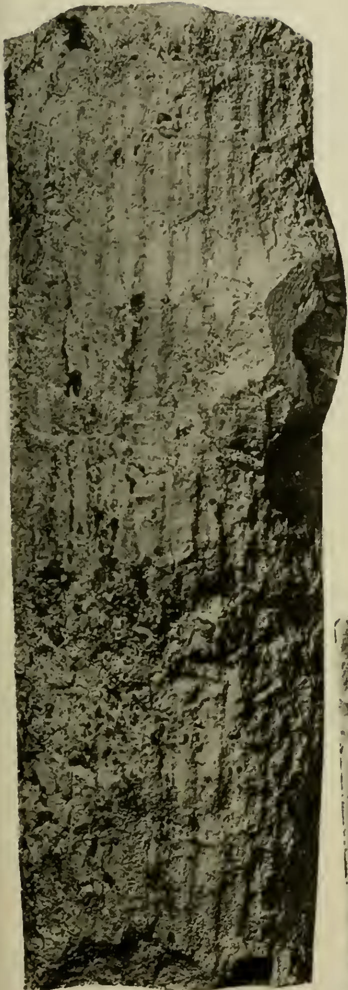
Figure — Page

1, 2. **Troedssonoceras cf. multiliratum** Flower 545
Plaster cast from natural external mold, Univ. of Cincinnati No. 24463. 1. Entire specimen, natural size. 2. Adoral portion slightly enlarged, showing detail of surface sculpture. Bellevue formation, English Homes, Western Hills Boulevard, Cincinnati, Ohio.

3-5. **Troedssonoceras baileyi** Flower 539
3. Enlargement of a portion of the surface; ×2. 4. Vertical section from adapical half of specimen; ×1½. 5. Exterior of holotype, entire. ×1, U. S. Nat. Mus. Trenton, probably Cathys, Nashville, Tenn.

6. **Troedssonoceras rowenæ** Flower, n. sp. 542
Paratype, oblique section; ×1. Univ. of Cincinnati, No. 24467. Leipers formation, Painted Cliffs, Cumberland River, Ky.

NOTE.—On page 13 of this Bulletin acknowledgment has been made to the Faber Fund of the University of Cincinnati Museum for financial assistance in the preparation of the illustrations for this work, and it now should be stated that the Trustees of the University of Cincinnati have appropriated from the funds of the College of Liberal Arts sufficient financial aid for the completion of the necessary illustrations.



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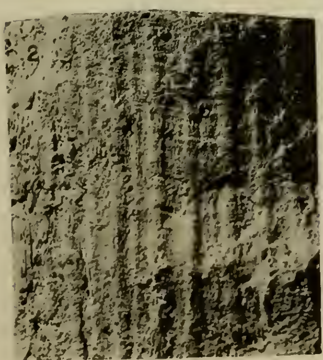

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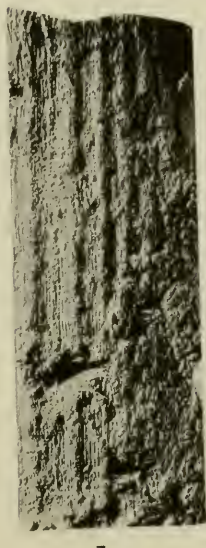

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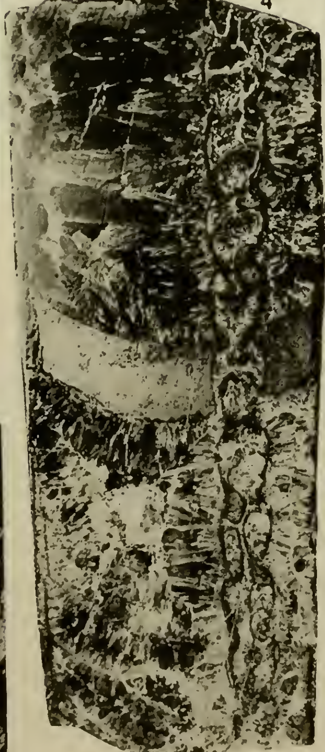

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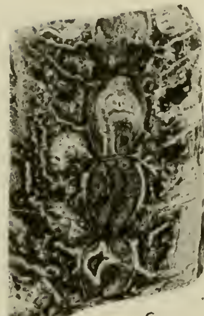

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