MEMOIR 12

The Nautiloid Order Ellesmeroceratida (Cephalopoda)

By ROUSSEAU H. FLOWER

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Abstract

The order Ellesmeroceratida is reviewed in terms of three new suborders, their families and genera. Species are listed under the genera in which they occur, with appropriate indications where transfer from one genus to another has been required. Detailed specific descriptions are confined to new species or to forms discussed and refigured for morphological purposes. Particular attention has been given, wherever material permitted, to the structure of the connecting rings, which are thick and commonly complex and show generally layered structure. Diaphragms, developed in the Plectronoceratina, Ellesmeroceratidae, and some Protocycloceratidae, appear to be extensions of the rings. They are suppressed in the Baltoceratidae, and in higher members of that group a ventral rod, presumably originally aragonitic, is developed and is found also in some forms otherwise assignable to the Protocycloceratidae, in which homeomorphic stocks may yet be included. Relationships and evolution of the stock are particularly investigated, and ranges are indicated, with some attention necessarily given to the derived orders Endoceratida, Tarphyceratida, and Michelinoceratida. The table of contents supplies a summary of the taxa to the generic level. A systematic appendix includes inadequately known genera, some forms removed from the Ellesmeroceratida, and some genera of doubtful position. A stratigraphic appendix includes detailed discussions of some sections and problems of ranges of some of the genera and species.

Introduction

This work deals with a study of the Ellesmeroceratida, the archaic order of the Nautiloidea and thus also of the Cephalopoda as a whole, for the Ammonoidea and Coleoidea are developed from later nautiloids, both possibly appearing in the Devonian. It seems generally true that the archaic members of every group have proved elusive, difficult to interpret, and the subject of conflicting opinions. This has certainly been true of the Cephalopoda. In another section, some of the vicissitudes of conflicting opinons and interpretations have been reviewed. It is evident now that the old concept of "*Orthoceras*" as primitive is false, and also we must abandon the view, so widely held in the 1920's, of the generally prevalent condition of holochoanitic structure among the older cephalopods. Indeed, prior to the development of long necks, it is evident that there was established a pattern of shells with siphuncles of short necks but with thick, commonly layered rings, the sort of structure generally developed in what is here called the suborder Ellesmeroceratina, though similar rings are found in the derived Endoceratida with endocones, and the derived exogastric Tarphyceratida, of simpler internal construction. But this is not all. Beginning earlier and disappearing earlier—the first form is in the Franconian of the Upper Cambrian and the last ones appear in the Wanwanian (Gasconadian) of Manchuria—is a stock in which the siphuncle segments are strongly inflated between the necks, the Plectronoceratina of the present work. These forms, so oddly at variance with what one expected as the oldest cephalopods that they were considered aberrant (Ulrich and Foerste, 1935) or were discredited completely (Miller 1943), are, surprisingly, the oldest cephalopods, and scrutiny of our objections to accepting them as primitive shows that such objections are perhaps not really valid (Flower, 1954).

The Ellesmeroceratida are a diverse lot. The older Plectronoceratidae with their siphuncular bulbs are in this respect so diverse from the Ellesmeroceratidae and their derivatives that they could be placed in a separate order. However, the shells are so closely similar in other respects that, without exceptionally well-preserved material, the two could be easily confused, and as a compromise, the two groups are recognized as suborders. To these are added a third suborder, the Cyrtocerinina, an odd, little-known group characterized by siphuncles in which the rings are swollen and extend as lobes into the cavity of the siphuncle. Such shells are a disparate lot, and were it possible to find some other possible origin for *Cyrtocerina*, which, though the best-known genus morphologically, seems the most isolated in form and in range, the group would be considered as polyphyletic.

Prior to the 1930's, only a few species of the present order were described, and none of them was properly understood morphologically. Indeed, it must be remembered that most of the representatives of the stock came from the present Canadian system, and in the old days, this was the "Calciferous Sandrock" of the early New York reports, for years regarded as proverbially barren. It is pointless to review here in detail the history of the discoveries of faunas and of the establishment of the faunal successions in this interval. It is, however, relevant to point out that our knowledge of the American forms, by far the largest group now known, began with the collections laboriously brought together by Ulrich and various of his coworkers, the study of which was initiated jointly by Ulrich and Foerste in the 1930's. Two preliminary reports appeared (Ulrich and Foerste, 1933, 1935), but the work was completed by Miller and various of his associates after the death of Foerste and later of Ulrich also.

Much of the material on which that study was based consists of chert-replaced specimens; further, many of these are chert replacements, not of the shells themselves, but of the steinkerns, matrix filling the shells; shell material is dissolved. Material from the southern Appalachians, from the upper Mississippi Valley, and from the Ozark and Llano uplifts then available consisted completely of such material insofar as the Gasconadian, Lower Canadian, is concerned, and it is in that interval that the crucial Ellesmeroceratidae are most fully developed. The limitations of such material are well illustrated by the section at Fort Ann, New York. There, the Lower Canadian consists largely of dolomites, but a few limestones are preserved which retain a rich and well-preserved association of shells. In such limestones, there are occasional cherts; in them are found silicified cephalopods, but they are so poor and so fragmentary that they were discarded in collecting in favor of the better and more complete limestone specimens. However, in some instances, such limestones were only lenses, and one could trace them laterally directly into dolomites. In this transition, the limestone fossils fade and disappear, and in the purer dolomites one is confined in collecting to the poorer fragments preserved in the cherts. It must be remembered that it is such cherts which have yielded the known cephalopod faunas of most of the Lower Canadian faunas known in North America. Such material is inadequate for proper structural study. The species are in some instances known from only a very few specimens, some of which are sadly fragmentary, but even so, the collected material represents certainly years of careful accumulation. It will be long before it is improved sufficiently to permit a more complete knowledge of the proportions of the species (important, as most species are differentiated primarily on proportions), and the accumulation of suites of material permitting a proper study of variation within the species is even farther in the remote future.

Our present study has been concerned largely with problems of structure and relationship. I have noted the confusion which greeted the discovery of the Plectronoceratina as the oldest cephalopods, with their completely unexpected siphuncular bulbs. Almost as much confusion has surrounded the higher Ellesmeroceratina, which were long, though erroneously, supposed to be holochoanitic. This could be disproved only by accumulating enough well-preserved material for adequate thinsections. This was impossible for every species, of course; some are quite limited geographically and confined in occurrence to beds yielding only chert steinkerns in dolomite. However, it was possible to obtain a fair sampling of the genera, enough to establish the prevalence of the short necks, the thick rings, and the diaphragms as general features of the Ellesmeroceratidae. It must be emphasized, however, that the available limestone material was not all that might be hoped, for some seemingly promising specimens in limestone proved, when thinsections were made, to show advanced alteration, and in some instances such recrystallization that the septal necks and connecting rings were no longer apparent as distinct entities of radically different texture and composition. More investigation of limestone material is needed, for we are possibly not at the end of the variations in the connecting ring, and fuller scrutiny of variation in the rings is needed also to evaluate organic versus inorganic factors in instances of apparent homogeneity of structure.

If the present investigation is incomplete, and indeed, it should be looked upon as a beginning rather than the end of the investigation of these older cephalopods, it is some satisfaction to reflect that it has contributed some surprises. Some of these surprises have tended to resolve problems for which there was, before, no ready solution. An opportunity to collect from the cephalopod bed of the San Saba limestone of the Llano uplift, with the guidance and help of Dr. Virgil Barnes, resulted in the material here described, permitting for the first time thinsection investigation of the structures of these forms. It also yielded the surprise of *Balkoceras*, showing a previously unsuspected exogastric development in the late Cambrian Plectronoceratina, and thus provided a basis for returning *Shelbyoceras* to the cephalopods, a most happy situation, as the genus failed to fit properly anywhere else. The same material yielded the only known Cambrian Ellesmeroceratidae (two specimens) and showed fine diaphragms in what is obviously a good *Ectenolites*. Gasconade material of the genus was unsatisfactory in this respect. For the Ellesmeroceratidae, surprises were less striking, but there was, happily, material for better demonstration of the diaphragms, and a good many genera were represented by material adequate for the interpretation of the siphuncle wall. It is, possibly, a surprise to find in this group evidence of short, rapidly expanding apices, such as one might expect for some of the cyrtoconic forms, but which were unexpected in the orthoconic *Pachendoceras* and *Eremoceras*.

It was known for some time that some Baltoceratidae characteristically had calcite in the siphuncles, too prevalent to be dismissed as certainly inorganic. New material has shown that such calcite is a structure previously unrecognized and unsuspected, a rod, generally round in section, secreted against the ventral wall of the siphuncle, pointed anteriorly, thickening apicad until it fills the whole of the siphuncle. Such rods, indeed, occur in some forms previously classed as members of the Endoceratida. Necessarily, the possibility that such a structure could be a modification of endoceroid endocones had to be considered, but the evidence fails to support such a possibility.

Difficulty in obtaining good sectionable material and difficulty in interpreting species and genera from fragmentary material have certainly resulted in some errors of taxonomic assignment and also in interpretation of evolution in the past. Some such errors have been corrected, but there still remain problems which can be solved only in the light of more abundant and better material than is now available. I refer specifically to the problem of the homeomorphy of the forms at present included in the Protocycloceratidae, discussed in more detail below, and the problem in assigning smooth orthocones correctly to the Ellesmeroceratida to the exclusion of the Endoceratida. More material is needed for the investigation of many odd structures, but the present work, though something like ten years in its building, cannot be delayed indefinitely in the hope of obtaining material adequate to the solution of many such problems.

Concurrent with the present investigation has been a study of the other two major orders developed in the Canadian, the Endoceratida and the Tarphyceratida. It was originally planned to include these three orders in a single work, but this proved unfeasible for a number of reasons, not the least of which was the fact that further study of new endoceroid material brought to light obviously new forms, not only new species, but a number of forms so distinct that they must be recognized as genera; yet the material failed to supply critical morphological features, as the structure of the siphuncle wall, needed for evaluation of their position within the Endoceratida as a whole. Some of the general remarks on evolution have drawn upon the study of these groups, a report on which will be published in the near future.

Progress in the last thirty years has brought the present Ellesmeroceratida largely to light and to the attention of paleontologists at large. It must be urged that further study and further material for adequate study of many of these forms is eminently to be desired, particularly in relation to critical matters of shell morphology and to the study of possible variations within the species. A colleague has raised the question as to whether the cephalopods, being so much more diverse in terms of described species than the associated gastropods, had not perhaps been divided too closely. Without material for a study of specific variation, this is possible,* but it must be remembered that the cephalopod shell, having more parts, presents a basis for a more refined taxonomy than do the gastropods; without septa and siphuncles we would be able to recognize many fewer species, and such distinctions as characterize the Plectronoceratina, Ellesmeroceratina, and Cyrtocerinina would not be apparent. Yet the fossil Gastropoda may have had comparable differences in their unknown soft parts, in forms as similar in external shells as the Plectronoceratidae and Ellesmeroceratidae.

From a systematic viewpoint, all the known species have been considered in the present work. In some instances, review of the genera has shown that, in order for the genera to be definable, some generic transfer of species has been necessary. A considerable amount of new material has required the description of new species, but such work has been deemed of importance secondary to the problem of morphology and evolution, discussed primarily at the levels of genera and families.

Much space has been saved by abbreviating the references to three major works in the following pages:

UFM&F, 1942—Ulrich, Foerste, Miller, and Furnish
UF&M, 1943—Ulrich, Foerste, and Miller
UFM&U, 1944—Ulrich, Foerste, Miller, and Unklesbay

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*No species is known from a good suite or reasonably complete specimens, without which variation within the species cannot be determined.

Acknowledgments

I am deeply indebted to Dr. G. A. Cooper and the U.S. National Museum for the loan of some critical materials, without which some problems faced in the present investigation could not have been solved, as well as for an opportunity to examine the extensive suite of types representing this order; probably no other institution has such a large assemblage of representatives of the Ellesmeroceratida, and it possesses the types of a great number of the described American species. Particularly important for the present work was the loan of some material of *Robsonoceras*, from which thinsection study was possible, and the material of *Cyptendoceras*, without which the error of the supposed endoceroid affinities of this genus could not have been corrected. I am also indebted for the loan of a considerable collection from the Pogonip group of Utah and Nevada, which contributed some critical material to the present study.

Dr. Carl Dunbar and Dr. Karl Waage generously permitted the loan of the material of *Boreoceras* from the arctic and permitted necessary sections which yielded gratifying examples of diaphragms.

Dr. Virgil Barnes and Dr. Charles Bell submitted some material for study from the Llano uplift; much of the present material was collected with the help and guidance of Dr. Virgil Barnes, who collected and sent some additional material from the Threadgill limestone.

Dr. Gunnar Henningsmoen and the Paleontologisk Museum of Oslo kindly loaned the holotype of *Ellesmeroceras scheii*, upon which the genus *Ellesmeroceras* and, ultimately, the family and order named from the genus depend. Dr. G. Marshall Kay submitted some Ellesmeroceratidae from Newfoundland for study, but the material showed distortion and loss of internal structure, and in the end, it was regretfully decided not to include it. Dr. J. Lee Wilson submitted some material from the Praesidio region of Texas. Dr. William Sando contributed some material from the Canadian of Maryland. It was not possible to borrow or to see at that institution the material at the Museum of Comparative Zoology on which Hyatt (1900) based his recognition of the genus *Diphragmoceras* and the Diphragmida. A request to Dr. Teiichi Kobayashi for the loan of some Asiatic material went unanswered, but happily Dr. Curt Teichert supplied information on the genotype of *Wolungoceras*, which he had succeeded in borrowing earlier. The writer discovered in 1940 a prolific ellesmeroceroid assemblage in the Smith Basin limestone of eastern New York, and over several years accumulated a large collection which it was hoped would supply a basis for a critical study of the extent of variation within the species. Most of this material was the property of the New York State Museum and the writer was informed (Goldring, *fide litt.*) that it could not be loaned for study. Present descriptions depend upon only a part of the material collected in 1941. Ironically, when it became necessary to bring this work to a close, scant but most promising material had come from the collecting of Dr. C. L. Sainsbury from Alaska, and I wish to express my indebtedness to him and to Dr. Reuben Ross, through whose kind offices this material was submitted to me for study. It seemed for some time that more material could not be collected in the near future, but just when this work was undergoing final revision, some most promising material arrived; this was in large boulders, and its study would have delayed the present work from nine months to a year. It had to be left for a future publication.

I wish also to make grateful acknowledgment to Miss Teri Ray, who shouldered the greater part of the responsibility in editing, reduced greatly the onus of work in proofreading, and supervised innumerable time-consuming details connected with publication. Mrs. Shirlee Stahmann, Miss Josie Baca, and Mrs. Lois Devlin supplied valuable help, particularly in retyping of the many-times-revised pages of the manuscript, during which they showed remarkable perspicacity in interpreting the changes written in what approached rather closely to cuneiform. Mr. William Arnold, Mr. Ray Molina, and Mr. Bob Price redrafted Figure 3 and made repairs on several of the other figures.

Evolution and Classification

In 1950, Flower and Kummel presented a scheme of evolution of the Nautiloidea and a revised classification. Some changes have since been made in both, and the current results are shown in part in Figure 1, which indicates ranges, something of the size, and the relationships of the orders, together with the more significant suborders and a few families. The Ellesmeroceratida is here divided into three suborders: the Plectronoceratina, with siphuncular bulbs and weak rings; the Ellesmeroceratina, with strong rings outlining concave to tubular segments; and the Cyrtocerinina, for forms with the rings so thickened that they extend as lobes into the cavity of the siphuncle. Rings of the type found in the Ellesmeroceratina are shared by the older Tarphyceratida and Endoceratida, though they are considerably modified in the higher Endoceratida and, to a lesser extent, in some of the higher Tarphyceratida also.

General changes from the 1950 classification include the suppression of the Bassleroceratida (Flower, *in* Flower and Teichert, 1957) and the assignment of one of its two families, the Bassleroceratidae, to the Tarphyceratida with which it agrees in the thick, layered rings; the other, the Graciloceratidae, with thin rings, is the archaic family of the Oncoceratida. The change involves redefinitions, largely designed to eliminate this small order of only two families. No changes of concepts of phylogeny are involved. The Discosorida is now traceable to the Plectronoceratidae and is the only younger group known that is derived in this way (Flower and Teichert, 1957). It retains thick rings within which are specialized regions peculiar to this order. All other orders are derived through the Ellesmeroceratina.

The discovery by Kummel (1953) that the main stock of the Nautilida of the 1950 classification stems from the Centroceratida is here indicated. This left the Liroceratidae, together with some obviously derived families, outside this main lineage, and various suggestions as to affinities were proposed. Another work now awaiting publication* discusses this matter in relation to the description of some Permian cyrtocones of the Scyphoceratidae. It is found that the Liroceratidae stem from the dominantly lirate coiled shells of the Nautilida of the Mississippian, the Triboloceratina. The Solenocheilida of the 1950 classification is not indicated here; in the same work, this name is suppressed, as the family name Aipoceratidae takes precedence over Solenocheilidae. The group is derived from and is properly a part of the Rutoceratida, though it may conveniently be regarded as a suborder.

Dr. Walter Sadlick sent me, some years back, a sketch that suggested one feature of the present diagram, which shows by dashed lines those orders having the thick rings which are, surprisingly, primitive and which are reduced to thin, homogeneous rings independently in the several derived orders. Unpublished observations show the thinning of the ring to take place within the Actinoceratida; thick rings of some complexity mark the Polydesmiidae and the more advanced family, Wutinoceratidae. The thickening of the rings in the Oncoceratida is peculiar to that group and is quite possibly a secondary feature; this group, with the rings thickened into "actinosiphonate deposits," is given a symbol of its own, and the continuation of similar rings in the archaic Rutoceratida is indicated.

Crucial families indicated include the Baltoceratidae (B), a lineage of the Ellesmeroceratina showing some simplification of the rings; it is from this family that, as indicated here, the Michelinoceratida arose. The Shideleroceratidae, a family for the single, stratigraphically isolated, *Shideleroceras* of the Ordovician, is indicated and also the recently described order Ecdyceratida (Flower, 1962), a group consisting as yet of only one known orthoconic genus, odd and highly specialized.

In Figure 2 is shown a more detailed concept of evolution and classification of the main orders and families of nautiloids developed up to the close of the Canadian, with a few younger stocks indicated. At the base is placed the family Plectronoceratidae, compressed endogastric to straight shells with ventral siphuncles. In the primitive *Plectronoceras*, necks remain short and the fragile rings, where preserved, outline siphuncular bulbs. In higher genera, there is gradual, progressive lengthening of the necks, with the suppression of the bulbs; such lengthening appears first, curiously, on the ventral side of the siphuncle.

Derived from this family, but giving rise to nothing higher, is the small exogastric family, Balkoceratidae. Insofar as is known, this family does not share the adoral lengthening of the necks found in the higher Plectronoceratidae. The two together constitute the suborder Plectronoceratina, characterized by the bulbs, with thick rings which are, surprisingly, quite fragile, being commonly destroyed; further, our material suggests that these rings were possibly flexible, as is not impossible, for their fragility indicates them to be poorly calcified and possibly largely organic in original composition. Diaphragms in the siphuncles are, like the rings, apparently fragile but are believed to be a general feature of the group.

In the Ellesmeroceratina, siphuncle segments are mainly faintly concave and moderate in thickness, commonly showing differentiation of layers in the best-preserved material, though such layering is commonly well developed only in late growth stages, being indistinct or wanting in the young and not fully developed in the adult of the smaller species. The first family, the Ellesmeroceratidae, contains dominantly endogastric to straight shells, dominantly compressed in cross section. The first known forms are two specimens (to date) of *Ectenolites* in the Trempealeauan, but in the Gasconadian, there are 22 of the 27 known genera of the family and about 220 known species. Generic boundaries involve problems, for there is apparent gradation here, alleviated somewhat by regrouping of the species but nevertheless real; it is possibly an indication of the fact that this group of cephalopods was a rapidly evolving one. It embraces most of the cephalopods known in the Gasconadian; other forms include four species and three genera of the Plectronoceratidae, known only from Manchuria as yet. The genus *Walcottoceras* is so intermedi-

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*This work has been published since completion of the present manuscript: Flower, R. H., 1963, Two Permian cyrtocones from New Mexico, with discussion of their relationships. Jour. Paleontology, vol. 37, no. 1, p. 86-96, pl. 13, pars.

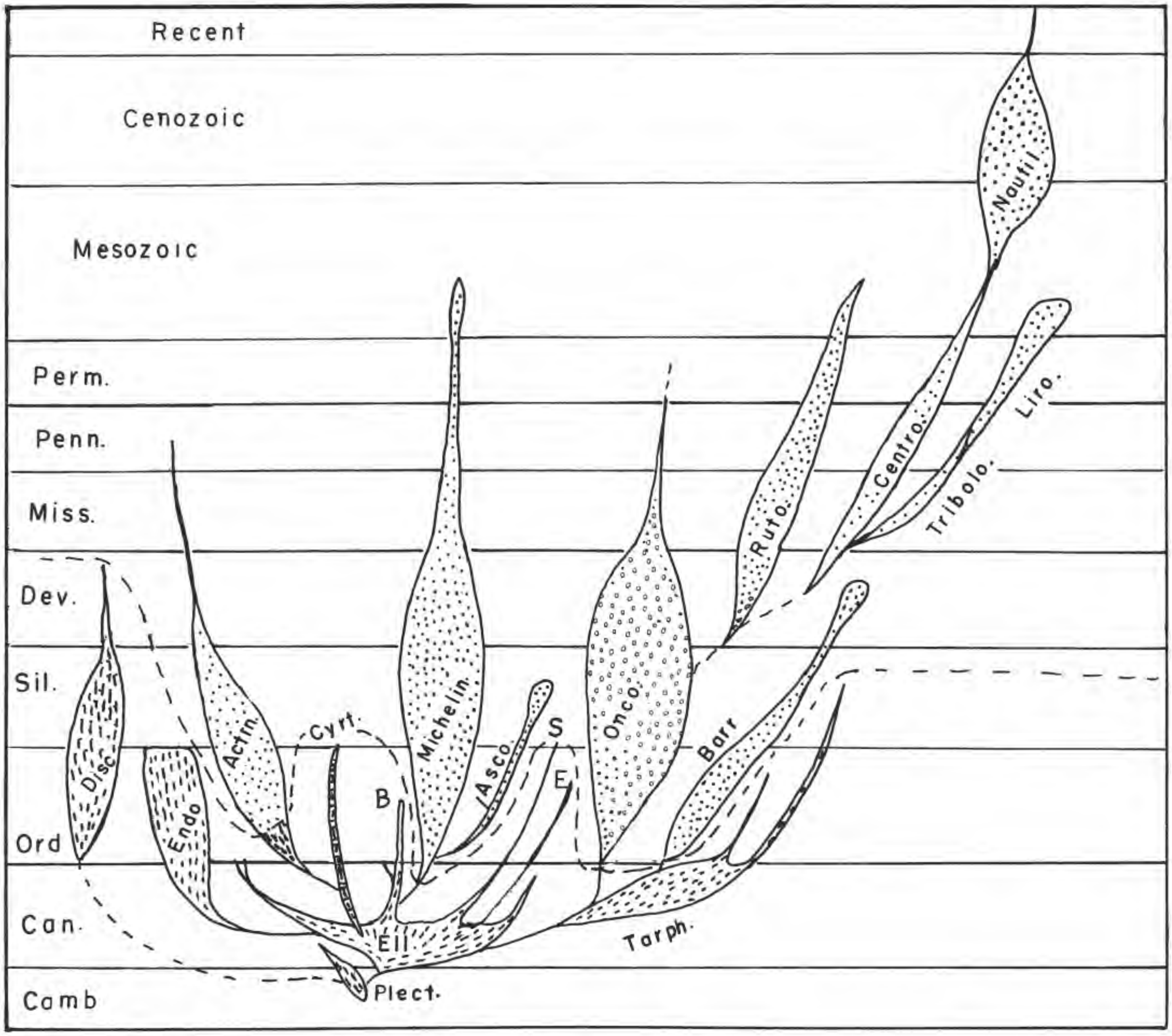

Figure 1
PHYLOGENY OF THE NAUTILOIDEA

Relationships of the main orders are shown, with suborders and a few crucial families indicated. Dashed lines indicate the thick rings; stipples, the thin homogeneous rings; small circles, the secondarily thickened rings of the Oncoceratida.

Plect.—Plectronoceratina (Ellesmeroceratida)
Ell.—Ellesmeroceratina (Ellesmeroceratida)
Cyrt.—Cyrtoceratina (Ellesmeroceratida)
Disc.—Discosorida
Asco.—Ascoceratida
Onco.—Oncoceratida
Ruto.—Rutoceratida
Centro.—Centroceratina (Nautilida)
Nautil.—Nautilina (Nautilida)
Endo.—Endoceratida
Actin.—Actinoceratida
Michelin.—Michelinoceratida
Tarph.—Tarphyceratida
B.—Baltoceratidae (Ellesmeroceratina)
Tribolo.—Triboloceratina
Liro.—Liroceratina
Barr.—Barrandeoceratidae
S.—Shideleroceratidae (Ellesmeroceratina)
E.—Ecdyceratida

ate between the Ellesmeroceratidae and Protocycloceratidae that it could really be put in either family, but with it are two species of *Rudolfoceras*. There is also *Microbaltoceras*, tentatively assigned to the Baltoceratidae, though if future work reveals diaphragms in the genus, it should be placed in the Ellesmeroceratidae, and reports, which seem to be questionable, include a representative of the dominantly Middle Canadian genus *Bassleroceras* and the associated monotypic genus, *Chepuloceras** (Unklesbay and Young, 1956).

With the sharp decline of the Ellesmeroceratidae at the close of the Lower Canadian is the apparently explosive ap-

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*I cannot but suspect the inclusion of some Middle Canadian fauna in this association.

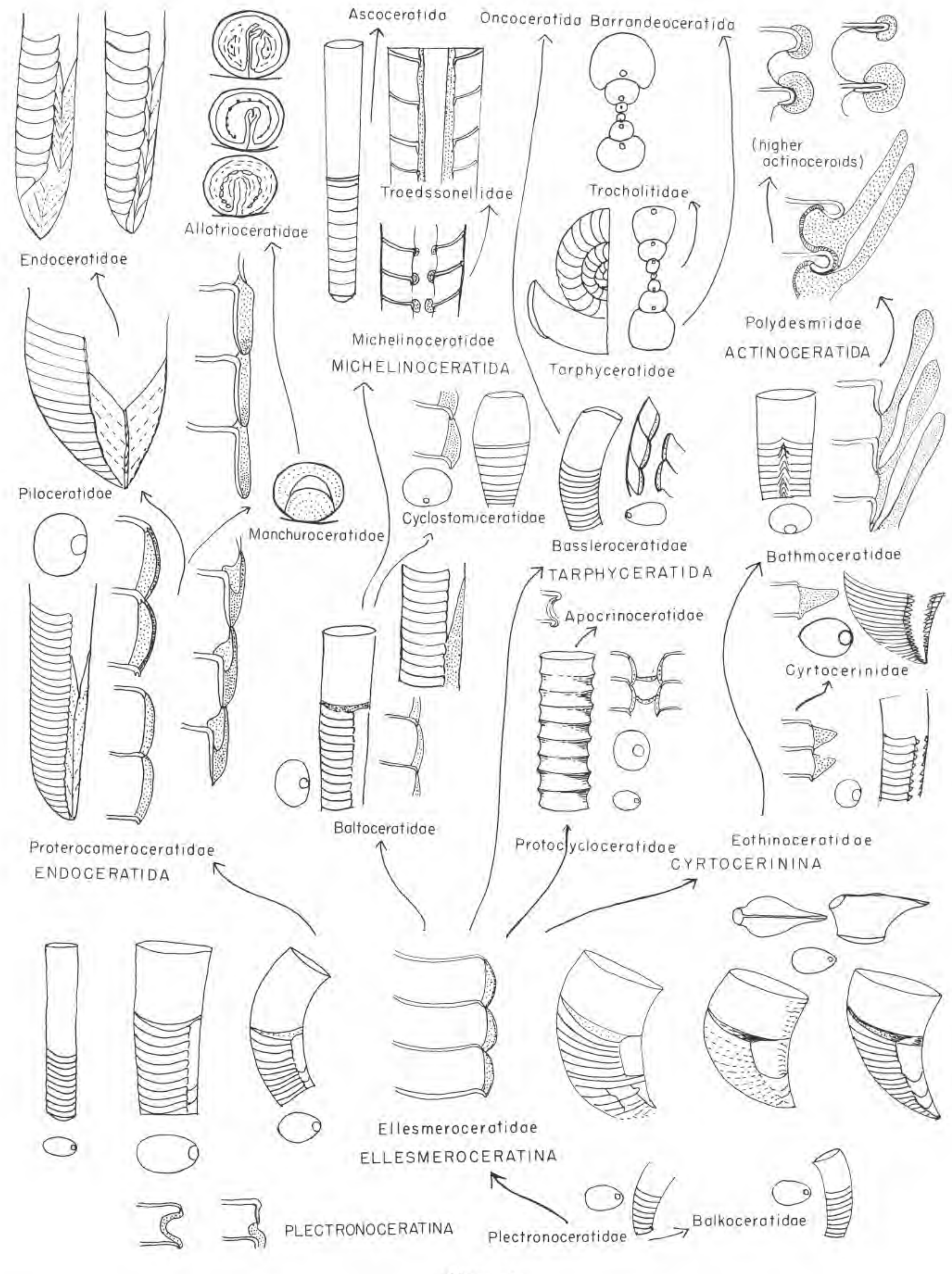

Figure 2

CEPHALOPOD EVOLUTION TO THE CLOSE OF THE CANADIAN

Families are indicated, their essential features shown diagrammatically. All families of the Ellesmeroceratida are shown. In the Endoceratida, some small families that would stem from the Proterocameroceratidae are omitted. Origins of the Ordovician orders Ascoceratida, Oncoceratida, and Barrandeoceratida are indicated. The Lituitidae, an Ordovician development of the Tarphyceratida, is not included.

pearance of the derived families of the Ellesmeroceratina, the Baltoceratidae and Protocycloceratidae, the suborder Cyrtocerinina, and the two new orders, Endoceratida and Tarphyceratida.

Inasmuch as problems of homeomorphy with the new orders will arise in the discussion of higher families of the Ellesmeroceratida, it is best to consider them first.

The first of the Endoceratida is *Proendoceras* of the Proterocameroceratidae. It is a shell having much the gross aspect of *Pachendoceras;* its siphuncle wall and early stages are like those of the Ellesmeroceratidae, and the essential difference, which marks the inception of the Endoceratida, is the suppression of diaphragms and the development of endocones instead. The Proterocameroceratidae is visualized as dominantly a group of straight, slender endoceroids, rather nondescript externally, but developing within endosiphuncles ranging from quite generalized to several diverse, highly specialized conditions. There is also, as shown in the figure, some elongation of the septal necks, which, in the example shown, taken from *Clitendoceras,* is gradual in ontogeny and fails to attain a completely holochoanitic condition. There are specializations here, some incompletely known as yet, but others have resulted in the recognition of several families (Flower, 1957), of which only two are here indicated: the Manchuroceratidae, breviconic shells which develop a ventral boss in the siphuncle, and the evidently derived Allotrioceratidae, the most remarkable of the endoceroids, in which the endosiphuncles are specialized by the development of multiple tubes. Two genera are shown here. The lowest and first is yet undescribed (to be named *Williamsoceras* and now completed in manuscript). The second and third figures represent early and late stages of *Allotrioceras;* the multiple tubes of the young are reduced to two in adult growth stages.

Surprisingly early in the Middle Canadian, there developed the first true Piloceratidae, endogastric, rapidly expanding shells with large conical siphuncles. Here septal necks become elongated and apparently remain in such a condition, while endosiphuncles remain relatively simple. It is held that in the first of the true Endoceratidae of the Ordovician, which agree in the siphuncle wall structure, and in the compressed early stages with the swollen siphuncle, first given the generic name of *Nanno,* there is a recapitulation of the piloceroid stage, unpopular as the concept of recapitulation may be at present. It is in younger Endoceratidae that the apical swelling of the siphuncle is reduced and finally lost completely.

The first Tarphyceratida are compressed cyrtocones with lateral lobes and ventral siphuncles; they are essentially Ellesmeroceratidae with reversed coiling, but show two other differences; diaphragms are suppressed, and the shells develop an appreciably larger size and proportionately longer phragmocones than do most Ellesmeroceratidae. The first of the shells is compressed, but later forms develop circular or depressed cross sections with straight transverse sutures. Connecting rings remain thick and show layering in adult stages. The Bassleroceratidae appear prolifically in the early Middle Canadian and are particularly prevalent in eastern North America. From them developed the first coiled forms. The first and simplest is the gyroconic *Aphetoceras.* Features of cross section and suture are so similar to those of *Bassleroceras* that from only a small fragment, one cannot be sure to which genus it should be attributed. Yet oddly, while a respectable group of species of each genus is now known, there is no single instance of transition from a cyrtocone of not more than three quarters of a volution to a gyrocone of at least a volution and a quarter. This led to the suggestion (Flower, 1955A) that the change is saltational, not gradual, and that quite possibly a determining factor is the radical change in the mode of life between a shell which lived with the aperture pointed obliquely down and forward to one in which the aperture was held horizontally. Further development in the family involves varying combinations of the following trends: (1) increased coiling, resulting finally in forms with appreciable impressed zones; (2) broadening of the cross section from the primitively compressed condition, most fully expressed in *Pionoceras;* and (3) migration of the siphuncle away from the venter, attaining a subcentral position in *Centrotarphyceras.* Apparently, our first *Aphetoceras* occurs quite low in the Middle Canadian, both in New York and New Mexico. Beginning in the Jeffersonian is a new trend, one in which the siphuncle moves to a dorsal position. This characterizes the family Trocholitidae. The development occurs prior to the evolution of *Centrotarphyceras.* Here the first forms are compressed in cross section and loosely coiled, and, as in the Tarphyceratidae, there is evolution expressed in broadening of the whorl and increased involution, both most fully shown by *Litoceras.* It is of interest that the earlier Trocholitidae retain, in the young, siphuncles that are ventral, a heritage from their ancestry in the Tarphyceratidae. The concept that early ontogenic stages indicate ancestry is at present out of fashion, but here there remains a striking example. Ordovician Trocholitidae accord with popular usage by reducing and obliterating this early condition (Hyatt, 1894). Those who deny recapitulation must find a different origin of the Trocholitidae. Oddly enough, this could be done, except that faith alone would be required to explain the ventral siphuncles in the early stages, to say nothing of the embarrassment involved in using the inadequately known *Beekmanoceras* as an ancestor.

While the Bassleroceratidae and Tarphyceratidae are not known to survive the close of the Canadian, the Trocholitidae continue throughout the Ordovician, and the last seemingly isolated example of the lineage is the Silurian genus *Graftonoceras.* The Lituitidae, regarded as derived from the Tarphyceratida in the light of Sweet's (1958) discovery of the thick rings, are not indicated on the diagram. Derived from the Tarphyceratida are two Ordovician orders. One, the Oncoceratida, is represented first by the Graciloceratidae, slender simple cyrtocones with ventral tubular siphuncles but with rings that are thin and homogeneous. Derived early, and established by Chazyan time, are the Oncoceratidae and Valcouroceratidae, forms with siphuncle segments expanded in the adult, though at first still slender in the young; the latter family has the rings thickened into the so-called actinosiphonate deposits. The Barrandeoceratida is an order of coiled cephalopods looking much like the Tarphyceratidae, but with thin homogeneous rings. It appears in the Chazyan, and the last known representatives are the highly specialized family, Rhadinoceratidae, of the Devonian.

Returning to the Ellesmeroceratina, we may first note the Middle Canadian development of the Cyrtocerinina, forms with the rings greatly thickened. *Eothinoceras* is logically derived from the Ellesmeroceratidae with little difficulty; in fact, we have an *Ellesmeroceras* (pl. 26, fig. 12) which shows some thickening of the ring trending toward this development.

Bathmoceras shows marked specializations in lengthening of the neck and forward projection of the lobes of the rings, but no other origin than *Eothinoceras* seems at all likely. *Cyrtocerina* is admittedly a puzzle, for it is isolated stratigraphically, appearing first in the Lowville, and in form is an endogastric cyrtocone strongly resembling the Lower Canadian genus *Levisoceras;* indeed, one would be tempted to suggest that *Levisoceras* is its ancestor, but this conclusion is suspect in the light of the wide morphological and stratigraphic gap separating the genera.

The Baltoceratidae is a derivation of the Ellesmeroceratida; precise origin is problematical, for there are two possible solutions conceivable from the present evidence, one through the Lower Canadian *Microbaltoceras,* but from the scant material we are not certain this form does not have diaphragms, though none is now known, and consequently assignment to the Ellesmeroceratidae is not justified. The other is the later suppression of the diaphragms; such a change could occur between *Robsonoceras,* believed to characterize the *Kainella* zone, and *Rioceras* of the early Middle Canadian. Indeed, the diaphragms of *Robsonoceras* supply the only difference distinguishing it from *Rioceras.* Once *Rioceras* is achieved, we are on firmer ground, for the changes required to derive higher genera of simple internal structures are relatively minor. It is apparently within the genus *Cyptendoceras* that there developed the rod, probably aragonitic, dominantly round in section, pointed anteriorly and lying always against the ventral side of the siphuncle, thickening apically until the entire cavity of the siphuncle is filled by it. This characterizes a group of genera including *Cyptendoceras, Rhabdiferoceras,* of the Canadian, and *Murrayoceras* and the secondarily cyrtochoanitic derivative of that genus, *Cartersoceras,* both of the Ordovician. The Cyclostomiceratidae are regarded as essentially straight breviconic forms derived from the Baltoceratidae. One genus, *Metabaltoceras,* is transitional to the extent that its assignment to either family could be justified. With it is found the exogastric *Cyrtobaltoceras* which, from its form, was at first considered a member of the Bassleroceratidae. The baltoceroid affinities are indicated, however, by the very large siphuncle and by the fact that similar ventral lobes are found in *Cyptendoceras* and *Metabaltoceras,* but not in the Bassleroceratidae.

Walcottoceras is a compressed, faintly endogastric shell with annuli. In section, sutures, and siphuncle, it is an annulated edition of *Ectenolites* and is the point of transition into the Protocycloceratidae. Assignment by age to the Ellesmeroceratidae would have been tempting had it not been that the Lower Canadian also contains two species of *Rudolfoceras,* more typical of the Protocycloceratidae in the broad cross section; both genera are here assigned to the Protocycloceratidae. This is a lineage of slender, dominantly straight shells with annuli, though faintly curved forms are known which are both exogastric and endogastric. Siphuncles of two sorts may be expected, those which are small and apparently empty and those which are larger and crossed by diaphragms. Both types are found. In addition, it seems possible to consider as members of this stock two forms with long septal necks, *Catoraphiceras (?) vaginatum* and *Notocycloceras,* in the absence of structures indicating other affinities. There are, however, species assigned not only to the Protocycloceratidae but to *Protocycloceras,* in which varied internal structures suggest that the genus and family contain slender annulated shells of more than one origin. Rods reported in *Protocycloceras* suggest possible derivation from the higher rod-bearing Baltoceratidae. A possible endocone, greatly prolonged ventrally in *Protocycloceras mendax,* suggests possible origin in the Proterocameroceratidae, and an illustrated lining in *P. affine* suggests possible derivation from the Troedssonellidae of the Michelinoceratida. The lining certainly rests upon misinterpretation of structure, and the reported endocone is probably only a ventral rod. We have also an apparent *Protocycloceras* from the closing phase of Canadian deposition showing rather long necks and thin rings, suggestive of the Michelinoceratida.

The small family, Apocrinoceratidae, is regarded as Protocycloceratidae which developed expanded siphuncle segments. The three genera and three species are late Canadian in age. No structures are known within the siphuncle, but the rings are certainly ellesmeroceroid in pattern. The Thylacoceratidae of Teichert and Glenister I have not included, in view of information (Glenister, *fide litt.*) that the group is largely if not completely of endoceroid derivation. Without evidence of endocones, it would seem that the Thylacoceratidae intergrade with the Baltoceratidae to such an extent that the advisability of recognizing two families is questionable.

In earlier works, *Buttsoceras* was placed in a family by itself, characterized by a free tube within the siphuncle believed to be, like similar tubes elsewhere, the calcified wall of the central artery. New material (Flower, 1962A) shows that the tube is only a preservation phenomenon; it results from leaching of the inner silicified surface of a lining, and as this lining is quite like that of the Troedssonellidae, *Buttsoceras* is assigned to that family. Assignment to the Michelinoceratida is indicated by thinsections of the siphuncle, showing well-developed necks and thin rings. Oddly, the material also shows associated species of *Michelinoceras* with good annuli in the siphuncle and one species which is slightly older, in the middle Cassinian. Present stratigraphic evidence suggests that the Michelinoceratidae is the older stock from which the Troedssonellidae are derived. The higher Baltoceratidae trend toward the Michelinoceratida in removal of the siphuncle from the venter, thinning of the rings, and development of cameral deposits, but the precise point of connection is difficult to determine among several baltoceroid genera of rather generalized aspect; possibly *Baltoceras* and *Bactroceras* are both close to the transition; the rod-bearing genera seem too specialized by the development of the rods.

Figure 2 shows relationships, but it proved impossible to indicate ranges or even the position of the first appearance of the major stocks. Stratigraphic sequence is violated seriously at only one point, for it was necessary to place *Cyrtocerina,* first appearing in the Lowville, close to *Eothinoceras* and below *Bathmoceras.* The origin of the Actinoceratida from *Bathmoceras* through *Polydesmia* has been previously discussed (Flower, 1957), and it is unnecessary to review these matters here, save to note that there have been no new contributions to the problem.

CONCEPTS OF NAUTILOID EVOLUTION AND CLASSIFICATION

The Ellesmeroceratida, as the primitive order of cephalopods, is particularly bound up with the concepts of nautiloid evolution and classification, and indeed, recognition of this group has resulted in profound changes in concepts of these interwoven subjects.

The old concept of nautiloid evolution proceeding from the orthocone through the cyrtocone and gyrocone to coiled forms is one which still lingers with us, though much evidence now shows it to be not only an oversimplification but one which is fundamentally misleading. The commonest group of orthocones, the Michelinoceratida, proves to be a lineage apart from those stocks in which exogastric coiling occurred. It is further evident that such orthocones as were considered potentially primitive, circular in section with a subcentral tubular siphuncle, are not ancient, appearing first in the Cassinian and becoming abundant only in the Ordovician above. That such shells should be primitive is, indeed, suspect on theoretical grounds, for the cephalopods are, in common with all molluscs and with other higher invertebrate phyla, bilaterally symmetrical, and such shells as show a superficial radial symmetry, we may view as probably derived rather than primitive. Oddly, while the primitive Ellesmeroceratida contain orthoconic as well as endogastric shells, very few of these species were known at the time when the primitive nature of the orthocone was proposed.

Hyatt (1900) developed a concept of classification based upon the dictum of Hagen, the pioneer in ecology: "Look at the inside of an animal to tell you what it is; the outside will tell you how it lived." (J. G. Needham, oral communication, 1935). Hyatt divided the nautiloid cephalopods into five orders based upon the form of the siphuncle and, in particular, on the form of the septal necks. In this classification he placed first the order Holochoanites, those forms in which the siphuncle was presumably composed of septal necks without the addition of connecting rings. This order, by implication of its position, was long believed to contain the archaic cephalopods. His Holochoanites he separated into two divisions, the rank of which remained undesignated, the Diphragmida and the Endoceratida. The Diphragmida remained long a mystery, for no forms were illustrated, one genus was briefly described which had no species and remained up to the present a *nomen nudum*. It contained orthocones and cyrtocones with diaphragms in the siphuncle and was based upon some material from Newfoundland. I have not been able to see this material, but there can be little doubt that it is the group which today is called the Ellesmeroceratidae. These cephalopods are not, however, holochoanitic. The Endoceratida seem an ancient group, for none survives the close of the Ordovician. Ruedemann (1905) suggested that the holochoanitic necks, being theoretically simpler than those with short necks supplemented by rings, were primitive and made the suggestion that with shortening of the necks, the rings developed from the endoceroid endosipholining. This concept must now be abandoned. It is now evident that the supposed endosipholining was largely based upon a replacement phenomenon; such a lining is, indeed, confined to a small group of extremely specialized Endoceratida, the Allotrioceratidae (Flower, 1955). Further, it is now evident that the holochoanitic condition is not one characterizing a general group of which the Endoceratida is a part but actually developed within the Endoceratida (Flower, 1947, 1955, 1957), more specifically characterizing the Endoceratina and found again within small specialized groups within the Proterocameroceratina. It is further evident that with elongation of the necks, the connecting rings are retained. In the light of a wider knowledge of the older cephalopods, it now appears that the Endoceratida did not develop prior to the Middle Canadian, after the rise and decline of the Plectronoceratina and most of the family Ellesmeroceratidae.

Much perplexity concerning the nature of the older cephalopods resulted from the acceptance as cephalopods of the two small Cambrian septate shells, *Volborthella* and *Salterella*. Grabau (*in* Grabau and Shimer, 1910) considered these genera primitive cephalopods and erected for them the order Protochoanites. He later (1919) proposed the hypothesis that these shells were homologous not with the shells of most cephalopods, but with the endoceroid endosiphuncles, the conch and phragmocones of the Endoceratida being new supplementary structures. While this view met with no general acceptance, the cephalopod nature of the Protochoanites did, and it proved a vexation, for no forms were found which seemed to connect them closely with other cephalopods. Schindewolf (1942, p. 329, fig. 1), while insisting upon their validity as cephalopods, was forced to place them in an isolated position. Gürich (1934), however, showed that the shell of *Volborthella* was an agglutinative structure and foreign to true cephalopods in this respect. Flower (1954) pointed out that both *Volborthella* and *Salterella* were seemingly radially symmetrical, to such an extent that no one had ever ventured to identify dorsal and ventral sides, that such a pattern is widely at variance with that of the oldest known cephalopods, and that while neither genus could be considered as a true cephalopod, they must remain of uncertain position. The two genera are not even obviously related to each other.

In the 1930's, various suggestions were made as to nautiloid classification and relationships, some of which do not have immediate bearing upon the Ellesmeroceratida but may be reviewed as affecting concepts of classification and phylogeny. Teichert (1933) in his study of the Actinoceroidea concluded that that group was not closely related to other cephalopods, but regarded it as probably closer to the Endoceratida than to any other group. This view was based upon the similarity of these two groups in the large diameter of the siphuncles and the relatively long necks. Today it is evident that the similarity is a result of a very approximate convergence, for the Endoceratidae with their long necks, which influenced Teichert's suggestion, were developed long after the Actinoceratida were established. He presented not one but two suggestions for cephalopod classification, thus doubling the possibility that one might have some validity. First, he suggested classing all shelled cephalopods in the orders Ammonoidea, Endoceroidea, Nautiloidea (which would include both the orthocones and the curved and coiled groups), Actinoceroidea, Cyrtoceroidea, for cyrtocones and brevicones with large siphuncles, and Gomphoceroidea, for similar shells with small siphuncles. Second, in a postscript he called attention to the then recent description of *Maruyamaceras* (here misspelled *Murayamaceras*) and made the further suggestion that the cephalopods could be divided into Eurysiphonata, for forms with large siphuncles, and Stenosiphonata, for forms with small siphuncles. I had supported this classification in part for some years (Flower, 1941), for it seemed to have merits, particularly in separating the Actinoceratida from the orthocones with tubular siphuncles, from which Schindewolf and Kobayashi considered them derived; but it is now evident that it must be abandoned, for the actinoceroids and endoceroids can be connected only through the Ellesmeroceratida which one can accommodate in the Eurysiphonata only by stretching the group beyond possible definition. Likewise, the six orders prove inadequate, for, apart from separating the actinoceroids and endoceroids from other orthocones, a proposal which was not entirely new, the Ellesmeroceratida were not taken into account; no provision was made for the Discosorida or Ascoceratida, and the placing of the main group of orthocones with the coiled orders of the Nautiloidea must now be rejected, for the two lineages prove to be quite distinct. Also, separation of Cyrtoceroidea and Gomphoceroidea has proved impossible.

At about this same time, studies of the older cephalopods in America undertaken by Ulrich and Foerste (1933, 1935) and Kobayashi (1930-1936) brought to light some remarkable primitive cephalopods from Manchuria and Korea. Kobayashi's results were published first with adequate illustration and detailed description. The detailed results of Ulrich and Foerste appeared much later, being completed by Miller and various coworkers. Without attempting to follow Kobayashi's discoveries in their strict chronology, we may note (1) the recognition of the Plectronoceratidae, as based upon the Cambrian *Plectronoceras* and three Wanwanian (Gasconadian) genera, as forms with the part of the siphuncle segments between the necks, outlined by the rings alone, expanded into a siphuncular bulb and (2) his recognition of the ellesmeroceroid as a stock with diaphragms in a ventral siphuncle, characteristic of the Lower Canadian (Wanwanian, Gasconadian). In his study of *Manchuroceras* (1935), he proposed an interesting scheme of phylogeny which is worth noting as it approaches that ultimately adopted. He accepted the Plectronoceratidae as primitive, and the Ellesmeroceratidae as the derived next step, one characterized by holochoanitic structure and diaphragms, and leading to a group of endoceroids; from these, however, he derived the Baltoceratidae, regarded as developing short necks, and the Troedssonellidae as showing a similar development but retaining the endoceroid endocones. A separate line leading from the Plectronoceratidae he regarded as leading through the holochoanitic Wolungoceratidae and Protocycloceratidae to the "Orthoceratidae" and thence to the Actinoceratidae. It is here that one first finds the Plectronoceratidae and Ellesmeroceratidae regarded as significant groups, and the two families are united under the heading of "Ellesmeroceroids." Unfortunately, this scheme accepted a then generally held concept that holochoanitic structure was general among the older cephalopods. In the higher Plectronoceratidae, the ontogeny shows a gradual lengthening of the necks, and the next step is quite logically a truly holochoanitic condition which was accepted for the Ellesmeroceratidae and the endoceroids in general and also for the Wolungoceratidae and Protocycloceratidae. However, in the light of closer morphological studies, it is now evident that the supposed holochoanitic condition, which had been accepted in general for the Canadian cephalopods, was false. The Canadian cephalopods do show, in general, siphuncle segments which are tubular or concave, quite generally preserved. This, to anyone whose work had centered about younger forms, seemed an indication that septal necks were involved rather than the connecting rings, for in many younger cephalopods the rings are thin and fragile, and in such genera as *Leurocycloceras* of the Michelinoceratida and *Cumingsoceras* of the Barrandeoceratida, rings are so fragile that they are more commonly destroyed than preserved. However, later work showed that the strong siphuncle walls were not holochoanitic in genera but were formed by remarkably thick rings commonly showing a layered structure.

Ulrich and Foerste (1933, 1935) called attention to some odd structures, some new, some reported previously but not generally known, as the diaphragms of Hyatt's Diphragmida. They called attention to the expanded siphuncles in *Plectronoceras* and its allies but regarded them as an early aberrant group. The name Diphragmida was used for some forms with diaphragms. Attention was called to some odd structures, possibly ventral rods, in the siphuncle of *Protocycloceras*, and the remarkable apparent free tube and cameral deposits in *Buttsoceras*. The completion of the Ozarkian-Canadian cephalopods, largely by Miller and various associates after the deaths of Foerste and Ulrich, de-emphasized these remarkable morphological features to a disappointing degree, used an obviously artificial grouping of the genera, and avoided most of the interesting questions of structure and relationship which these cephalopods raised. Meanwhile, Flower (1941, 1941A) began investigation of the siphuncles of some of these older cephalopods, continued later (1946, 1947) and, in fact, is still continuing. Thinsection study showed that the Ellesmeroceratidae and the exogastric forms, the present Tarphyceratida and the primitive endoceroids of the Canadian, had short necks but that the concave segments were commonly outlined by connecting rings which are evidently well calcified and strong, for they may be preserved where even septa are destroyed; such rings show considerable complexity of structure, most commonly a layered pattern. The siphuncular bulbs of the Plectronoceratidae are far from what we were prepared to expect in the oldest cephalopods. Miller (1943) pointed out that only one apparent ring was known in *Plectronoceras* and that the structure might well be adventitious. Flower (1950, *in* Flower and Kummel) accepted this view and placed only *Plectronoceras* in the Plectronoceratidae, uniting the other genera which belonged with it in the Ellesmeroceratida. More material, however (Flower, 1954), supplied additional evidence of the validity of the siphuncular bulb, and though this was in a new genus, *Palaeoceras*, from the Cambrian of the Llano uplift, it did much to re-establish the group as outlined by Kobayashi previously; while this different genus did not prove the reality of the bulb in *Plectronoceras*, it did re-establish the structure in a certainly allied Cambrian cephalopod and made the validity of the structure in *Plectronoceras* highly probable. In that work, the Plectronoceratidae was re-established essentially as recognized by Kobayashi, with the addition of the new genus *Palaeoceras*. In the present work, two modifications are made. The first is the discovery of additional material, yielding a form similar to the Plectronoceratidae except in exogastric curvature; this is the new genus and species *Balkoceras gracile*, the basis of the family Balkoceratidae. This provides a logical place for the perplexing genus *Shelbyoceras*, at first thought to be an endogastric shell. Flower (1954) found a septum well preserved on the concave side of the shell, which showed no septal foramen, and concluded that the shell was either exogastric or was not a cephalopod at all. At that time, there was no indication of an exogastric cephalopod prior to the development of the Bassleroceratidae in the Middle Canadian, so it was concluded that *Shelbyoceras* might not be a cephalopod. With the discovery of *Balkoceras*, the nature of *Shelbyoceras* as a cephalopod becomes possible and logical, though even yet the siphuncle is not known and, indeed, we have for the phragmocone only a small part of an external mold (Flower, 1954). The second, not concerned with the present family or suborder, is the addition to the Late Cambrian faunas of *Ectenolites primus*, the only Cambrian member of the Ellesmeroceratidae and of the Ellesmeroceratina so far known.

Schindewolf (1942) presented a scheme of phylogeny of the nautiloids approaching a classification. He regards *Volborthella* as a cephalopod but gives it an isolated position in his scheme. He traces two lineages from *Plectronoceras*, one through the Diphragmida and Ellesmeroceratida (to both of which he gives holochoanitic necks) to the "Endoceracea," in which he includes *Nanno, Endoceras, Piloceras, Cyrtendoceras, Wolungoceras*, and *Baltoceras*, another to the "Orthoceracea," from which he derives the "Actinoceracea," the Lituitidae, the "Nautilacea" and the "Cyrtoceracea," while he derives the "Ascoceracea" from the "Orthoceracea." In the main, this seems a slight elaboration of Kobayashi's 1935 proposal with the addition of the lituitids, the nautilicones, and the actinosiphonate Cyrtoceracea. It is interesting to note that he attributes to *Baltoceras* a structure which may well be a ventral rod, such as is found here in higher Baltoceratidae. On what material this was based is not made evident. Our findings fail to support the presence of a rod in *Baltoceras*, but Schindewolf may well have had something which represented possibly one of our higher genera of the Baltoceratidae and might even conceivably have been a true *Baltoceras* with a rod, though this seems most unlikely from the material of *B. burchardi* examined for the present study.

The classification of Flower and Kummel (1950) recognized in the pre-Ordovician cephalopods the order Ellesmeroceratida, with essentially the scope given to it in the present work, the Endoceratida, also with essentially the same scope, though the details of classification have since been modified, and some new types that have been described (Flower, 1954, 1957), and classification will be even further modified in the light of new material now at hand. The order Bassleroceratida, for exogastric cyrtocones, was regarded as the primitive cyrtoconic lineage from which sprang Canadian Tarphyceratida on one hand and the Ordovician Oncoceratida on the other.

Among the oddest revision was that presented by Moore, Lalicker, and Fischer (1952). Ordinal groups, being essentially new and having no relationship to those of Hyatt (1900), were given *-ida* endings. Memoranda circulated in connection with the Treatise of Paleontology had gone so far as to recommend such endings and even to recommend the universal use of these endings in the animal kingdom, a suggestion which would hardly be accepted in the light of the general use of *-optera* endings for the winged insects, and the ending *-formes* which had become long established for the birds.* However, in this work, the major groups were changed to *-oidea* endings; the origin of this and the reason for modification is not divulged, but it seems to have been an effort to make these divisions more similar to the taxonomic guesses made by Teichert in 1933. An even odder change was the reduction of all the coiled groups to a single order, Nautilida, which seems a step backward rather than forward. Oddly, this came at a time when earlier suspicions had become confirmed that while the later coiled forms showed some general unity, their archaic stock, the Rutoceratidae, sprang, not from earlier coiled forms as had been considered possible, but from the Oncoceratida (Flower, 1952). Kummel (1953) found evidence of the derivation of most of the Nautilida from the Centroceratida and proposed uniting these orders, leaving the Liroceratidae and obvious descendant families outside this scheme of relationship. Other suggestions have been made by Shimansky concerning the coiled forms, which will be reviewed in detail on another occasion; it will suffice to note that the Liroceratina stem from the coiled Mississippian forms of the Triboloceratidae which, as more than a single family seems desirable for the expression of variation, may be referred to as the Triboloceratina.

Flower and Teichert (1957) elaborated the classification of the Discosorida, and found evidence in the siphuncular bulbs in the young stages of *Ruedemannoceras* suggesting derivation from the Plectronoceratidae independent of other cephalopod stocks which are derived similarly of course, but indirectly, through the Ellesmeroceratina.

Teichert and Glenister (1952) described some new cephalopods from Australia among which was the genus *Thylacoceras*, an orthocone with a ventral siphuncle and long necks. Believing such long necks to characterize slender Canadian endoceroids in general, they assigned it to that order.† In 1954, realizing that the form lacked demonstrable endocones, they erected the family Thylacoceratidae, assigned to the Ellesmeroceratida, but suggested that these forms were, by virtue of their long necks, of endoceroid origin, but that below a certain critical size, the endocones disappeared from the siphuncles. Of this, I took a dim view, having in El Paso materials even smaller siphuncles with good endocones within. The same work included the new genus *Apocrinoceras*, assigned to the Discosorida on the basis of the fact that its siphuncle segments resembled those of the young of *Westenoceras*, being subquadrate in section. This presented a dilemma, for the shell was a slender annulated orthocone, and if the Westonoceratidae were traceable back to it, the Ruedemannoceratidae could not belong in the discosorid lineage. Further investigation showed that *Apocrinoceras* was one of three genera (Flower, *in* Flower and Teichert, 1957) of annulated orthocones evidently derived from the Protocycloceratidae but differing from that family in that the siphuncle segments are expanded in the camerae. Their rings are of the ellesmeroceroid pattern and show no indication of a real relationship with the Discosorida. The dilemma of the Thylacoceratidae is not yet resolved, though current studies by Glenister (*fide litt.*) show that with more material, endocones have been found in *Thylacoceras* and in some of the other genera.

The restudy of *Ecdyceras* (Flower, 1962) reveals it as not an ascoceroid but an orthoconic cephalopod retaining a phragmocone, in which are amazingly deep septa, and camerae, in which are extensive cameral deposits. The genus is unique among the nautiloids and is given an order of its own. The retention of thick rings and diaphragms in early growth stages is indicative of ellesmeroceroid derivation, but no close connection has yet been found.

Buttsoceras, supposedly an orthoconic cephalopod with a

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*It was nevertheless felt that inasmuch as the cephalopod orders were essentially new, these endings were as good as any others and shorter than the *-oidea* or *-acea* endings used by Teichert (1933) and Schindewolf (1942).

†The idea that slender Canadian endoceroid genera are holochoanitic was a matter of pure supposition. Of the genera then known, short necks had been demonstrated in three of them. Two others prove not to be endoceroids, and siphuncle and structure remain unknown in the remaining three.

free tube in the siphuncle, was given a family by itself by virtue of this singular feature (Flower, *in* Flower and Kummel, 1950) and assigned to the Ellesmeroceratida. Restudy, including some finely preserved new material, shows that the tube is a preservation phenomenon; it results from, first, silicification and then extensive leaching, not of a free tube, but of the inner surface of a lining in the siphuncle. Further, new and better-preserved material shows necks and thin, homogeneous rings of the Michelinoceratida and indicates that *Buttsoceras* should be assigned to the formerly monotypic family, Troedssonellidae. With *Buttsoceras* in the late Canadian, and also in slightly older beds, are found species assigned to *Michelinoceras,* with good annuli in the siphuncles. While present known ranges may be modified with further discoveries, it appears probable that the Michelinoceratidae is older than the Troedssonellidae and is the archaic stock of the order Michelinoceratida (Flower, 1962A).

These are the essential changes in concept up to the present time. Oddly, since 1950, several diagrams of phylogeny of the older cephalopods have been prepared involving these various changes in concept. One (Flower, 1954) was published. Since then, the Endoceratida have been elaborated and other families recognized. The Thylacoceratidae now seem doubtful as to position but are probably an odd Canadian stock of the Endoceratida. *Apocrinoceras* appeared as a Canadian genus of the Discosorida, and then this interpretation was rejected. The Buttsoceratidae has been suppressed, *Buttsoceras* included in the Troedssonellidae, and the Troedssonellidae are traced back to the latest Canadian; the Michelinoceratidae begin in slightly older beds, thus bringing the beginning of the Michelinoceratida back into the middle Cassinian. In the Actinoceratida, the Wutinoceratidae have been recognized (Flower, 1957) as a stock particularly characteristic of the Whiterock, and here we have returned to the interpretation of the Maruyama beds of Manchuria as latest Canadian.

Sweet (1958) has found evidence of thick rings of the Lituitidae, and though their structure shows specializations of their own, there is a sufficient basis for assigning this family to the Tarphyceratida instead of to the Barrandeoceratida. Unpublished evidence suggests that the Allumettoceratidae should be assigned to the Michelinoceratidae; problems in tracing lineages in that order are discussed elsewhere (Flower, 1962B), where the new family Proteoceratidae also is proposed.

Current Problems

I HOMEOMORPHY

If the history of the understanding of the older cephalopods has proved to contain some comedies of errors, it is not altogether surprising, for one is forced to deal with rare material, often fragmentary and more or less altered, and we are possibly not yet at the end of such mistakes. The present work has encountered some odd dilemmas, the certain solution of which must await the discovery of more complete and better-preserved specimens than are now available. Perhaps the oddest situation thus uncovered is the fact that in the Middle and Upper Canadian, there are generalized straight shells with ventral siphuncles, that such shells are generalized for this time interval, and that they are possibly attained not only in the Ellesmeroceratida but in the Endoceratida and possibly even in the Bassleroceratidae of the Tarphyceratida; some early Michelinoceratidae may be involved also. Such possible homeomorphy is involved in smooth shells of the Baltoceratidae and shells with annuli assigned to the Protocycloceratidae.

In the Cambrian and Lower Canadian there are, happily, only a few problems of this sort, probably because we are there near the beginning of the cephalopods and there were not yet the diverse stocks from which such homeomorphs might develop.

The Cambrian cephalopods are tiny shells, compressed, with ventral siphuncles. We know only a few species as yet, three of *Plectronoceras*, two of *Palaeoceras*, of the Plectronoceratidae, and one of *Balkoceras* and five of *Shelbyoceras* of the Balkoceratidae; in addition, one species, known from two specimens, belongs to *Ectenolites* of the Ellesmeroceratidae and is the only member of that family or of the Ellesmeroceratina thus far found in the Cambrian. In the Gasconadian, the Ellesmeroceratidae constitute the dominant stock and are dominantly endogastric to straight, compressed shells, though a few broaden their cross sections. We know 21 of the 27 genera of the family, which include better than nine tenths of the known species, in that age interval. With them, known as yet only from the Wanwanian of Manchuria, are the last of the Plectronoceratidae; three genera and four species are recognized. Real or possible forerunners of more advanced stocks are few. *Walcottoceras* is so intermediate between the Ellesmeroceratidae and the Protocycloceratidae that it could be put in either family; were it not that with it, in the Smith Basin limestone, are found more advanced forms with broad cross sections with the lateral lobes lost, two species assigned to *Rudolfoceras*, *Walcottoceras* might have been placed in the Ellesmeroceratidae by its section and sutures instead of with the *Protocycloceras* because of its strong annuli. We have also in the Lower Canadian the small, conical, straight shell *Microbaltoceras*. From the absence of diaphragms, this is tentatively assigned to the Baltoceratidae, but future finds may require transfer of the genus to the Ellesmeroceratidae should diaphragms be found. This would not be surprising, for an alternate origin of the Baltoceratidae is possible, through *Robsonoceras* of the Ellesmeroceratidae by the loss of diaphragms. We are here, it should be noted, entering upon consideration of a group of essentially straight shells of subcircular section, ventral siphuncle, and straight traverse sutures, a generalized type beyond the Lower Canadian and prior to the Ordovician proper in which it is hard to find reliable indications of affinities.

In the study of the Baltoceratidae, we have faced the current dilemma already referred to, first brought to general attention by the description of the Thylacoceratidae. The family, as known from Teichert and Glenister (1954), contained simple orthocones with ventral siphuncles, in which relatively small modifications of section and suture, together with variations in siphuncle wall structure, were made the criteria of genera. As thus defined, the Thylacoceratidae contained orthocones with siphuncles of small diameter and with long necks, thus contrasting with the Baltoceratidae, which have generally larger siphuncles with very short necks. I had for some time questioned the distinctness of these two families for two reasons: (1) Isolated instances of lengthening of the necks were known in the Ellesmeroceratidae (in *Metaellesmeroceras* and in species of *Clarkeoceras*) and a similar development in the Baltoceratidae seems possible. (2) The separation of Thylacoceratidae and Baltoceratidae on the criteria noted above is imperfect, in relation to both the diameter of the siphuncle and the lengthening of the neck, and it seemed possible that the two families as thus defined represented two extreme developments in what remained essentially a single lineage of the Middle and Upper Canadian. Indeed, one reason for the long delay from which the present work has suffered was the hope of more material by which this questionable matter could be investigated.* The discovery by Dr. Glenister that some shells at least assigned to the Thylacoceratidae are true endoceroids shows that smooth generalized orthocones with ventral siphuncles, simple sutures, and circular to depressed sections are potentially homeomorphs of both ellesmeroceroid and endoceroid derivation, and that description and assignment of such specimens from fragmentary material may be both premature and, ultimately, embarrassing and erroneous. It may be pointed out that in the Late Canadian where the exogastric Bassleroceratidae developed exogastric shells of circular or depressed section, with ventral siphuncles and simple sutures, straightening of such shells (a development of which there is already some indication in known species of *Onychoceras* which show a marked adoral reduction of curvature) may again produce homeomorphs of the Baltoceratidae. Nevertheless, the validity of the Baltoceratidae in the main is shown by the fact that the stock appears early in the Middle Canadian, where it not only merges in gross features with demonstrable Ellesmeroceratidae but appears prior to the broadening of the cross

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*Oddly, some such material came to hand, some orthoconic cephalopods from boulders of conglomerate from the Praesidio region of Texas, submitted by Dr. J. L. Wilson. Though associated faunas suggest Lower Canadian assignment for these forms, they show the general features of the dominantly younger Baltoceratidae but have the small siphuncles and rather long necks of the Thylacoceratidae. The material was not included in the present work because the small suite of specimens (though good in relation to material by which some other Canadian stocks are known) showed calcite in the siphuncle but was inadequate to show whether such calcite was inorganic, represented endocones or possibly some other type of structure, or was adventitious.

section in the Bassleroceratidae. The possible origin of the exogastric *Cyrtobaltoceras* in the Bassleroceratidae was, indeed, given serious consideration. It was rejected, however, because no Bassleroceratidae are known to combine broad cross sections with such large siphuncles or with sutures which develop marked ventral lobes, while both developments are to be found in unquestionable Baltoceratidae; such lobes are common to *Cyptendoceras*, a baltoceratid in the siphuncle of which the peculiar ventral rods are developed, a type of structure apparently peculiar to and developed within this family and shared by *Metabaltoceras*. This last genus supplies a transition from the Baltoceratidae into the breviconic Cyclostomiceratidae; without such evidence, Bassleroceratidae could be considered as validly as the Baltoceratidae as the source of that small family.

A similar problem of homeomorphy surrounds the straight shells with annuli of the Canadian, the Protocycloceratidae. It was realized, in assigning genera to this family (Flower, *in* Flower and Kummel, 1950), that it was possible that this Canadian group might contain homeomorphs, but no evidence of such homeomorphy was then apparent. Slender shells with annuli have developed several times independently in various parts of the Michelinoceratidae. UFM&U assigned these genera to three families, the Endocycloceratidae, regarded as stemming from the smooth endogastric *Stemtonoceras*, the Rudolfoceratidae, regarded as stemming from the exogastric Bassleroceratidae, and the "Spyroceratidae," used for orthoconic forms apparently regarded as stemming from the "Orthocerotidae" of that same work. It has been apparent that curvature is an unsafe guide to relationship since the work of Hyatt (1883-1900), and though such relationships are possible, closer scrutiny failed to supply evidence in more fundamental structures to support it. Teichert and Glenister (1954) raised the question of homeomorphy anew and assigned *Notocycloceras*, by virtue of its long septal necks, to the Thylacoceratidae. This seems possible, but not adequately demonstrated, and it seems possible that elongation of necks could occur within the Protocycloceratidae as a valid unified lineage.

However, other evidence suggests varied derivations not only of the Protocycloceratidae but of species which have been assigned to the genus *Protocycloceras* itself. Our present work shows that in some Protocycloceratidae, siphuncles are small and apparently empty. Others are large and contain diaphragms. Both conditions are possible in a lineage derived from the Ellesmeroceratidae, as the family is believed to be, for in small Ellesmeroceratidae diaphragms are retarded and difficult to demonstrate in the absence of apical parts of shells, and they may be absent in some species altogether. However, there are suggestions of other derivations which it was not possible to investigate adequately in the present work. Ulrich and Foerste (1936) called attention to structures in *Protocycloceras lamarcki* and *P. mendax* which, in the light of the findings of the present work, are probably ventral rods developed in the Baltoceratidae, and the possibility that some Protocycloceratidae are nothing more than Baltoceratidae which developed annuli on the shell surface must be considered. However, UFM&U (1944), who say nothing about the structure in *P. lamarcki*, described that of *P. mendax* in such a way as to suggest, not the ventral rod of the Baltoceratidae, but ventrally prolonged endocones such as characterize *Mcqueenoceras*, which may show grooved or ridged surfaces.* Likewise, we have figured here an apparent *Protocycloceras* from the highest Canadian (Odenville equivalent) of the Florida Mountains (pl. 29, figs. 1, 4, 5) which suggests that this form, with long necks and apparently thin rings, may possible belong to the Michelinoceratida rather than to the Protocycloceratidae of the Ellesmeroceratida.

It is interesting, if a little irritating, to reflect that these generalized orthocones of the later Canadian require either exceptionally complete specimens or large suite of fragments which, on the basis of probability, may be expected to yield a fair assortment of early and late growth stages of mature and immature shells. Yet it is true in the case of endoceroids, that sorting may play such peculiar tricks as supplying only endosiphuncles in some beds, while, more rarely, the lighter anterior parts of shells without the endocones may be deposited elsewhere by themselves.† Often, description from a few fragmentary specimens may lead to errors, as shown in *Thylacoceras;* and quite possibly we are not yet at the end of such comedies of errors. In one respect, the requirements here seem almost as demanding as though one were to require specimens of trilobites, complete as to thoracic segments and even legs, for recognition of family, genus, and species; but in the case of the cephalopods, the homeomorphy is here quite well demonstrated, and the features required for the separation of the groups are those which are commonly shown in either reasonably complete shells or species represented by reasonable suites of material. Even were this not true, the reality of the homeomorphy of these straight, slender shells with circular or depressed sections and ventral siphuncles would be none the less valid.

It is some comfort that, as fas as is now known, this dilemma is faced largely in the interval embraced by the Middle and Upper Canadian. There are a few such shells in the Lower Canadian, but there the Endoceratida and Bassleroceratidae or the Tarphyceratida had not yet developed. In the Ordovician, the Baltoceratidae persist, but other stocks which could be confused with them are not evident; there the endoceroids are mainly so much larger that no problem exists in distinguishing them, and other orthoconic stocks show the more obvious necks and thin rings of the Michelinoceratidae and are commonly of such an aspect that no confusion with the Baltoceratidae is likely. Likewise, the orthocones with annuli are obvious Michelinoceratida, with siphuncles generally smaller and more removed from the venter; where ventral siphuncles prevail elsewhere in the order, as in some Proteoceratidae and Allumettoceratidae, the broadly expanded siphuncle segments supply obvious distinctions.

II STRATIGRAPHIC GAPS AND ANOMALIES

In relation to the Ellesmeroceratida and derived orders, there remain some vexing stratigraphic gaps between the supposed ancestor and descendant. In each instance, the forms bounding such gaps have been scrutinized to see whether

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*Further investigation has failed to support the development here of endocones and suggests that the structures are ventral rods similar to those of the Baltoceratidae.

†I found a striking example of this in the Trenton near Point Rouge, Quebec; lower beds yielded only endosiphuncles which, from the generalized cross section, are probably assignable to *Cyclendoceras;* but specimens showing the conch were found only in superadjacent beds of the same stratigraphic unit, a Hull equivalent.

some alternate interpretation of relationship could be found, for such gaps may reflect the existence of homeomorphy rather than real relationship. Quite the widest gap is that separating the Plectronoceratidae (Upper Cambrian and Lower Canadian) from the first of the Discosorida, *Ruedemannoceras,* known from the Chazyan, with one possible but too fragmentary form recently found in beds of probable Whiterock age. There are in this instance no other possible ancestors of the Discosorida known in the later Canadian. As shown elsewhere (Flower, *in* Flower and Teichert, 1957), we must reject *Apocrinoceras* of the late Canadian of Australia as supplying either such a possible connection or evidence of homeomorphy between the Plectronoceratidae and the early stages of *Ruedemannoceras.*

Both a morphological and stratigraphic gap separates *Cyrtocerina,* which ranges from the Lowville to the Richmond, from *Eothinoceras* of the Middle Canadian, its most likely ancestor on the basis of the structure of the siphuncle wall. In form, *Cyrtocerina* is more like *Levisoceras,* but postulating such an origin involves an even wider stratigraphic gap, for we know *Levisoceras* only in the Lower Canadian. Higher in the section, there are no rapidly expanding endogastric cyrtocones except for *Cumberloceras* of the Middle Canadian, which is not adequately known as to details of the siphuncle wall but has diaphragms typical of the Ellesmeroceratidae.

The genus *Shideleroceras,* given a family of its own and assigned to the Ellesmeroceratina, is a rather simple endogastric cyrtocone, and in view of its simplicity it is rather odd that we have no similar forms lower in the Ordovician and nothing very much like it in the Upper or Middle Canadian, and though I have not been happy about the assignment of this form to the Ellesmeroceratida, no other course has been found which seems at all tenable. *Ecdyceras* (Flower, 1962) as revised is a cephalopod so peculiar that it is given an order by itself; it must spring from some part of the Ellesmeroceratida, and, from the diaphragms in the siphuncle, quite probably from the Ellesmeroceratidae. If we have no forms in the Middle and Upper Canadian supplying such a connection, it is perhaps not surprising, in view of the known occurrence of *Ecdyceras* itself, which is known from three isolated occurrences, the Chazy of the Champlain Valley, the lower Viola of Oklahoma, and the Arnheim of Kentucky.

Canadian Stratigraphy and History

The Canadian, here treated as a system distinct from the Ordovician above, embraces that part of the column known for many years as the "Calciferous sandrock" of the older New York Reports. It was regarded as almost proverbially barren, yielding here and there a few nondescript fossils. In New York, as time went on, two distinct faunas came to light, the Fort Cassin fauna described by Whitfield (1886, 1890) and the fauna found by Professor G. D. Harris and students, later described by Cleland (1900), which has come to be known as the Tribes Hill. Meanwhile in Canada, Billings was describing fossils from the "Quebec group," but unfortunately his descriptions are generalized and brief, many species were unillustrated, and except where subsequent work has been done, the species remain largely unrecognizable, so that one must consult the types in Ottawa to learn what they are.

Ulrich brought together extensive collections of the Canadian and "Ozarkian" and planned a series of studies of the faunal elements. Of these, only two appeared, the brachiopods by Ulrich and Cooper (1938) and the cephalopods, begun by Ulrich and Foerste (1933, 1935) and later completed by Miller with various associates (UFM&F, 1942; UF&M, 1943; UFM&U, 1944). Ulrich recognized a faunal succession characterizing the formations of the Ozark uplift. Bridge (1930) described some of the older fossils and Cullison (1944) those of the Jefferson City, which he divided into the Rich Fountain and Theodosia formations, and also species from the Cotter and the Missouri Powell formations; Heller (1954) has described Roubidoux faunas, and all have contributed to description of the formations and sections. However, even yet the descriptions of the faunas are not complete for those intervals already covered, and our knowledge of the higher Powell of the south side of the Ozark uplift, the Smithville and Black Rock formations, is confined to the brachiopods and cephalopods described in the works noted above, while Ruedemann (1947) had included the few graptolites. The Ozark column in a generalized form is as follows:

UPPER CANADIAN	Black Rock	
	Smithville	
	Powell	
	Cotter	
	Theodosia	Jefferson City group
	Rich Fountain	
MIDDLE CANADIAN	Roubidoux	
LOWER CANADIAN	Gasconade	
(or UPPER OZARKIAN)	Van Buren	

The work was complicated by some changing views. It is today quite generally recognized, largely through the efforts of Bridge, that the Lower Ozarkian is nothing more than the Trempealeauan, while the Upper Ozarkian is the equivalent of the Lower Canadian. There were detailed changes in concept of the formations. For years, the New York State Museum had on exhibit gastropods from the "Bald Mt. Limestone" of Middle Falls, New York, labeled as *Eccyliopterus planibasalis* and *E. planidorsalis* Ulrich. These were manuscript species, which Ulrich considered diagnostic of the Cotter formation. Cullison finally described one of these as *Leseurilla planodorsalis* and considered it diagnostic, not of the Cotter, but of the Theodosia formation. It is well to note, however, that for years the Canadian has been correlated in terms of the Ozark section, and the faunal criteria depend to a large extent on species undescribed and a concept of faunal successions which has not even yet been recorded completely.

Usage has varied in recent years, but there is a tendency to forget the Ozarkian completely and to treat the Canadian as merely the basal part of the Ordovician, a usage which the writer finds impossible in relation to the cephalopods. Flower (1957) presented a general summary of the Canadian, pointing out the distinctness from the Ordovician in faunas and in general paleogeography, and proposed divisions, the Gasconadian for the Lower Canadian, the Demingian for the Middle Canadian, and the Jeffersonian for the lower Upper Canadian and the Cassinian for the later part, the two showing strikingly different patterns of distribution of the sediments. In the meantime, some fine detailed work was done on the Llano uplift (Cloud and Barnes, 1946) contributing to the understanding of the stratigraphy and faunal succession. Of particular significance and value was the study here of the first extensive and relatively fossiliferous section of the Middle Canadian, the Gorman formation. Ross (1951) and Hintze (1952) presented studies of the Garden City and Pogonip successions, respectively. They established a faunal succession depending primarily upon the zonation of the trilobites, recognizing, in the Garden City, zones A through L with M in the overlying Swan Peak quartzite, and in the Pogonip succession farther west, zones A through O.

These zones are of particular importance and will be referred to in detail further on; it should be noted here that the successions are valid, but that inasmuch as they are zoned from the trilobites, which are not completely known in eastern sections, some difficulty attends their precise correlation with eastern beds at the present time.

GASCONADIAN

The Gasconadian, Lower Canadian, is here conceived as represented in eastern North America by, first, rarely preserved, scattered, very early beds which, though their faunas seem oddly disparate and most are not adequately described, seem to be equivalents of the Van Buren formation of the Ozarks. Ulrich recognized the Van Buren on the basis of the combination of beds lithically more like those of the Cambrian below than those of the Gasconade above, but containing faunas of "Ordovician" rather than Cambrian aspect. Oddly, one could say the same for the Baldwin Corner formation of the Fort Ann region of eastern New York, and in the last years unpublished work (Barnes, *fide litt.*) has shown Ordovician faunas in the upper beds grouped lithically with the Cambrian San Saba limestone of the Llano uplift. We could make the same claim for the upper beds included in the Bliss sandstone of New Mexico. However, there are extensive regions where no beds of this age interval have been recognized, and it seems generally true that they are wanting over large areas, are present only where the Trempealeauan is developed below, and are apparently lacking in some regions, as in the northern Mississippi Valley, where the Trempealeauan is fully developed.

The next interval, the Gasconade proper, is divisible into several faunal units in the Ozark uplift, indicated by Bridge (1930). In central Texas, it is divided into two members, the Tanyard and the Standebach (Cloud and Barnes, 1946). At Fort Ann, I have recognized the Skene and Vly Summit members, with some significant faunal differences.

As yet, enough sections have not been studied in sufficient detail to make certain that there is a general faunal succession in the Gasconade of general and widespread significance; some intervals are dolomites with only sparse fossils preserved in scattered cherts. It is easier to find specimens in loose cherts than in place, and the scarcity of fossils is such that possibly a considerable part of our knowledge of the faunas rests upon such loose specimens, but zonation is, of course, obscured by this situation. There is some indication that while there is variation, the eastern sections have *Helicotoma angulata* and *Paraplethopeltis* in the higher beds only.

Ulrich believed that conglomerates in the Gasconade surface indicated a period of uplift and erosion; Bridge (1930) concluded that in the Ozark region, where there is so much collapse structure of later origin, evidence of such a condition was inconclusive. However, in eastern New York and Vermont, where later collapse features are not evident, the Gasconade surface shows such features with remarkable clarity, and they can be seen at Fort Ann on the surface of the Smith Basin limestone; they continue into Vermont, where they are evident on the equivalent top of the Shelburne marble. I have seen a suggestion of a similar solution at the top of the Tanyard formation of central Texas, but it may be open to other interpretations there. The upper pebble bed of the El Paso section, noted by Cloud and Barnes (1946), marks this same horizon, and it is apparently in this interval that the beds with *Kainella* found in the section in the Big Hatchet Mountains of southwestern New Mexico belong.

The Lower Canadian in New Mexico consists of (1) the upper, thin-bedded beds of the Bliss sandstone over most of New Mexico, but in the eastern sections in the San Andres Mountains, this interval shows a remrakable southward increase in thickness, and from present evidence, the extremely thick section at El Paso contains only Canadian beds; (2) the lower Sierrite member of the El Paso, of generally thin beds with undulate bedding planes, largely produced by styliolitic solution; and (3) alternating shales and dolomites in the Hatchet Mountains with massive dolomites above with large conspicuous chert nodules. The lower shales contain *Kainella*; the upper beds with cystid and trilobite fragments have yielded nothing definitely identifiable as yet.

DEMINGIAN

The Middle Canadian beds in eastern North America are in general not very thick, and many of them are rather barren. They are most commonly recognized on the basis of the widespread gastropod *Lecanospira*. Dwight (1880, 1883, 1887) made known some of the crucial faunal elements in what is now known as the Rochdale limestone (Knopf, 1946) where two types of cephalopods are particularly characteristic. The same types, the first Tarphyceratida, mainly *Bassleroceras*, and the first endoceroids, the genera *Clitendoceras* and *Proendoceras*, are striking and dominant elements in the Fort Ann limestone faunas, and similar types are conspicuous in the fossils described from the Kirby and Spellman ledges near Beekmantown, New York (Whitfield, 1889). It was something of a surprise to find, however, that at Fort Ann this general fauna is well established in beds with a large *Leseurilla*, developed slightly before *Lecanospira* appears in the section. Oddly, while the fauna is primitive as to both Tarphyceratida and Endoceratida, as one traces the Fort Ann formation to the north, there are added to the base of the section 300 feet of Cutting dolomite, with, finally, a characteristic sandstone at the base; onlap conditions of deposition from north, perhaps northeast, to the south are suggested, and possibly this continues southward; the fact that no beds below those containing *Lecanospira* are known in the Rochdale succession of the southern Hudson Valley is at least consistent with this interpretation.

Heller (1954) found a zonation in the Roubidoux of the Ozark uplift, a conspicious feature of which is the presence of *Campbelloceras* in the upper beds, similar to the upper limestone of the lower member of the Fort Ann formation.

Cloud and Barnes (1946) found a significant succession in the Gorman formation and a considerable fauna. It is, however, in the El Paso limestone that one finds the most marked succession of faunas. The first endoceroid zone contains endoceroids *(Proendoceras?)*, rare *Bassleroceras*, an *Aphetoceras* but has abundant gastropods, including *Lytospira*, *Ozarkina*, and *Ophileta*, of Gasconade aspect, but with them a new form allied to *Liospira*, and *Diaphelasma pennsylvanicum*. This bed, 60 feet thick, is succeeded by the first piloceroid zone (60-80 feet), characterized by *Piloceras*, *Bisonoceras*, some undescribed genera, with *Rioceras* well developed and relatively common, and coiled forms in which several species of *Campbelloceras* are the commonest and most conspicuous elements. Here sponges are significant and common for the first time in the section. The 60-80 feet of this interval are succeeded by 35-40 feet of beds in which black oolitic limestones are prevalent and significant, containing flocks of trilobite fragments, mainly a form which is apparently a *Megalaspis*, with high- and low-spired gastropods. A reef above has yielded *Bridgeites*, a flat-spired gastropod, but most other faunal elements, though present, decline to come out in identifiable conditions. There follow thin-bedded limestones of calcilutite, bearing mainly tiny gastropods strongly reminiscent of the Lowville but containing *Leiostegium* in places, seemingly grading up into more massive beds, reefy in some sections, with *Mcqueenoceras*, regarded as marking the base of the Upper Canadian. At El Paso, oddly, the upper beds of the Middle Canadian are gone, but the higher dolomites of the basal member contain the fauna of the first endoceroid zone, then alternating dolomites and limestones, first massive, thinner above, containing the first piloceroid fauna, above which thin sandy beds set off a dolomitic phase of the oolite. More sandy beds follow, above which is a stromatolitic reef with *Mcqueenoceras* marking the base of the Upper Canadian.

JEFFERSONIAN

This interval in the Ozarks consists of the Rich Fountain and Theodosia formations, formerly united as the Jefferson City, and the Cotter formation. For some time it was doubtful whether the Powell formation belongs here or in the Cassinian above; puzzlement was increased by the fact that the fauna recorded for the type Powell is a small one and consists of species representing genera known to have wide stratigraphic ranges. The exclusion of the Powell rests upon (1) the previously suggested affinities of the Powell and Fort Cassin faunas and (2) the presence of forms close to but not identical with the Powell forms in the Cassinian part of the El Paso.

The Jeffersonian is quite widespread in the Ozarks, in central Texas, and in the southern Appalachians. Oddly, in New York we find evidence only of remnants of beds of the Theodosia formation, present in scattered remnants in the Mohawk and Champlain valleys and included in the Ogdensburg sequence of northeastern New York. Faunas are incompletely recorded, but Cullison (1944) has made a significant contribution to the knowledge of those of the Ozark uplift. Starting in this interval are several horizons of operculae, to which the generic name *Ceratopea* has been given, and the characteristic genus *Orospira* appears.

In the El Paso succession, the Jeffersonian, largely eroded in northern sections, as at Mud Springs Mountain and Rhodes Canyon, thickens southward and is represented in New Mexico by (1) the *Mcqueenoceras* zone, (2) the second piloceroid zone, characterized by piloceroid siphuncles, almost completely of the aspect of *Allopiloceras*, and (3) upper calcilutites which, where present, are largely barren but contain some higher stromatolitic beds with endoceroid and piloceroid siphuncles and sponges as the only conspicuous fossils. The few sections where these beds are preserved in New Mexico show some variation, evidently faciological. At El Paso, we find (1) stromatolitic, reefy dolomites with the *Mcqueenoceras* endosiphuncles prominently displayed, (2) relatively barren, thin beds of alternating limestone and dolomite, (3) a massive, reefy succession with abundant *Allopiloceras* and sponges, (4) massive nonreefy limestones with piloceroids, and (5) thin-bedded limestones with few recognizable fossils, the whole occupying some 400 feet. The section continues with a second succession of reefy beds, massive and then thin-bedded limestones, and a third occurrence of reefy beds which promises to repeat this succession yet again, but here higher beds have become dolomite, and a disconformity in the middle of sandy dolomites marks the base of the Cassinian.

CASSINIAN

The Cassinian shows a distinctive base in the El Paso of conspicuous cross-bedded sandy layers. In New York, the Cassinian shows onlap relationships on an eroded surface dominantly of Demingian but with remnants of a Theodosia equivalent; it, too, has conspicuous sandstones at the base. In many regions the Cassinian seems to have been removed by post-Canadian elevation and erosion. Faunally, it is here that the Tarphyceratida attain their greatest diversity, with both Tarphyceratidae and Trocholitidae attaining their peak of abundance and variety. Protocycloceratidae are particularly abundant in this interval, though not confined to it; in the Baltoceratidae, *Cyptendoceras* is particularly characteristic, and in the Bassleroceratidae, *Onychoceras* and *Leptocyrtoceras*, though they are not strictly confined to this interval, appearing also more sparingly in the Jeffersonian. Characteristic, but limited and not generally abundant, are the Cyclostomiceratidae and the Apocrinoceratidae. True *Proterocameroceras* is found only here, and large *Cassinoceras* is characteristic.

A closing phase of the Cassinian has been found to be particularly characterized by a "*Maclurea*" of the general aspect of *M. sordida* (Hall), the cephalopod *Buttsoceras*, and a rather characteristic brachiopod association. Cloud and Barnes (1946) noted, on the basis of the brachiopods, the similarities in faunas of the Odenville, Black Rock, highest Arbuckle limestone, and the highest El Paso. It is now evident that extensions of this fauna are to be found in the highest Canadian of the Garden City limestone in the form of *Buttsoceras* and, also, in the brachiopod and gastropod types, high in zone K in the Pogonip succession of the Ibex area. I had at first thought the characteristic assemblage in the highest El Paso, occurring as it does in calcarenites among orange silty beds, might be a facies phenomenon, but the various faunal elements have proved too widespread and independent of lithology for this interpretation. Oddly, while calcarenites of similar aspect occur in the western Pogonip, in the more easterly Garden City no such lithological distinction occurs.

INADEQUATELY KNOWN SECTIONS

A number of significant sections are not included in the above discussion, largely because the faunal succession is not recorded in detail. This is true for the St. George beds of Newfoundland and the Phillipsburg series of Quebec, though there it is evident that the Hastings Creek and Lake Hill are certainly Demingian, but the Naylor ledge could be either Demingian or early Jeffersonian. In the northern Mississippi Valley the Oneota is unquestionably Gasconadian, but precise placing of the relatively barren Shakopee is somewhat doubtful, though nothing there suggests Demingian and the fauna favors Jeffersonian rather than Cassinian assignment.

The Manitou dolomite of Colorado is similar faunally to the El Paso. I have recognized the first endoceroid and first piloceroid zones there, but no indication of higher faunas in the rather thick, largely barren, upper part, but these observations are certainly superficial.

I have also little data on the faunal succession of the Arbuckle succession of Oklahoma, which embraces probably the entire Canadian interval.

It is apparent that more collecting and observation are needed in the Canadian of North America.

Stratigraphic Distribution of the Cephalopods

CAMBRIAN CEPHALOPODS

Undoubted Cambrian cephalopods are known only from two regions as yet; the *Tsinania canens* zone, probably late Franconian, of North China and Manchuria, and a single 2.5-foot bed in the upper part of the Trempealeauan San Saba limestone of the Llano uplift of central Texas. The Asiatic occurrence has yielded only two species of tiny, compressed, rather rapidly expanding phragmocones of the genus *Plectronoceras*. The San Saba limestone occurrence yielded originally only the two specimens upon which *Palaeoceras mutabile* was based. Some years ago, I had an opportunity to visit this locality under the guidance of Dr. Virgil Barnes, and a second collection was made from this horizon. At that time, it had been recognized by Dr. Barnes and Dr. Charles Bell that the Cambro–Ordovician contact lay somewhat lower than had been supposed previously, but Trempealeauan trilobites still persist 20-30 feet above the cephalopod-bearing bed.

This cephalopod bed is a yellow oolitic limestone showing some dolomitization in places and a rather abundant development of styliolites. Its fauna includes (1) some scarce and extremely fragmentary trilobite remains, (2) abundant ribeirids, all apparently of a single species, (3) *Kygmaeoceras perplexum*, and (4) the cephalopods. The new collection of cephalopods contained about 14 fairly good specimens, but they showed a variation which was completely beyond our expectations. There were not only straight shells but also some shells curved both endogastrically and exogastrically. Some were smooth, some showed faint transverse expansions and constrictions, perhaps incipient costae. For such variation, I was completely unprepared and put the material aside for a time, hoping that with another look the differences would disappear. This they failed to do. The material was photographed largely externally, and then various of the specimens were sectioned. The tiny size of the shells and the faint color contrast of structures made it desirable, and indeed mandatory, that thinsections be employed for the bulk of the material. The small size of the specimens made it necessary to grind to the level of the siphuncle for mounting. Only the thinsections of some of the specimens remain, and the external aspect is preserved only in photographic records. Unfortunately, two of the most exciting specimens were not photographed prior to sectioning, and they proved the most unusual of the lot. One was a bit of phragmocone not discovered until a chance cut gave us a nearly longitudinal section. The other was a specimen so unprepossessing externally that it was not photographed at all and was sectioned only with a faint hope that it would yield any structure. Both seemed, however, to differ from the other forms in having a rather thicker shell wall and septa which were much more deeply curved. The differences proved more significant than that, for the siphuncles of these two forms are tubular, the species are assignable to *Ectenolites* and are the first members of the genus and the first true Ellesmeroceratidae to be found in the Cambrian.

The remainder of the material is divided as follows: (1) A moderately expanding endogastric cyrtocone, rather slender for the genus, with faint constrictions and expansions, but assigned in spite of this slight difference to *Plectronoceras*. (2) Typical *Palaeoceras mutabile*, a smooth straight shell. (3) Straight forms with faint constrictions and expansions, a distinct species, *Palaeoceras undulatum*. (4) Smooth, compressed, slender, faintly exogastric shells. Internally, they are quite like *Palaeoceras*, and I at first considered redefining the genus to accommodate this species. However, exogastric curvature, though slight, is as amazing a thing in a Cambrian cephalopod as would be a spondylium in a Cambrian linguloid, and I have separated this form as *Balkoceras gracile*, and separated it in the family Balkoceratidae, apart from the Plectronoceratidae. The implications of this form are even more interesting. Some years ago (Flower, 1954), new material of *Shelbyoceras* showed that it had no siphuncle on the clearly observed parts of the septum, that either the siphuncle was wanting, and the thing was not a cephalopod at all, or the siphuncle was on the convex side of the shell. As no exogastric cephalopods were then known in Cambrian or Lower Canadian beds (the oldest ones being the Bassleroceratidae of the Middle Canadian), it was concluded that probably *Shelbyoceras* was not a cephalopod at all. However, this reasoning left *Shelbyoceras* without any possible close relatives; it was not at all similar to septate hyolithids or the peculiar *Salterella and Volbothella*. The new discovery suggests, however, that *Shelbyoceras* might be a true cephalopod, derived from *Balkoceras*, and the genus is here tentatively assigned to the Balkoceratidae. Specimens showing the structure of siphuncle and phragmocone remain to be found, and any taxonomic disposal of this poorly known genus must be inferrential, but the features known are consistent with interpretation of the shell as an exogastric cephalopod; no other forms, even among the hyolithids, are known which are at all closely similar.

It may be noted that *Plectronoceras* occurs in China in beds which are almost certainly of Franconian age and that the Llano uplift of central Texas has yielded an additional, much more slender, endogastric form assigned here to *Plectronoceras*, two species of *Palaeoceras*, both genera of the Plectronoceratidae, with the exogastric *Balkoceras* of the Balkoceratidae. *Shelbyoceras*, here tentatively assigned to the Balkoceratidae, is rare but known to be more widely distributed. Moore's (1960, p. 12) statement, "The purpose of [making these] observations is to point out features of the early fossil record that distinguish monoplacophorans and gastropods from other molluscs, none of which are recognized without question in rocks older than Lower Ordovician . . . ," is quite contrary to facts which have been known generally for some years. Walcott described *Cyrtoceras cambria* in 1905, later made the genotype of *Plectronoceras* Ulrich and Foerste. In 1936, Kobayashi added a second species; these were reviewed and *Palaeoceras mutabile* added in 1954 (Flower). Moore is not quite up to date in his information. The present work brings the genera occurring in the Cambrian to five, the species to thirteen, including the cephalopod *Shelbyoceras* with its six species but excluding the *Ruthenoceras* and *Shantungendoceras*. *Shantungendoceras* is not a recognizable genus, but its age is not Cambrian; it was apparently based on Ellesmeroceratidae of the general aspect of *Ectenolites*, *Ellesmeroceras*, and *Stemtonoceras* (Flower, 1951, 1954).

Ruthenoceras Kordé (*see* Flower, 1954) and its synonym, *Angaroceras*, were based upon chance-oriented sections of a small endogastric cephalopod which belongs evidently to the Ellesmeroceratidae. Though the genus is so poorly known that intelligent comparison with others is not strictly possible, it is of interest that in the present investigation two similar fragments have been found, not in the Cambrian but in the Gasconadian of the Llano uplift. While this does not disprove the Cambrian age of the Siberian material, it must be noted that the associated fauna, which would supply the needed evidence, has not been listed. Oddly, the Tanyard occurrence suggests that this may be one more mistaken assignment of a Canadian cephalopod to the Cambrian, but our finding of *Ectenolites*, a member of the Ellesmeroceratidae in the Cambrian of the Llano uplift, would lead one to lend credence to the Cambrian age of this genus, as yet another member of that family in that age interval.

GASCONADIAN CEPHALOPODS

The 21 of the 27 known genera of the Ellesmeroceratidae now recognized are confined to the Lower Canadian, with the exception of the Cambrian *Ectenolites primus*, already noted, and one species from the Middle Canadian tentatively assigned to the otherwise Lower Canadian *Muriceras*. With them, known only from the Wanwanian of Manchuria, are three genera and four known species assignable to the Plectronoceratidae. *Walcottoceras*, in which genus only three species are recognized, is assigned to the Protocycloceratidae but is so close to the Ellesmeroceratidae that assignment to that family instead could be considered almost equally justified. The Smith Basin limestone has yielded two species of the more advanced *Rudolfoceras*. *Microbaltoceras*, which from the absence of diaphragms is assigned to the Baltoceratidae, though it is realized that future material may require reversal of this decision, is yet known only from three specimens from the Tanyard of the Llano uplift of central Texas.

HIGHER CANADIAN CEPHALOPOD SUCCESSIONS

In general, the Plectronoceratina characterize the Upper Cambrian, the Ellesmeroceratidae the Lower Canadian, though there are a few overlaps. Above the top of the Lower Canadian, we find the Baltoceratidae and Protocycloceratidae of the Ellesmeroceratida, the Endoceratida, and Tarphyceratida as major constituents of the faunas, but similar broad distinctions cannot be used to characterize the Demingian, Jeffersonian, and Cassinian. In general, one may expect in the early Demingian faunas a domination of the simpler Proterocameroceratidae of the endoceroids and of the simpler Bassleroceratidae, those with compressed sections, of the Tarphyceratida as dominant types. Oddly, while this is the situation at Fort Ann, where there are added only a few Tarphyceratidae, an *Aphetoceras*, and *Campbelloceras* a little higher, one finds in tracing these beds to the north 300 feet of barren beds coming in below, but still above the erosion surface on the Smith Basin limestone. In the El Paso succession, where the break at the base of the Middle Canadian is most obscure, one finds a very different situation. With *Diaphelasma* and a "*Liospira*" one finds gastropods of genera which one would expect to find instead in the Gasconadian, but the cephalopods, though simple Proterocameroceratidae are dominant, contain few and only rare *Bassleroceras*, and one finds coiled forms, though not abundantly, and a few piloceroids, which one would expect from their relationships to follow these simpler members of the Endoceratida. Higher in the Demingian, the first piloceroid zone shows a great diversity of the Endoceratida, with not only true *Piloceras* and *Bisonoceras* but a number of other types, some with siphuncles of highly distinctive form. Only piloceroid fragments are known in the Gorman, and farther east piloceroids in this interval are very few and remain most inadequately known. Baltoceratidae and Protocycloceratidae occur but are minor faunal constituents. *Cumberloceras* is largely characteristic of the Demingian, but known species and specimens are few, and one Jeffersonian species is known.

Typical Jeffersonian faunas are known from steinkerns in dolomites. Here there is further expansion of the Endoceratida; slender shells dominate in the east, but a number of *Allopiloceras* are known, largely in beds regarded as equivalents of the Cotter. In the Bassleroceratidae, there is a transition from the simpler genera of the Demingian to those of broader whorl or with moderately contracted apertures. The Tarphyceratidae are more varied, and the Trocholitidae appear. It is in the Cassinian that the coiled Tarphyceratidae and Trocholitidae attain their acme. Protocycloceratidae, and particularly shells of the aspect of *Protocycloceras* itself as now restricted, attain their peak here, and it is to this interval that the Cyclostomiceratidae and Apocrinoceratidae are confined. Here also appear the first of the Michelinoceratida, though neither *Michelinoceras* nor *Buttsoceras* is common until the closing phase of the Cassinian deposition.

In the Fort Ann section, where the section is most incomplete, the contrast among the cephalopod faunas is striking with (1) Ellesmeroceratidae dominating the Lower Canadian, (2) *Bassleroceras* and primitive Proterocameroceratidae dominating the Middle Canadian, with a very few coiled Tarphyceratidae which are not abundant, and (3) the addition of the abundant and varied coiled forms, Tarphyceratidae and Trocholitidae and the piloceroid *Cassinoceras*, characterizing the Cassinian. Cephalopods of (1) the first endoceroid zone, (2) the first piloceroid zone, and (3) a group which could belong to either of these horizons, but not higher or lower, was found in the Garden City limestone of northern Utah, but without data as to associated trilobites.* Nothing

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*Some were picked up loose. Others came from sections where associated or nearby beds fail to show the trilobites. No Jeffersonian nautiloids have been found, but forms of Cassinian aspect come from zones J and K. It is apparently K which yielded the *Buttsoceras* in the Garden City formation. In the examination of the Pogonip section, the writer found small orthoconic forms, largely Baltoceratidae and Protocycloceratidae, in zone K very reminiscent of forms in the Cassinian of El Paso. The same sections show near the top of K some calcarenites with the brachiopod and gastropod association of the highest El Paso, but the *Buttsoceras* was not found there.

The position of the *Kainella* below the first endoceroid zone of the El Paso in the Hatchet Mountains suggests that this zone may mark the time interval in which in the east the Gasconade was elevated, and solution features were developed on its surface. Knowledge of the faunas of this zone is still certainly most incomplete; with more complete knowledge, it may become advisable to place it on the other side of the Gasconadian–Demingian boundary.

indicating the second piloceroid zone of the Jeffersonian has yet been found.

WESTERN SUCCESSIONS

The foregoing discussion has extended only as far west as the El Paso succession. The zonations of Ross (1951) for the Garden City and Swan Peak formations of northern Utah and of Hintze (1952) for the Pogonip have already been noted. Inasmuch as zonation depended primarily on the trilobites, which are poorly known for the eastern Canadian in general, there was some difficulty in precise correlation. The El Paso succession contains trilobites, but in most parts of the section they fail to chop out, and good forms which can be etched from the matrix have not been found. Fortunately, the Utah and Nevada regions have much in common, and the lettered designated zones are equivalent, or nearly so. Ross (1951) and Hintze (1952) had recognized that the sections extend largely through the Canadian and that zone L marks the initiation of faunas which they then called Chazyan, but which fall more precisely in the subsequently designated Whiterock stage of Cooper (1956). Some difficulty and some differences of opinion are involved in the Whiterock–Chazy boundary, not of immediate concern to the present problems of Canadian correlations. They also noted the indication that the Demingian–Jeffersonian boundary occurs within subdivisions G1 and G2. It was hoped that perhaps the cephalopods in that region might be of help but the results, though interesting, fail to supply the needed data because the specimens available were very largely without precise zonal data. These results, now completed to the limit of the material now available, will be published later.

DETAILED ZONATION OF THE CEPHALOPODS

Text Figure 3

In 1954, I presented a scheme of cephalopod evolution showing the then-apparent relationships and ranges of families up to the early Ordovician. The present chart attempts not only to revise the previous work on the basis of new information but to indicate ranges in terms of closer stratigraphic units and to continue the stratigraphic scope to the close of the Ordovician. Necessarily, this attempt has encountered questions of correlation for which the present evidence seems ambiguous and on which there is quite probably no general agreement. Opinions of others have been widely solicited, but such suggestions as were received were, as one might expect, somewhat conflicting, and in the end I had to make my own decisions on a number of matters. It was not possible to indicate in the chart the concepts of correlation involved in detail. It would be too much to hope that all details can be correct, and we may preface this chart appropriately with the remark of the Golux in Thurber's *Thirteen Clocks*: "These things, I hope, are true."*

If one cannot attain perfection in correlation, there is at least some necessity of attempting the phylogeny now in these more precise stratigraphic terms and of providing sufficient explanation to show what concepts of correlation are involved.

Much of this information is included in the preceding section discussing the North American Canadian. There follow specific notes, indicated by numbers, the numbers referring to specific points on the diagram shown in Figure 3. There follow brief notes on some more general questions.

NOTES ON SPECIFIC POINTS

1. Vexingly, no forms are yet known connecting the Plectronoceratidae and the Ruedemannoceratidae. One small fragment of a *Ruedemannoceras* or an allied undescribed genus was recently obtained from beds of possible Whiterock age.

2. The Westonoceratidae give rise to the Lowoceratidae and Discosoridae in the Silurian.

3. The present treatment of the Proterocameroceratidae is generalized; there will be more families required in the slender Canadian Endoceratida.

4. New material indicates the Interjectoceratina to be endoceroids in which blades bifurcate and ramify. Precise relationship with other families has not been established; hence, the group is indicated but not the origin. Range of the Siberian material seems doubtful. An undescribed genus occurs in the Whiterock (zones L, M, and N) in Nevada and Utah.

5. Only the main lineage of the Protocycloceratidae is indicated here, not including possible homeomorphs stemming possibly from the Endoceratida, Baltoceratidae, or Michelinoceratida.

6. How high in the Gasconadian the Plectronoceratidae extend is uncertain.

7. The post-Gasconade survivors of the Ellesmeroceratidae constitute actually several unrelated lineages. The single line here is admittedly a generalization.

8. Precise equivalence of the oldest beds containing *Bathmoceras* is debatable but quite evidently Cassinian; the youngest form known is from the *Orthoceras* shale of Norway, here considered Chazyan, following Sweet (1958).

9. The Maruyama bed of Manchuria, the source of the only specimens of certainly known stratigraphic origin, is here placed as late Canadian, following Kobayashi's conclusions, and the evidence of associated piloceroids. Some species are possibly from slightly younger beds.

The Wutinoceratidae are known from the Wuting limestone of Manchuria, the Whiterock of Nevada and Utah, the Table Head of Newfoundland, and the Aseri limestone of Sweden, all regarded as essentially equivalent. Extension into younger beds is doubtful.

10. The first of the Michelinoceratidae occurs in the middle Cassinian division of the El Paso limestone.

11. The late Cassinian occurrence is the genus *Buttsoceras*, formerly assigned a family by itself. Precise equivalence of the beds containing *Troedssonella* is not certain, but the genus occurs above the Aseri limestone of certain Whiterock equivalence.

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*The reader should be warned that the present diagram is a summary of our present state of knowledge, and, just as there have been numerous changes from the chart presented in 1954, further work may require emendation, particularly in ranges of families and in some relationships. Oddly, between first and second proofs, new material has shown the necessity of two such changes: (1) the Piloceratidae, though unknown in the Ordovician, are represented in the Silurian by *Humeoceras*, and (2) the Narthecoceratidae are probably Michelinoceratida, derived from the Troedssonellidae rather than Endoceratida, and extend also into the Silurian.

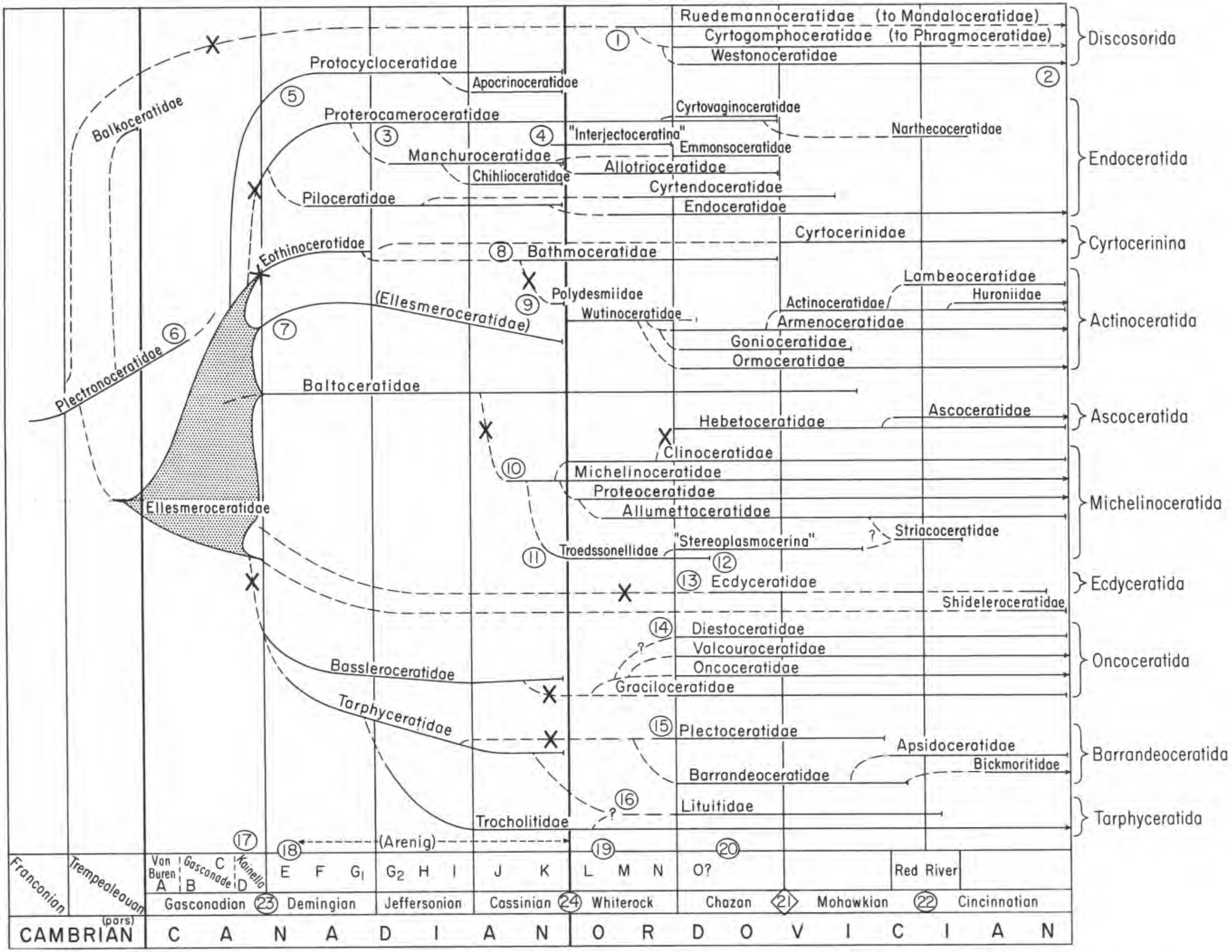

Figure 3

PHYLOGENY OF THE CEPHALOPODS TO THE CLOSE OF THE ORDOVICIAN; CLASSIFICATION AND RANGES ARE INDICATED IN TERMS OF FAMILIES

12. Some family relationships in the Michelinoceratida remain problematical. Possibly *Stereoplasmocerina* connects the Troedssonellidae with the Striatoceratidae, but the family may also spring from the Proteoceratidae (Flower, 1962B). Some other families have been proposed ranging in the Ordovician, but their validity and boundaries seem yet uncertain, as Orthocerotidae, Sinoceratidae, and the nature of *Stereoplasmoceras* as a member of the order is doubtful; therefore, the family Stereoplasmoceratidae is not included.

13. The Ecdyceratida (Flower, 1962) contains only *Ecdyceras;* three occurrences are known, later Chazyan, basal Viola, and Arnheim.

14. The position of the Diestoceratidae is doubtful; it may conceivably belong to the Discosorida rather than to the Oncoceratida.

15. The Plectoceratidae resemble some Tarphyceratidae strongly; the essential difference, the thinning of the ring, is not evident from some material; however, reputed *Plectoceras* and Plectoceratidae in the Canadian are doubtful and are probably really *Campbelloceras.* However, there is little doubt that the Plectoceratidae stem from the Tarphyceratidae.

16. Whether the Lituitidae sprang from Tarphyceratidae or Trocholitidae is not yet demonstrated. Sweet (1958) has shown affinities with the Tarphyceratida from the thick rings which show, however, some specializations peculiar to this family.

17. The *Kainella* zone is regarded as occupying a period of general emergence in eastern North America, at the close of Gasconade time. The cephalopod evidence is meager and consists only of doubtful *Robsonoceras.* Questions could be raised as to the precise correlation here of the zones C and D.

18. Precise equivalence of H is uncertain from present evidence; considerable evidence supports the theory that the closing phase of the Canadian lies within the upper part or at the top of zone K.

19. The Whiterock is here recognized as a pre-Chazyan interval, and the Day Point is grouped with it. The Aseri and Wuting are considered equivalents.

20. I have used Chazyan here rather than Marmour, as the known cephalopod faunas rest upon the type Chazyan and the Mingan Island section.

21. Much evidence, including the more advanced Black River types of cephalopods, suggest an appreciable Chazy–Black River hiatus. It is not included here because the evidence of the cephalopods in this interval is all but nonexistent. Oddly, few new families appear in the Black River interval.

22. The Red River faunas of western and northern North America are regarded as lying athwart the present Mohawkian–Cincinnatian boundary, as shown by related forms in the late Trenton Cobourg faunas in the broadest possible sense (Cobourg of Ontario, Terrebonne of Quebec, Cynthiana and Catheys of Kentucky and Tennessee). Evidence suggests a depositional break between the Red River sediments and superadjacent beds with a fauna of Richmond aspect. Probably the present Mohawkian–Cincinnatian boundary fails to represent a major break in deposition, as we would like to think such boundaries might indicate.

23. It is of interest that the top of the Gasconade marks a profound change in the cephalopod faunas; with reservations that the Lower Canadian and Upper Ozarkian were equivalent, this was the top of Ulrich's Ozarkian system.

24. It should be noted that the Canadian–Ordovician break marks a great change in the cephalopod faunas; though recent work has established the beginning of a few major Ordovician stocks in the Cassinian, and a few Canadian survivors in the earlier Ordovician, the change is still one of major dimensions.

EUROPEAN SECTIONS

It is evident that the Tremadoc is embraced by the Lower Canadian; in the upper Bliss *Dictyonema flabelliforme* var. *anglicum* occurs with, and actually in a thin layer largely above, beds with *Symphysurina* and *Bellefontia,* though *Symphysurina* also extends higher. Likewise, a general correlation of the Arenig with the Middle and Upper Canadian seems supported by considerable evidence. The Glauconitkalk contains a cephalopod fauna of Canadian aspect. How higher beds should be distributed is not yet perfectly clear; the conclusion of Jaanusson (1960) in placing the Canadian–Ordovician boundary, though those terms are not used, in the middle of the series with dependent didymograpti, *D. muchisoni* lying above the break, seems eminently reasonable. The Aseri limestone, the *Platyurus*–kalk, is thus placed as the equivalent of the Whiterock. Considerable effort was made to attempt to place the zonation indicated for the Scandinavian and Baltic region in the chart shown in Figure 3, but two dilemmas are encountered here. Except for some recent work of Jaanusson, the zonation of the cephalopods is not dealt with in most works on the faunal succession. Unfortunately, many of the species were described with most approximate stratigraphic indication or none, aside from the general lithology; indeed, some were first made known on the basis of erratics on the North German plains. For some, the precise stratigraphic position has not yet been recorded. Also, some perplexity still surrounds details of intercontinental correlation.

WHITEROCK STAGE

Cooper (1956) proposed the Whiterock Stage for strata younger than the Canadian but older than the Chazyan. That there should be such strata is clearly evident from the advanced stage of some stocks which show marked advances in Chazyan time, some of which were only beginning in the latest Canadian, while others are new in the Chazyan.

Some questions have been raised as to the validity of the Whiterock, on the grounds that some Chazy equivalents may be included. It is the belief of the writer that in Nevada, the Chazy Crown Point and Valcour have their equivalents in somewhat higher beds; the lower yellow limestone of the Copenhagen, though Cooper, from the brachiopods, places this horizon somewhat higher, in the Chazy–Black River hiatus. Possible equivalence with the Lower Chazy, the Day Point limestone, seems irrelevant. If, as is claimed, the formational names should not have their boundaries changed (presumably such a course should involve the proposal of a different name, a course for which there is something to be said), we must consider the Chazy as excluding the Day Point limestone. Emmons (1842) in proposing the Chazy limestone, clearly included the beds which everyone since Brainerd and Seely has called Lower Chazy (their division A) not in the Chazy, but in the underlying "Calciferous Sandrock." Cooper found the brachiopod assemblage so anomalous that he could not place any other stratigraphic unit as its precise equivalent. The writer found in the cephalopods a small, odd fauna, disparate with that of the middle and upper Chazy above and showing possible Whiterock affinities. Some perplexity has developed from the identification as Day Point of some higher calcarenite beds, as the section at the shore at Valcour, New York. With evidence of such sections eliminated, it seems possible that the forms common to the Day Point and higher Chazy beds now reported may be diminished appreciably.

General Nautiloid Shell Morphology

Another work, completed concurrently with the present one, will deal with problems of cephalopod shell morphology in a more critical way. The present section is designed merely to define the terms used in the present work.

Shell form. Various terms have been used for shell form: orthocone, orthoceracone (for complete shells), and the adjectival orthoconic and orthoceraconic for straight shells; cyrtocone, with similar variations, for slightly curved forms; gyrocone for loosely coiled shells; tarphycone for forms with the whorls in contact or shallowly involute; nautilicone for involute shells; trochoceroid for shells symmetrically coiled; brevicone for short, rapidly expanding shells. In the Ellesmeroceratida there are only cyrtocones, orthocones, and a very few gyrocones; many are more or less breviconic. Curvature is largely endogastric, with the venter concave, the dorsum convex; this is the primitive nautiloid condition apparently, and exogastric cyrtocones (here found only in the small family Balkoceratidae) are largely more specialized forms.

Conch. The conch is the outer shell, taking the form of a cone, more or less curved or straight. The apex varies, but in the Ellesmeroceratida only one type is found; it is simple, rather rapidly expanding, with the siphuncle continued to its tip, and with no trace of a scar or indication of a small, swollen, apical protoconch.

Aperture. The aperture in its simplest form may be straight and transverse but is commonly more or less modified; a forward-projecting part is termed a crest; a re-entrant portion, a sinus. Commonest of the modifications is a sinus on the venter for the protrusion of the hyponome, termed the hyponomic sinus.

Septum. The septum is one of the transverse partitions produced as the shell grows forward, anterior to it at the living chamber, which contained the vital parts of the animal. The chambered part, divided by septa, is termed the *phragmocone.* Three parts of the septum are recognized, the mural part extending along the interior of the conch, the free part, which transverses the conch, and the septal neck, the part of the septum modified and extending apicad in all Nautiloidea along the siphuncle.

Suture. The suture is the line of contact, conspicuous on internal molds of most cephalopods, where the free part of the septum joins the shell wall. It may be transverse or complex. Forward-projecting portions are termed saddles, apically-projecting portions, lobes. In the Ellesmeroceratida, modifications of the suture are slight. Apparently lateral lobes are commonly connected with the primitively compressed cross section of the shell; in forms of broader whorl the suture tends to be transverse. In the higher Ellesmeroceratina we find conspicuous ventral lobes in *Cyptendoceras* of the Baltoceratidae and *Catoraphiceras* of the Protocycloceratidae. *Bathmoceras* is unique in developing a high, pointed, ventral saddle.

Siphuncle. The siphuncle is a tube which extends for the length of the phragmocone. It is generally considered as formed of two parts, the septal neck, already mentioned, and the connecting ring; these structures are repeated segmentally. Actually, the primitive siphuncles have vestigial necks, and one ring extends to the tip of the next, so that rings alone essentially outline the siphuncle. Hyatt (1900) used terms for the condition of the septal necks: holochoanitic, for necks of one segment in length; orthochoanitic for shorter necks parallel to the siphuncle axis; cyrtochoanitic for necks recurved and found in conjunction with expanded siphuncle segments. Foerste used the term *concavosiphonate* for siphuncle segments which are slightly concave in outline. Other terms have been proposed: aneuchoanitic or achoanitic for septal necks which are barely developed, hemichoanitic for necks half the length of the segment, subholochoanitic for necks not quite extending the length of a segment, macrochoanitic for necks extending for more than the length of one segment. Siphuncular bulbs, peculiar to the Plectronoceratina, are expansions of the siphuncle segment outlined only by the rings and between the septal necks. In the Ellesmeroceratina and Cyrtocerinina, siphuncle segments are dominantly tubular or faintly concave, though secondary expansion is developed in the Apocrinoceratidae and in the genus *Clelandoceras.*

Connecting rings. Rings vary in composition, thickness, differentiation of regions by texture and composition, and somewhat in form. Rings are regarded as dominantly organic in the Plectronoceratina, as dominantly calcitic in higher Ellesmeroceratida and in all higher nautiloid orders. Oddly, the primitive rings are thick, even in the Plectronoceratina where they are clearly fragile, possibly flexible, and commonly destroyed. They are thick but better calcified in higher Ellesmeroceratida and show some differentiation of layers. Oddly, while similar rings are found in the Endoceratida and Tarphyceratida, the higher orders with the rings thin and homogeneous are a derived condition. The structure and thickness of the ring has become a matter of considerable importance in tracing relationships in the Nautiloidea.

Diaphragms. Diaphragms, curved, convex apically, are common in the siphuncles of the Ellesmeroceratidae. Apparently they are derived from the rings. They are found also in the Plectronoceratina where they are rarely preserved, being, like the rings, quite fragile. In higher forms they are certainly retained only in the Protocycloceratidae, but are lost in the other major family of the late Canadian, the Baltoceratidae. Diaphragms are unknown in higher derived forms, the Michelinoceratida or Tarphyceratida. In some Endoceratida diaphragms may fill the endosiphotube and may continue on into the endosiphocone in mature shells, but for a variety of reasons, homology of these structures with the diaphragms of the primitive Ellesmeroceratida is most questionable. The diaphragms are known only in one derived order, the Ecdyceratida.

Rods. Rods, round in section, lying against the ventral wall of the siphuncle, thinning adorally to a point, thickening gently apicad until they fill the siphuncle, are here reported for the first time. They are known only in a group of genera within the family Baltoceratidae and are described more fully under the discussion of that family.

Siphonal deposits. In the broadest sense, siphonal deposits cover all structures in the siphuncle of which two present in the Ellesmeroceratida, the diaphragms and the rods, are noted above. In form they may be annuli, radial deposits, linings, diaphragms, rods, or endocones, the last consisting of conical deposits of lime, with a conical anterior cavity. It is now evident, however, that this treatment is inadequate, for deposits of similar form show differences in texture and composition, are nonhomologous, and appear at different points in the evolution of the nautiloids.

Cameral deposits. Cameral deposits are organic limy deposits formed in the camerae. They are gradually growing, and first appear some distance from the base of the living chamber, being secreted in closed camerae by tissues termed the *cameral mantle.* They are bilaterally symmetrical deposits, and their surfaces, which may change as growth progresses, may show varied and sometimes elaborate patterns. Cameral deposits are unknown in the older Ellesmeroceratida, but are developed in some of the Protocycloceratidae and some of the higher Baltoceratidae. Their function was largely hydrostatic, weighing the shell apex, while gas in the camerae still made the shell light; thus it was possible for the cephalopod to swim actively, holding the straight shell in a horizontal position. Absence of the deposits in the older Ellesmeroceratida reflects a combination of several conditions. The septa are very close in these older forms, and the buoyant effect of gas probably did not overbalance the additional weight which these septa provided. The older forms, which were endogastric cyrtocones, were probably crawlers rather than swimmers, and the same may have been true of some of the older orthoconic shells; only a few of these shells really developed very long phragmocones in the Plectronoceratidae and Ellesmeroceratidae.

Cameral deposits in the Ellesmeroceratida are known as yet only in two longiconic stocks, the Baltoceratidae and the Protocycloceratidae, but are apparently developed only in the more specialized genera in each family. In the Baltoceratidae, the cameral deposits are markedly confined to the ventral side of the shell and are best displayed in *Cyptendoceras* and *Murrayoceras.* The ventral concentration is less strongly confined to the venter in *Protocycloceras.* In view of the possible homeomorphy in *Protocycloceras,* it should be noted that the cameral deposits occur in forms which are considered typical, possessing diaphragms and thus clearly derived from the Ellesmeroceratidae, and are not confined to possible homeomorphs derived from the Baltoceratidae. Episeptal deposits are those formed mainly against the apical side of the camera, the anterior side of the septum. Hyposeptal deposits are those formed on the anterior side of the camera, the apical side of the septum. Mural deposits are those formed primarily against the outer wall; they grade to some extent into episeptal deposits.

Systematic Descriptions

ORDER ELLESMEROCERATIDA

Flower, 1950

This order contains the archaic cephalopods and with them are grouped such early derivatives as constitute no major successful lineages. Primitively, shells are compressed, straight to endogastric, sutures show lateral lobes, the ventral siphuncle has rings tenuous at first and outlining bulbs, later well calcified, relatively thick, and showing layered structure; diaphragms are present in primitive stocks.

One by one, exceptions have been found to every matter mentioned in this general definition, and we have been left with the choice whether to include these departures from the general pattern, the most startling of which are known only from small genera and rare species, or to divide the order. To this last procedure there would have been almost no end. Such departures are discussed below in the treatment of the Ellesmeroceratida and the Ellesmeroceratidae.

Three suborders are recognized, here briefly defined as follows:

Plectronoceratina. Rings outline siphuncular bulbs, are fragile, commonly destroyed, and quite probably poorly calcified. In late growth stages of Plectronoceratidae, necks may lengthen, resulting in reduction and ultimate suppression of the bulbs. The new family Balkoceratidae is erected for late Cambrian exogastric shells plainly derived from the Plectronoceratidae.

Ellesmeroceratina. Rings well calcified, commonly showing layering in adult stages. Necks primitively short, segments tubular or faintly concave. In the Ellesmeroceratidae, the archaic family, several genera show broadening of the cross section, but the trend developed clearly not in a single lineage but three times independently. Necks lengthen in *Metaellesmeroceras* and in some species of *Clarkeoceras.* New evidence suggests that in *Clelandoceras* siphuncle segments become faintly expanded. Siphonal segments are dominantly concave or tubular, rarely expanded.

There are several derived stocks. One is the Protocycloceratidae, which develop annuli early, later show a broadening of the cross section and removal of the siphuncle from the venter. The family is the source of the small family Apocrinoceratidae (three genera and three species known at present from three specimens) in which the siphuncles become expanded.

Another is the Baltoceratidae, dominantly smooth, slender shells with the cross section broadened. The small family Cyclostomiceratidae is a breviconic modification. Teichert and Glenister (1954) have described the Thylacoceratidae, differing in the small diameter of the siphuncle and the lengthening of the septal neck but the ellesmeroceroid affinities of the family are doubtful. In the Baltoceratidae diaphragms are unknown, and a few forms have revealed a ventral rod within the siphuncle, a structure previously unknown.

New evidence has resulted in the suppression of the Buttsoceratidae and the removal of *Buttsoceras* to the Troedssonellidae of the Michelinoceratida. The suppressed free tube is only the silicified inner surface of a lining within the siphuncle which thickens very gently apicad and thus resembles very slender endocones (Flower, 1962A).

Cyrtocerinina. This suborder is characterized by rings greatly thickened and extended as lobes into the cavity of the siphuncle. The three genera are bewilderingly diverse and are accommodated in separate families.

Suborder Plectronoceratina

Flower, New suborder

This suborder is erected for Ellesmeroceratida characterized by siphuncular bulbs and expansions into the camerae of the parts of the siphuncle not bounded by septal necks. The known forms are simple in general aspect, endogastric cyrtocones, orthocones, or even faintly exogastric cyrtocones, compressed in cross section, with sutures describing lateral lobes, and a small siphuncle close to the venter. As at present understood, it contains the endogastric to straight family Plectronoceratidae and the exogastric family Balkoceratidae.

Figure 4 shows range and relationship of the families and their genera.

The essential features of the two families, genera, their ranges, and apparent relationships are shown. All forms are oriented with the venter beneath, the apex to the left.

FAMILY PLECTRONOCERATIDAE

Kobayashi

Here are placed Plectronoceratina characterized by endogastric to straight shells, with cross section compressed, sutures with lateral lobes, siphuncles ventral, with short necks and tenuous rings outlining siphuncular bulbs. Specialized forms may show gradual lengthening of necks in adoral segments, a development found first on the ventral side, but which may spread to the dorsum later. Upper Cambrian, Eastern Asia and North America; Lower Canadian (Wanwanian), Eastern Asia.

Material showing the mural part of the septum for this family has been inconclusive. That the mural part of the septum is short in both the derived Ellesmeroceratinae and the Discosorida would suggest that it is short here also; such a condition would be consistent with the absence of demonstrable septal furrows throughout the Ellesmeroceratida and Discosorida. Thinsection material of the Plectronoceratidae consists, unfortunately, of internal molds, and the mural part of the septum is lost with the conch. One section shows on the dorsal side septa which steepen as they approach the conch, and there is indication that such septa extend nearly if not completely the length of the camerae, but they are narrowly free throughout most of that length.

The present study shows that in some instances the siphuncle is in such close contact with the venter that no septal structures can be made out on its ventral side. In this, our present *Plectronoceras exile* is consistent with what Kobayashi (1935) has found and illustrated for *Plectronoceras*

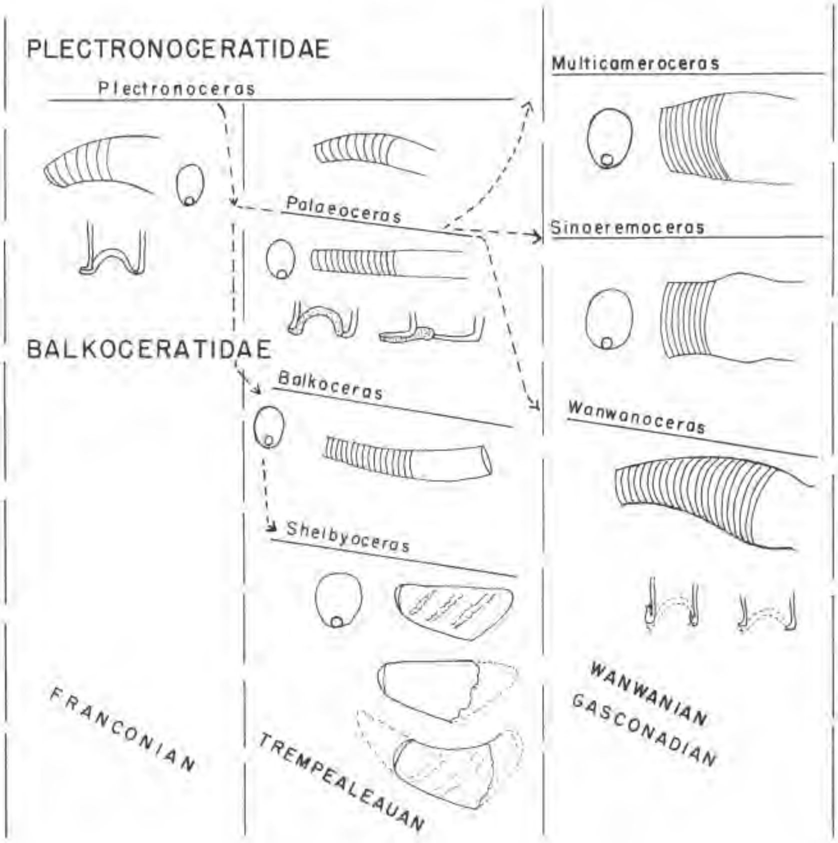

Figure 4
PHYLOGENY OF THE PLECTRONOCERATINA

liaotungense. In other instances, however, good septal structures are to be found between the siphuncle and the ventral wall. Further, it is of interest that where such septa are found on the ventral side of the siphuncle they are extremely steeply inclined; indeed, there is some difficulty encountered in identifying as pertaining to a single septum the septal structures on the two sides of the siphuncle as seen in a vertical longitudinal section. In the holotype of *Palaeoceras undulatum* (pl. 1, fig. 1-7), the adoral end of the section shows the last septum, that at the base of the living chamber. On the dorsal side of the siphuncle the septum is nearly transverse, but on the ventral side it is not only steeply inclined, but extends so far orad that, were this not the last septum, one could not be certain of matching correctly the two parts of the septum on either side of the siphuncle. In some other forms, notably Plate 2, Figure 15, the septum is curving forward as it approaches the siphuncle from the dorsal side, and the identification of the ventral continuation of the septum is at once obvious.

Such discordance among specimens as to the development of septal structures on the ventral side of the siphuncle is not remarkable. A fine suite of specimens of *Bactrites arkonensis* indicates that there may be variation, not only within the species, but in parts of a single specimen in this respect, and the variation is such that some specimens show on well-preserved internal molds clear terminations of the septal necks, while on others the septal neck is not apparent on the exterior at all. Indeed, there is indication of similar but less extreme variation in the Mississippian belemnites described by Flower and Gordon (1959), particularly in the genus *Bactritimimus.*

Fragility of the connecting ring seems to be a common feature in the Plectronoceratidae; indeed, destruction of the ring seems far commoner here than its preservation, while in the Ellesmeroceratidae the reverse is true. In the latter family the rings are thickened and late growth stages of many, perhaps most, of the members of that family show a ring which is evidently strong enough to be commonly preserved; one is tempted to say that such a ring is well calcified, though it should be remembered that caution must be exercised in attributing such toughness to calcification; specimens are now calcitic, of course, and the conclusion is a logical one, but the known forms occurred in limestone and calcitic replacement is a possibility. However, in the Plectronoceratidae our present thinsections show a very different sort of ring; progressive grinding has shown that there is no clearly defined margin to this structure; our present thinsections have failed to show any indication of the layered structure which characterizes the bulk of the Ellesmeroceratidae though color differentiation in the type material showed such layers in opaque sections. Rather, the ring appears as material poorly differentiated from matrix in the siphuncle, suggesting a structure that was originally most tenuous and quite possibly largely of organic material. Such a conclusion is consistent with the general tendency of the ring to be destroyed; in the Asiatic material of *Plectronoceras,* only one ring was found in one camera of one specimen; in our present material the average is considerably better, but preservation is still strangely erratic. Curious also are those segments which show suggestions of a siphuncular bulb far more inflated than any previously known; indeed, in Plate 2, Figures 17-18, some segments suggest the elaborately expanded segments found in some such Actinoceratida as *Armenoceras,* with the ring so broadly expanded that it comes to lie against the free part of the septum. Wide variation in shape suggests that matrix filled the siphuncle after the death of the organism and that subsequent pressure forced this material into the cameral spaces; if so, the sections suggest also that where the ring is preserved, it must have behaved as an elastic structure, capable of stretching without breaking. This explanation seems at present the only one which is consistent with the observed phenomena; it should hardly be necessary to note the desirability of checking it against future observations.

One aspect of the present material of *Palaeoceras* seemed puzzling at first; namely, the failure of the thinsections in the present material to accord clearly with the progressive lengthening of the septal necks as growth proceeds. Adoral sections showed instead septal necks which were long ventrally but always shorter, usually half the length of the camera or less, on the dorsum. Doubtless, the phenomenon observed here is simply a progressive lengthening of the septal necks which begins on the ventral side of the shell (fig. 5), and in the observed materials the vertical thinsections show necks which have not been lengthened appreciably on the middorsal side of the siphuncle. The previous observations on the siphuncles of *Palaeoceras* were based upon specimens in which gentle etching had reduced the whole surface of the internal mold, and the lateral portions of the siphuncle walls were the parts observed; one would, in the light of the thinsections, expect such necks in the mature part of a *Palaeoceras* to be about half way in length between those of the dorsum and those of the venter, and our present observations indicate just this condition.

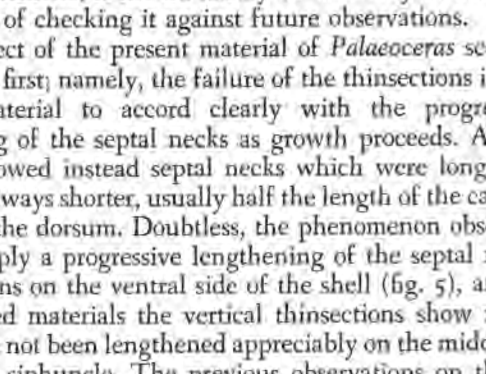

Figure 5
SIPHUNCLE OF *Paleoceras*

A. A section through an immature segment, with the neck short and the bulb extensive.
B. A section from a later stage, showing neck lengthening and bulb more restricted.
C. Hypothetical external view, venter on right, showing greater extension of the neck on the venter, and consequent greater restriction of the bulb on that side.

The family is recognized as containing the genera *Plectronoceras* and *Palaeoceras,* discussed below, both known from the Upper Cambrian. In addition, the Wanwanian (Lower Canadian) of Manchuria has yielded *Sinoeremoceras, Multicameroceras,* and *Wanwanoceras,* not as yet recognized elsewhere in the Lower Canadian or in any other region. These genera have been summarized previously (Flower, 1954).

Diaphragms crossing the siphuncle are known only in the holotype of *Palaeoceras mutabile* and in *Sinoeremoceras wanwanense*. Diaphragms seem irregular in form and erratic in distribution. They have not been observed in thinsections, but in opaque sections seem similar in color and texture to the connecting rings. Their rarity may, then, be a result of common destruction rather than an indication of original absence. If, as appears true of the rings, they were flexible, this condition will account for their irregularity of form.

Kobayashi referred to these forms as having pseudodiaphragms. In part, their apparent peculiarity rests on tangential sections through the siphuncle wall, rather than across the siphuncle cavity, but in that diaphragms agree with the rings, of which they are possibly extensions, in being poorly calcified, the diaphragms differ from the better calcified diaphragms of the Ellesmeroceratida.

Genus PLECTRONOCERAS Ulrich and Foerste

Genotype: *Cyrtoceras cambria* Walcott

Plectronoceras Ulrich and Foerste, 1933, Science, n.s., vol. 78, p. 289.
———Kobayashi, 1935, Japanese Jour. Geol., Geogr., vol. 12, p. 19.
———Flower, 1954, N. Mex. Inst. Min. and Tech., State Bur. Mines and Mineral Res., Bull. 40, p. 15 (contains intervening references).

Endogastric cyrtocones, small, moderately expanding, section compressed, sutures with lateral lobes. Septal necks short, rings tenuous, rarely preserved, but outlining siphuncular bulbs. Siphuncle in contact with ventral wall, septal structures between siphuncle and venter vestigial or wanting.

To the two tiny, rather rapidly expanding shells from the *Tsinania canens* zone of North China and Manchuria (*P. cambria* Walcott and *P. liaotungense* Kobayashi) is here added a somewhat larger and more slender form, faintly costate, from the cephalopod bed high in the Trempealeauan of the Llano uplift, described below.

Plectronoceras exile Flower, n. sp.

Pl. 4, fig. 13-16; pl. 5, fig. 1

This is a slender endogastric shell; our single specimen preserves 22 mm of the phragmocone, increasing in height from 3.5 to 5.5 mm. The basal part is rather poorly preserved, but increases in height from 3.5 to 4.5 mm in 15 mm; in the adoral 7 mm, the shell increases from 3.5 and 4.5 mm to 4.5 and 5.5 mm. The cross section is compressed, elliptical, venter scarcely more narrowly rounded than dorsum, siphuncle small, in contact with the ventral wall. The sutures describe broad, shallow, lateral lobes, with dorsal and ventral saddles subequal in height. Except for the adoral two camerae, which are slightly shorter than the others, camerae average six in a length of 5 mm. The surface of the internal mold is marked by shallow, distant constrictions.

A longitudinal thinsection was made of the basal part of the specimen, comprising 15 camerae. The convex dorsal side is incomplete, having been destroyed by weathering. On the venter, the septal foramen is clearly seen. Its dorsal side is marked by short orthochoanitic septal necks. On the ventral side, however, no septal structures whatsoever can be seen, but in the adoral camerae there is a slight rhythmic thickening and thinning of the ventral shell wall, which may be the result of very thin septal structures; if so, the septa are inclined here parallel to the shell wall and not obviously distinct from it, evidently from recrystallization. The adoral five camerae (pl. 4, fig. 16) show both siphuncle and camerae closely packed with oolites, but the connecting rings are destroyed; the adoral septal neck shows remains of a small bit of the connecting ring attached to its adoral and inner surfaces. The next two camerae are filled with fine-grained, light gray material free from oolites; similar but slightly lighter material fills the siphuncle. This material expands in two of the camerae with the edges slightly lighter than the remainder, so as to suggest a siphunclar bulb; in the remaining six apical camerae the siphuncle departs from the plane of the section.

Discussion. The internal structure shown by our single specimen is, as usual, somewhat ambiguous as to the nature of the connecting rings. However, it is plain that the rings here, as in other sections in this association, are extremely fragile structures, and when represented at all, appear only as calcitic material slightly lighter in color than the material filling the siphuncle and poorly differentiated in texture. This species differs from the two previously described species of *Plectronoceras* in being somewhat larger and much more slender and in the development of faint constrictions on the internal mold. It is possible that the more slender shell and the faint constrictions could be used to separate this species generically from *Plectronoceras*, but at the present time it is not evident that any more useful purpose would be fulfilled than the erection of a new generic group. The slender form, slight curvature, and the similarity of the undulations of the internal mold with those of *Palaeoceras undulatum* serve to reduce the contrast which, from our previous knowledge, seemed to set *Plectronoceras* and *Palaeoceras* quite well apart.

Type and occurrence. The holotype, No. 303 in the collection of the writer, is from the cephalopod bed, now closer to 30 feet than 67 feet, the previous estimate, below the top of the San Saba limestone, Threadgill Creek section, Gillespie County, Texas.

Genus PALAEOCERAS Flower

Genotype: *Palaeoceras mutabile* Flower 1954

Palaeoceras Flower, 1954, N. Mex. Inst. Min. and Tech., State Bur. Mines and Mineral Res., Bull 40, p 7.

Slender orthoconic Plectronoceratidae, sutures with lateral lobes, ventral siphuncle with short necks and bulbs in the young, necks progressively lengthening with growth, reducing the bulbs to vestiges; but such lengthening begins on the ventral side of the shell and spreads laterally, and while necks in these regions may become subholochoanitic, they remain relatively short, at the most hemichoanitic, on the dorsum.

New material reveals the connecting rings as extremely tenuous structures so little differentiated from the matrix as to suggest structures that are more organic than calcareous. The previous specimens studied indicated the rings as rather thick and as showing faint color differentiation of layers. Layers are not shown clearly in thinsections provided by the new material.

As yet, only *P. mutabile*, redescribed below from additional material, and *P. undulatum* are known; both occur in a single bed in the San Saba limestone of the Llano uplift of central Texas and are known only from the section on Threadgill Creek, Gillespie County, Texas.

Palaeoceras mutabile Flower

P. 2, fig. 4-7, 11-18; pl. 3, fig. 1-9

Palaeocras mutabile Flower, 1954, N. Mex. Inst. Min. and Tech., State Bur. Mines and Mineral Res., Bull. 40, p. 10, pl. 1, fig. 5, 9, 10; pl. 2, fig. 11; pl. 3.

Several additional specimens, smooth straight shells, are here assigned to the species, though it is evident that they show some differences from the material previously described. One, No. 304 (pl. 3, fig. 1-9), is a phragmocone 17.5 mm long, increasing from 3.2 and 4.5 mm to 5 and 7 mm, with 22 camerae spaced 5.5 in the basal 5 mm and 6.7 in the adoral 5 mm. The septal surface is quite flat. Sutures show lateral lobes deepest at the middle as seen in lateral view, but not quite symmetrical, slightly geniculate where the suture swings forward to form the dorsal saddle. Dorsal and ventral saddles are subequal in height, but the dorsal saddle is broad, flattened middorsally, while the ventral saddle is narrower and lacks any median flattening. A horizontal, longitudinal section was ground across the venter, exposing the siphuncle. Though pyritization has affected a good part of the siphuncle, it is evident that at the base of the specimen the septal necks extend a little more than half the length of the siphuncle segment; rings are not preserved. In adoral segments the necks are longer, becoming holochoanitic, or nearly so, near the anterior end. Matrix, including groups of oolites, fills the siphuncle; there are no diaphragms. Although this specimen is, at its apical end, essentially commensurate with the holotype of the species, its septal necks are appreciably longer. No other differences are apparent; the septa are similar in spacing. Possibly our new specimen differs slightly in cross section and in the course of the sutures, but the etching to which the holotype was subjected has altered these features slightly; it appears, however, that in the holotype the cross section is considerably more prominently narrowed on the venter, and the lobes of the sutures are shallower and simpler in pattern.

A second specimen, No. 305 (pl. 2, fig. 4-7, 16), is a phragmocone of eight camerae and a living chamber, apparently complete to the aperture on one side. The cross section is elliptical, without obvious narrowing of the venter, the sides strongly flattened. The septum at the base shows the siphuncle narrowly but definitely separated from the ventral wall of the shell. The specimen is 5 mm wide and 6.2 mm high at the base, increasing in the length of the eight camerae of the phragmocone, in a length of 5 mm, to 5.3 mm and 6.5 mm. The living chamber extends 9 mm farther, and terminates in what appears to be a bit of the aperture. A faint constriction near the anterior end of the living chamber suggests maturity. Sutures show lateral lobes with a slight geniculation where they rise dorsolaterally; the dorsal saddle is higher than the ventral one, broad, flattened in the center.

A third specimen (pl. 2, fig. 11-13, 17, 18) was originally an extremely smooth shell, expanding from 3 and 5 mm to 7.5 and 5.0 mm in 26 mm. Camerae occur five in the basal 5 mm, six in the adoral 5 mm. The cross section shows no perceptible narrowing of the venter, lateral lobes of the sutures are nearly symmetrical, the saddles subequal in height, the ventral one narrow, the dorsal one broader and flattened centrally. The entire specimen was sectioned in two parts. The apical portion shows siphuncle segments which are much more expanded than one would expect; the septa terminate in short necks, bent rather abruptly, and with a terminal straight interval parallel to the siphuncle axis; beyond the neck there is indication in the basal segment, and clear evidence in the next two, of a connecting ring so expanded that it is broadly adnate to the septa forming both walls of the camera; except that the neck is not recurved, the condition here recalls that in the actinoceroid *Polydesmia*. Anterior segments show the same condition, but less clearly. On the ventral wall of the siphuncle are seen strongly inclined septa, not perceptibly bent to terminate in septal necks, with a considerable space between. There is, further, a suggestion that in this interval the connecting ring, here marked by very light-colored material as on the dorsal side of the siphuncle, also outlines siphuncular bulbs.

The anterior part of the section shows a progressive lengthening of the septal necks on the ventral side of the siphuncle, but they are not holochoanitic even at the anterior end, and a faint suggestion of a siphuncular bulb remains. On the dorsal side, the curvature of the septal necks has become more gradual; their tips may point inward toward the center of the siphuncle slightly. Most of the segments here show no connecting rings whatsoever, but they are retained in two segments near the base, while in the next anterior segment an adventitious structure presents the appearance of a perfectly straight ring such as one finds in the Ellesmeroceratidae.

Another specimen (No. 307) is a small bit of phragmocone 7 mm long, containing ten camerae, incomplete dorsally at the base, 6.5 mm high adorally, with the ventral side only shown in Plate 5, Figure 2. Here can be seen septa on the ventral side gently bent from an oblique position to one parallel to the siphuncle axis; a considerable space remains between the tip of one neck and the base of the next; in two segments only is there a trace of the rings; they both appear to be straight, failing to outline any bulbs whatsoever on the ventral side. On the dorsal side gently bent necks are seen. Light material in the siphuncle is expanded slightly in the basal segment, conforming to the slight expansion one would expect of a bulb here; in the next segment, however, such material expands beyond any reasonable limit of a siphuncular bulb. The next two segments fail to show other than a nearly straight boundary between siphonal and cameral filling, but the fifth segment again shows a boundary suggestive of a moderately expanded bulb, and there is a similar suggestion of a bulb in the penultimate camera.

Types. Holotype and paratype, Bureau of Economic Geology, University of Texas. Hypotypes, collection of the writer, Nos. 304-307.

Occurrence. From the upper part of the San Saba limestone (Trempealeauan), Threadgill Creek, Gillespie County, Texas.

Palaeoceras undulatum Flower, n. sp.

Pl. 1, entire; pl. 2, fig. 8-10

Shell slender, straight, cross section compressed with greatest width well dorsad of center, venter more narrowly rounded than dorsum. Siphuncle circular in section, separated from venter by about half its own diameter, surface of shell and internal mold bear a series of broad, shallow, transverse constrictions, most marked in maturity. Septa very steep on ventral side of siphuncle, bent only slightly to form subholochoanitic necks; on the dorsal side septal necks are very gently bent, extending one third to one half the length of the segment.

We know this species thus far from bits of shells ranging from 5.5 and 6.3 mm to 5.7 and 7.5 mm, covering a length of about 24 mm. In comparable growth stages *P. mutabile* shows a considerably broader cross section, the narrowing of the venter is less marked, the siphuncle is not clearly separated from the ventral wall of the shell.

The holotype (pl. 1, fig. 1-7) is known from one fragment with the above dimensions, including a phragmocone of 12 septa in a length of 8 mm and an essentially complete living chamber of 12 mm; the surfaces of the internal mold and also of the shell surface are both smooth; the shell is unusually thick, as shown by the fragment on the right side of Plate 1, Figure 4. The shell bears faint, rounded expansions with shallow constrictions between; two such constrictions occur on the phragmocone, a third on the base of the living chamber, and a fourth shortly before the aperture; those on the living chamber are more prominent than those on the phragmocone. The specimen retains an essentially complete living chamber, but the aperture is obscure. A small midventral portion is straight and transverse; laterally the aperture extends scarcely farther forward, indicating that any hyponomic sinus must be very shallow. The phragmocone shows shallow lateral lobes attaining their greatest depth ventrad of midheight; dorsal and ventral saddles are equal in height, the ventral saddles narrow, the dorsal saddles broader and slightly flattened. At the base of the specimen the siphuncle, circular and 1 mm across, is separated from the venter by an interval of 0.4 mm. A break occurs just orad of the last suture; the region apicad of this was sectioned vertically to show the siphuncle; also a small fragment of four camerae which fitted imperfectly on the base (some material being lost at the break) was sectioned. On the venter, sutures leave the ventral wall of the shell at a steep angle; one so steep that the further bend at the base of the septal neck is commonly indistinct. On the venter, necks are long, subholochoanitic. Only in a few parts of the section are the connecting rings retained; they clearly pass, as is usual, from the tip of one neck to the tip of the next, and fail to expand outward into the extremely limited region between necks where they alone form the outline of the siphuncle. On the dorsal side of the section, the septa slope apicad as they leave the shell wall but become transverse, or nearly so, across the central part of the camerae, then swing forward markedly toward the siphuncle. The septal surface steepens markedly at the region of the siphuncle, the septum on the ventral side of the siphuncle lies so far forward that matching of septal necks on the two sides is difficult. On the dorsal side, the septal necks are very gently curved, their tips parallel to the siphuncle axis. Rings are faint where indicated and altogether absent in most segments. However, the second ring from the anterior end (pl. 1, fig. 2) shows faintly, and a slight bulb is outlined; there is an indication of the ring in the fifth segment, though its apical part is interrupted by an oolite. At the base of the same figure, calcite in the camerae is retraced in the apical part close to the siphuncle, though no ring as such is seen. In the apical fragment (pl. 1, fig. 3) calcite occupies the two adoral camerae; in the more apical of these, calcite is again retracted where the bulb would be expected, but in the anterior one the retraction is extremely slight, though it still leaves room for a vestigial bulb.

A second sectioned specimen, No. 301 (pl. 1, fig. 8-10), was, prior to sectioning, a fragment 11 mm long containing 12 camerae visible externally; in this length there were two shallow lateral constrictions. At the base its section was 6.5 mm high and 5.1 mm wide, appreciably more narrowly rounded ventrally than dorsally. The section shows parts of 15 camerae. Septa are arched, attaining greatest depth in the center, rising orad slightly from there as they approach the siphuncle. As before, septal necks are most gently bent on the dorsal side of the siphuncle; on the ventral side septa are steep, and only slightly steeper where they become septal necks. Here, the necks are appreciably shorter in the apical part of the specimen, though they lengthen adorally, but the section is incomplete there. On the dorsal side, the gently bent necks are somewhat variable in length, but again shorter in general than those of the holotype; the tips of the necks are not parallel to the siphuncle axis but are directed slightly inward. Two apical segments show matrix of the siphuncle, here slightly lighter than material filling the camerae, expanded and suggesting siphuncular bulbs; the margins of these regions are not, however, differentiated and there is nothing which can be identified with certainty as a connecting ring. The next three segments lack all trace of the ring, but the one following them shows calcite extending from the siphuncle out, and part of its outline may represent the ring. The next segment, however, shows a good bulb, similar in form to those of the apical two segments, and its margin is composed of material differentiated from the matrix on both of its sides, and is plainly a ring. In the next segment, a calcite patch passes without interruption from the camerae into the siphuncle a little way; the next three segments again show outlines of the bulbs as expected, but only one shows any material which enables one to differentiate the ring from the matrix. The third segment from the anterior end again outlines a bulb, but only most imperfectly; calcite in the siphuncle is expanded into the camerae, but this apparent bulb is somewhat more expanded than are the others; it appears, indeed, as though material from the siphuncle had been squeezed slightly and had, as a plastic material, penetrated the camerae slightly farther than the original limits of the bulb.

A third fragment, showing rather poor preservation of the interior, 11 mm long, with a shell 5.5 mm wide, 7.5 mm, shows two prominent constrictions of the interior and is here figured (pl. 2, fig. 8-10), being the one remaining specimen showing the general features of the internal mold. The cross section is typical in the narrowly rounded venter, the attainment of the greatest width well dorsad of the center.

Discussion. The cross section and undulations of the shell characterize this species. Known portions are commensurate with the paratype of *P. mutabile*, which shows differences in cross section and which is proportionately slightly broader; lacks the conspicuous narrowing of the ventral half of the shell.

Types. Holotype, No. 300, paratypes, Nos. 301, 302; collection of the writer.

Occurrence. From the cephalopod bed, not far below the top (now closer to 30 feet than to 67 feet, the previous estimate) of the San Saba limestone, Threadgill Creek section, Gillespie County, Texas.

Genus MULTICAMEROCERAS Kobayashi 1933

Genotype: *Ellesmeroceras (?) multicameratum* Kobayashi

Multicameroceras Kobayashi, 1933, Tokyo Imp. Univ., Fac. Sci., Jour., sec. 2, vol. 3, p. 273.

This contains moderate-sized compressed endogastric shells, the siphuncle showing ontogenetic elongation of the necks, the mature living chamber slightly contracted adorally, the dorsum becoming faintly convex. There are two species *M. multicameratum* (Kobayashi, 1931) first assigned to *Ellesmeroceras*, and *M. cylindricum* Kobayashi, 1933; both are from the Wan-wan-kou limestone of Manchuria.

Genus SINOEREMOCERAS Kobayashi, 1933

Genotype: *Eremoceras wanwanense* Kobayashi

Sinoeremoceras Kobayashi, 1933, Tokyo Imp. Univ., Fac. Sci., Jour., sec. 2, vol. 3, p. 272.

This form is like *Multicameroceras* in size and structure of the siphuncle but is more gently expanding apically. The mature living chamber resembles that of *Eremoceras* in being faintly gibbous at midlength, but shows faintly concave profiles on both dorsum and venter just before the aperture.

Only the genotype *S. wanwanense* (Kobayashi, 1931) is known; it was originally placed in *Eremoceras*. It is known only from the Wan-wan-kou limestone of Manchuria.

Genus WANWANOCERAS Kobayashi, 1933

Genotype: *Wanwanoceras peculiare* Kobayashi, 1933

Wanwanoceras Kobayashi, 1933, Tokyo Imp. Univ., Fac. Sci., Jour., sec. 2, vol. 3, p. 271.

Only the phragmocone of this form is known, which enlarges moderately vertically at first, but shows a slight convexity and a marked adoral reduction in vertical expansion. Kobayashi regarded the siphuncle as cyrtochoanitic in the young, orthochoanitic in the adult. Preservation is rather poor, and though I have followed this interpretation in Figure 4, it seems possible that the young stage has aneuchoanitic necks and that the apparent recurved brims are parts of the connecting ring; if so, the ontogenetic progression of the siphuncle is similar to that of the preceding genera. The form of the living chamber is not known.

The genotype and only known species is *Wanwanoceras peculiare*.

FAMILY BALKOCERATIDAE
Flower, n. fam.

This family is erected for plectronoceroids which differ from the endogastric to straight Plectronoceratidae in developing exogastric curvature. Previously, the development of exogastric shells in cephalopods prior to the appearance of the Bassleroceratidae in the Middle Canadian was unsuspected. That group is derived from the Ellesmeroceratidae, and *Ectenolites extensus* shows how this development could have occurred.

Balkoceras is very similar in most features to *Palaeoceras*, but even small fragments of the two can be distinguished; *Balkoceras* has a siphuncle so close to the venter that its cross section is slightly flattened there, and the very steep septa between the siphuncle and the ventral wall occupy only a very narrow space. The cross section of the shell shows the sides well rounded, the venter scarcely more narrowly rounded than the dorsum. The sutures describe broad shallow lateral lobes, symmetrical centrally, but the ventral saddle is the higher of the two, and the sutures thus appear slightly oblique.

The discovery of *Balkoceras* serves to indicate, but not to prove, a solution to another vexing problem. Previously it was concluded (Flower, 1954) that *Shelbyoceras*, known from little more than rough internal molds of the living chambers, could be a cephalopod only if it was exogastrically curved. The conclusion was reached from (1) the narrowing of the cross section on the convex side of the shell, (2) the clear absence of a septal foramen against the concave side of the shell, (3) the development of costae which slope down from the concave to the convex side, thus suggesting a hyponomic sinus on the convex side of the shell. At that time there was no indication that exogastric shells had appeared prior to the development of the Bassleroceratidae in the Middle Canadian, and the conclusion was reached that *Shelbyoceras* was probably not a cephalopod. The new evidence supplied by *Balkoceras* makes it possible to reverse this decision, and *Shelbyoceras* is tentatively referred to this family; tentatively, because the siphuncle is still unknown, and indeed we still know the septa only from the features shown by the internal mold of the living chamber, which has given only the course of the suture and a part of the septal surface.

Genus BALKOCERAS Flower, n. gen.

Genotype: *Balkoceras gracile* Flower, n. sp.

This genus is erected for slender shells closely resembling *Palaeoceras* except that they are slightly exogastrically curved. Shells are slender, compressed in section, venter more narrowly rounded than dorsum, siphuncle close to ventral margin, its cross section commonly flattened there; sutures tend to form shallow lateral lobes, with a high ventral saddle and a lower dorsal saddle. The shell and internal mold are both smooth, the former with only the faintest transverse markings. A vestigial hyponomic sinus is developed.

Discussion. Exogastric curvature in Upper Cambrian cephalopods has not been found or even suspected previously; this fact gives great importance to the curvature shown by the species for which this genus is erected, even though the curvature is slight, and the shells are closely similar in all other respects to the associated *Palaeoceras*. Indeed, I had at first assigned the present species to *Palaeoceras*, and surely the affinities are close enough that this course would have been eminently justifiable, but so great has the importance of curvature become that such a course would only result in the proposal of a new genus for this form by the next person to give these older cephalopods any attention.

The genus is distinguished from *Plectronoceratidae* by its exogastric curvature. *Shelbyoceras* is distinct, being a very much larger shell, more rapidly expanding; costae in that genus suggest a strongly developed hyponomic sinus. The exogastric Bassleroceratidae have tubular siphuncles with well-calcified layered rings. They are dominantly slender shells, but all are two to five times the size of our one known species of *Balkoceras*. The genus is named for Dr. Christina L. Balk in recognition of her valuable contributions to Cambrian paleontology.

Balkoceras gracile Flower, n. sp.

Pl. 2, fig. 1-3; pl. 3, fig. 10-15

Shell a very slender exogastric cyrtocone, compressed, venter faintly more narrowly rounded than dorsum, sutures with lateral lobes, broad, shallow, rising to saddles high and narrow ventrally, low and broad dorsally, so that the suture may appear in general to slope forward slightly on the venter. The siphuncle is extremely close to the venter; its cross section is slightly flattened ventrally; the known portion shows septal necks and siphuncular bulbs; in the adult the necks are long ventrally and laterally and the bulb greatly reduced, but dorsally necks remain short. Surface with only fine growth lines, transverse, but outlining a very faint shallow hyponomic sinus.

The holotype, No. 307 (pl. 3, fig. 10-15), is a fragment 28 mm in length increasing in shell height from 6.5 to 8 mm, 4.8 wide at the base. The phragmocone, 21 mm long, contains 28 camerae, five in 5 mm in the basal part, but with the adoral camerae shorter; six in a length of 4 mm. Sutures describe only very broad, shallow, lateral lobes, rising higher ventrally than dorsally, so that the suture may be called faintly oblique. In cross section the greatest shell width is attained at midheight, and the venter is scarcely more narrowly rounded than the dorsum.

The siphuncle is small, and at the base its cross section is slightly flattened where it lies close against the ventral wall of the shell. The specimen was ground from the ventral side to expose the siphuncle. In such a section (pl. 3, fig. 15), the basal segments show long necks, parallel with the shell axis, but the apical third of the segment, which lies beyond the tip of the neck is faintly expanded into a siphuncular bulb. More anterior segments show a somewhat different form, in which the segments are slightly concave, the necks being inclined inward toward the siphuncle center, but with the apical part of the segment faintly expanded. As segments are traced forward there is a gradual but progressive elongation of the necks, and in the adoral 10 segments the concave segments seem to be bounded only by holochoanitic necks. Two faint transverse markings in the siphuncle may represent diaphragms but the anterior one, near the middle of the specimen is transverse, irregular, and its interpretation remains dubious; near the apex a curved diaphragm is seen, but its color differentiation is extremely slight. The shortening of the adoral camerae suggest the specimen to be mature, but we have only a basal 6 mm of a living chamber, evidently very incomplete, and probably only about half of the complete length.

A second specimen, No. 308 (pl. 4, fig. 5-9), shows a living chamber, incomplete dorsally, but preserving the slightly convex ventral profile to the aperture. The appearance of the aperture, which seems to slope forward strongly from the midlateral to the ventral region, is adventitious. The living chamber is 9 mm long ventrally; at its base the shell is 7 mm high, and all indications are that the height was scarcely greater at the aperture. A part of the phragmocone shows eight camerae in a length of 8 mm; lateral lobes are broad, gently curved, sutures rise to high ventral and lower dorsal saddles. On the venter, the siphuncle was exposed by etching; it shows only obscurely, but there is indication of faintly concave segments, with long necks. It is not clear exactly how far the necks extend; possibly they terminate shortly before reaching the next apical septum, leaving room for a vestigial development of the bulbs.

A third specimen, No. 309 (pl. 4, fig. 1-4, 10), is a portion of shell 35 mm long, slender, faintly exogastric, a phragmocone of 28 camerae in a length of 26 mm, with 11 mm of an incomplete living chamber. The specimen was weathered obliquely from one side (pl. 4, fig. 1, 2, 10), the weathered surface exposing a bit of the siphuncle which apparently is not separated from the ventral wall. Sutures show only faint, broad lobes but seem oblique, rising perceptibly higher ventrally than dorsally. Bits of shell adhere to the internal mold; they show no surface markings. There is a faint constriction of the living chamber, most prominent in dorsal view, and not shown in the accompanying illustrations. The remainder of the shell is smooth; the internal mold shows some very faint longitudinal markings (pl. 4, fig. 3).

A fourth specimen, No. 310 (pl. 2, fig. 1-3; pl. 4, fig. 11, 12), shows a lateral view of a complete living chamber, apparently of a mature shell, for the adoral camerae are crowded, closely similar in spacing with the commensurate adoral part of the phragmocone of the holotype. The living chamber, 10.5 mm long, increases in height from 7.0 to 7.5 mm. The whitened surface (pl. 2, fig. 3) shows fine transverse markings which slope very faintly apicad on the venter, defining a vestigial hyponomic sinus. The phragmocone of 20 camerae is 13 mm long ventrally. Apically, eight camerae occupy 5 mm; adorally, nine camerae occupy the same length, due mainly to the shortening of the last four camerae. At the base, the cross section is elliptical, venter scarely more narrowed than the dorsum, 6 mm high, 4.5 mm wide. The siphuncle is 1 mm wide, flattened slightly on the ventral side, and appears to be in contact with the ventral wall of the shell. Etching of the ventral surface revealed siphuncle segments slightly concave in lateral outlines, evidently with subholochoanitic necks, but as usual in such preparations, it was not evident to what extent bulbs occupy the expanding apical parts of the segments. A fragment lost from the apical end, and so broken that it fitted only imperfectly, was sectioned vertically. It shows (pl. 4, fig. 11) orthochoanitic, sharply bent necks on the dorsal side of the siphuncle. On the ventral side, there is only the faintest trace of extremely steeply inclined septa. The section may not be strictly central. The shell wall is wanting here. This specimen shows somewhat less curvature than the others attributed to this species and the adoral sutures show a better development of lateral lobes, but the faint exogastric curvature, the nature of the cross section, the extreme ventral position of the siphuncle all indicate its affinities with *B. gracile* rather than with the associated *Palaeoceras*.

Discussion. The slight exogastric curvature, the elliptical cross section with venter and dorsum nearly equally rounded, the shallow lateral lobes which rise to higher saddles ventrally than dorsally, the absence of a dorsolateral geniculation of the suture as it swings forward to form the dorsal saddle, the extreme ventral position of the siphuncle, the cross section of which is flattened ventrally where it is separated from the ventral wall by only the merest vestiges of extremely steep septa, all serve to distinguish this species from the associated *Palaeoceras*, even when only small fragments are involved.

Types. Collection of the writer; holotype, No. 307; paratypes, Nos. 308-310.

Occurrence. From the cephalopod bed near the top of the San Saba limestone, Threadgill Creek section, Gillespie County, Texas.

Genus SHELBYOCERAS Ulrich and Foerste

Genotype: *Shelbyoceras robustum* Ulrich and Foerste

Shelbyoceras Ulrich and Foerste, *in* Bridge, 1930, Missouri Bur. Mines, 2nd ser., vol. 24, p. 207.
——— Flower, 1954, N. Mex. Inst. Min. and Tech., State Bur. Mines and Mineral Res., Bull. 40, p. 26 (gives complete references).

As previously noted under the family discussion, *Balkoceras* makes it possible to regard *Shelbyoceras* as a possible cephalopod, for if it is a cephalopod it is exogastric. Its siphuncle, which must lie against the convex side of the shell, is completely unknown. The shells are rapidly expanding, presumably exogastric, cyrtocones; the last septum, the only one observed, is transverse, shows slight lateral lobes; the cross section of the shell is compressed, more narrowly rounded on the convex (ventral) than on the concave side, costae may be present, and costae and aperture slope apicad strongly from dorsum to venter. The larger size, rapid expansion, strong costae, and the strongly oblique aperture set the genus well apart from *Balkoceras*. It may be noted that Unklesbay and Young (1956) have assigned to *Shelbyoceras* two forms from the Chepultapec limestone of Virginia. They show siphuncles close to the concave side of the shell and cannot possibly belong to this genus. Rather, they are curved Ellesmeroceratidae, fragmentary, and are here refigured and assigned to the genus *Muriceras*. Preservation of the materials is very poor, and precise determination most inferential. *Shelbyoceras* is represented by the following species:

S. robustum Ulrich and Foerste, 1935, Eminence of Missouri

S. bessermense UF&M, 1943, Copper Ridge of Alabama

S. cf. *bessemerense* UF&M, 1943, Potosi of Missouri

S. unguliforme UF&M, 1943, Copper Ridge of Alabama

S. ellinwoodi Flower, 1954, Pedernales dolomites, Central Texas

S. cf. *ellinwoodi* Flower, 1954, same occurrence

Suborder Ellesmeroceratina

In this suborder are grouped those ellesmeroceroids, as previously noted, in which the ring is well calcified, primitively showing layering of structure, and of some appreciable thickness. In contrast, the Plectronoceratina show poorly calcified rings and the Cyrtocerinina show rings which are well calcified but are extended into conspicuous lobes into the cavity of the siphuncle. Relationships have been shown in Text Figure 2.

The nucleus of the suborder is the family Ellesmerocertidae, discussed more fully below. These shells are dominantly compressed in section, have short, rapidly expanding apices, relatively short phragmocones, and the ventral siphuncles commonly contain diaphragms. It is this family which dominates the Lower Canadian, and in its development, variable as to form, prolific as to species, is found the first expansion of the cephalopods great enough that they became significant and, in places, dominant constituents of the preserved marine faunas. The present study has brought to light the first recognized forerunner of the family in the Upper Cambrian. Beyond the close of the Lower Canadian, the stock declines markedly. The five surviving genera of the later Canadian are known from few species, few specimens, and some are inadequately known morphologically. *Cumberloceras* of the Demingian is a typical member of the family, but the other genera are little known morphologically, and future work may show that they have specializations, as already indicated for *Clelandoceras,* which may eventually prove a basis for setting them apart in separate families.

There are two strongly curved genera, *Oelandoceras* of the Glaucontkalk of the Baltic region, and *Beekmanoceras* of the Middle Canadian or New York. For the latter, the family Beekmanoceratidae was proposed, but structure is not distinctive nor is the strong curvature, which is equaled in *Woosteroceras.*

As originally conceived, the Ellesmeroceratina consists of the Lower Canadian Ellesmeroceratidae and two major derived stocks known mainly from younger strata, the dominantly annular Protocycloceratidae and the dominantly smooth Baltoceratidae. Further specializations have been found in both lineages which are set apart as separate families. The Protocycloceratidae is already differentiated from the Ellesmeroceratidae in the Lower Canadian. There one finds *Walcottoceras,* a genus so intermediate between the two that it could be assigned with about equal justification to either group, but the broader-whorled *Rudolfoceras* is already developed in the late Lower Canadian also. Simplicity of definition is the main consideration in assigning *Walcottoceras* to the Protocycloceratidae. The Apocrinoceratidae is a very small family differing from the Protocycloceratidae in the cyrtochoanitic expansion of the segments of the siphuncle. To separate such a small family, known at present from three genera, three species, and from what I have been able to learn, apparently from only three known specimens, as an order or suborder by itself would be a little absurd, placing too much emphasis on matters of definition. That a similar trend is evident in *Clelandoceras(?) rarum* shows the inadvisability of the course. Teichert and Glenister, in describing *Apocrinoceras,* mistakenly regarded it as a primitive member of the Discosorida, allied to *Westonoceras,* a matter happily corrected already (Flower and Teichert, 1957, p. 44, 138).

The Baltoceratidae is a long-ranging lineage, at its beginning in the Lower or early Middle Canadian there is such close resemblance to the ancestral Ellesmeroceratidae that decision as to the placing of certain genera has been most difficult; in general, genera with diaphragms are retained in the Ellesmeroceratidae, but the absence of diaphragms in species known from scant material may later prove to be more apparent than real, and future work may well emend the present boundaries slightly. The later Canadian Baltoceratidae remain inadequately known, largely because available material is as yet very scant indeed. Recent work has shown some surprising morphological deviations. Teichert and Glenister (1954) have recognized the Thylacoceratidae as a lineage derived from the Baltoceratidae, characterized by siphuncles of small diameter and with long septal necks. These forms also are as yet known from relatively few species and very few specimens. Work on further material, as yet unpublished, indicates that this family has endocones and is assignable to the Endoceratida (Glenister, *fide litt.,* 1961). *Cyclostomiceras,* a genus which seems little more than a baltoceroid which becomes somewhat more rapidly expanding and develops a contracted living chamber, is a Cassinian development. Foerste (1925) made the family Cyclostomiceratidae, but the only other genus, *Eremoceras,* which he placed in it with *Cyclostomiceras,* is placed here in the Ellesmeroceratidae. The form distinction between the Baltoceratidae and Cyclostomiceratidae is not great and is bridged further by the new material here described as *Metabaltoceras.* It seems better to recognize the two families, but the considerations involved are largely subjective, mainly involving the desirability of having a family of dominantly smooth, slender orthocones derived from the Ellesmeroceratidae, and undoubtedly containing the ancestors of the Michelinoceratida. Diaphragms are suppressed in the Baltoceratidae and their derivatives. The present investigation yielded in the family a most unexpected structure, the development of a solid, round, calcareous rod secreted against the ventral side of the siphuncle. As yet, forms showing this structure are few. No attempt is made here to divide such forms into a separate family, largely because it is felt that our knowledge of the range of structures of this type is still so inadequately known that any separation made at the present time will require radical revision in the near future. The procedure is one which may be desirable should future work show that, as present observations suggest, some Baltoceratidae possess this rod while others lack it.

The Cincinnatian genus *Shideleroceras* is morphologically isolated as an endogastric cyrtocone with a subcentral aneuchoanitic siphuncle. It is set apart in a family by itself. Form and structure indicate that it is a derived ellesmeroceroid, logically derived from the Ellesmeroceratidae, but as yet forms connecting it morphologically and stratigraphically with its ancestors are unknown.

The Buttsoceratidae, formerly included in this group of families is suppressed. New material shows the supposed tube to be only the silicified inner surface of a lining, quite similar to that of *Troedssonella,* and the siphuncle wall has thin homogeneous rings of the Michelinoceratidae. *Buttsoceras* is referred to the Troedssonellidae of the Michelinoceratida (Flower, 1962).

It should be noted that there is considerable variation in thickness of the rings and differentiation of layers within them in the Ellesmeroceratina. Some such apparent variation is attributable to alteration and replacement, and apparent absence of layering is, in some instances, to be directly correlated with advanced alteration; this is certainly true for the holotype of *Ellesmeroceras scheii* and for the material from the Threadgill limestone of the Tanyard formation of the Llano uplift. There appears also to be real variation which was original and organic. In general, layering is wanting in early stages, and also in adults of some forms which are only small, and is best developed in the late growth stages of the larger species. In the higher Baltoceratidae there is a tendency even in late growth stages toward thinning and simplification of the rings. In that family there is considerable variation, the full extent of which is possibly not even yet fully explored. In general, however, the thick rings with layering persist in well-preserved members of the Ellesmeroceratidae, Protocycloceratidae, Apocrinoceratidae, in primitive Baltoceratidae, and in the derived Cyclostomiceratidae. Variation of the rings in the Ellesmeroceratina and Cyrtoceratinina is illustrated in Figure 6.

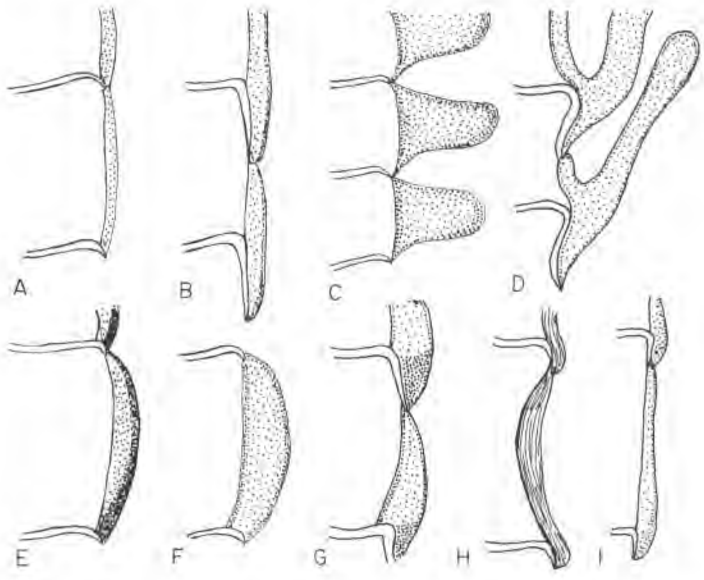

Figure 6

TYPES OF RINGS FOUND IN THE ELLESMEROCERATINA AND CYRTOCERININA

A. Moderately thick, apparently homogeneous ring from the holotype of *Ellesmeroceras scheii*. Alteration is involved and may explain the loss of layering.
B. Lengthening of neck and imperfect differentiation of a dark inner (siphonal) layer, from *Metaellesmeroceras anomalum*.
C. Inflated rings of *Cyrtocerina*.
D. Inflated rings of *Bathmoceras*, extended strongly forward into prominent lobes, the tips rounded and slightly expanded and rounded. Note also sinuate outline of exterior of siphuncle.
E. Differentiation of thin, dark, inner surface of ring, from *Ellesmeroceras bridgei* Flower (1941A).
F. Exceptionally thick ring, from *Ellesmeroceras* sp., from Alaska; see Pl. 26, fig. 12, and Pl. 27, fig. 8.
G. Differentiation of bands on inner and outer surfaces, with similar material concentrated at the tip, from *Loxochoanella*; modified from Teichert and Glenister, 1954.
H. Ring of *Cartersoceras*, with fine lammelar structure.
I. Obscure indication of differentiation of dark, dense, inner layer, as seen in *Rioceras* and *Baltoceras*.

FAMILY ELLESMEROCERATIDAE
Kobayashi

General Discussion

Here are straight and endogastric shells with ventral tubular siphuncles, primitively and dominantly compressed in cross section. Rings are thick, showing layered structure in late growth stages of the larger forms; diaphragms are common, probably universal, though fragmentary material limits their demonstration in many species.

Within the family, which is large, widespread, and diverse as to form within the above general limits, there are exceptions to many items in the definition. The cross section broadens in some genera, being circular or depressed, but the broadening thus attained is obviously developed within several distinct and unrelated lineages within the family. The small straight *Robsonoceras* attains a circular section, and only the prevalence of diaphragms within it leads to its retention in the Ellesmeroceratidae rather than assignment to the dominantly younger Baltoceratidae. There is some question as to the stratigraphic range of this genus. The Lower Canadian *Pachendoceras* attains a broad cross section, and the shell was, quite naturally, at first identified with the endoceroids which it resembles in this feature, rather than the ellesmeroceroids. The absence of endocones and the presence of diaphragms indicate that it is, however, a member of the Ellesmeroceratidae aberrant only in the broad cross section of the shell and suppression of lateral lobes. Within the genus *Anguloceras*, characterized by very strongly inclined sutures and septa, the cross section ranges from the primitive compressed condition to circular in one species and depressed in another. Again, broadening of the section is found in a group of species formerly included in *Dakeoceras*, which is typically compressed, and while these forms are set aside in the genus *Paradakeoceras*, their origin in *Dakeoceras* is a conclusion which there is no good reason to question. Again, a broadening of the cross section characterizes *Woosteroceras*, but it is clearly allied to simple, very slender, compressed cyrtocones such as *Stemtonoceras*. It is obvious that the examples of broadening of the primitively compressed cross section represent individual departures from a primitive and general pattern, which it would be absurd to place in a family by themselves. At the same time, the dominant surviving stock of the Ellesmeroceratidae in the Middle and Later Canadian is the Baltoceratidae, a family of straight shells of circular or depressed section, and quite possibly *Robsonoceras* and *Pachendoceras* might be related to the beginning of this lineage. Where sections broaden, the lateral lobes of the sutures, prevalent in the compressed forms, are lost.

Septal necks are generally very short but may become elongated. Such elongation has been known previously within the genus *Clarkeoceras* but is by no means characteristic of all the species.* *Metaellesmeroceras* was set apart as a subgenus

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*Some but not all such species have had to be removed to other genera.

from typical *Ellesmeroceras* by virtue of the elongation of the necks and the flattening of the siphuncle where it meets the ventral wall of the shell.

The layered structure of the connecting ring is a general feature of the family but is certainly not universal. It is, however, extremely difficult to say to what extent the apparent absence of this phenomenon is biologically significant and to what extent its apparent absence in certain forms stems from phenomena of recrystallization and replacement. There is, however, a strong suggestion that layering is best developed in late growth stages of forms attaining an appreciable size, is absent in young stages of these same species, and is perhaps never fully developed in the microellesmeroceroids, species which never attain any great size. On the other hand, the Plectronoceratina have shown a suggestion of similar structures, though the shells are tiny, their rings are certainly quite unlike those of the Ellesmeroceratidae, and there is reason to believe that the difference is, in a large part at least, due to the presence of more organic and less calcitic structure in the rings of the Plectronoceratina. This would suggest that similar layering would be general throughout the Ellesmeroceratida.

Some confusion has existed in the past concerning the recognition and the prevalence of diaphragms in the family. Curiously, the first illustration of diaphragms in a cephalopod was that of Clarke (1897) for *Piloceras newton-winchelli*, which was later to become the genotype of *Clarkeoceras*. Hyatt (1894, p. 363) reported diaphragms in a group of shells from Newfoundland for which he later (1900) erected the Diphragmida, containing the Diphragmidae and the single genus *Diphragmoceras*. His diagnosis of the genus is as follows: "Orthoceracones and cyrtoceracones having simple septa and sutures as in the Endoceratida, but siphuncle divided by tabulae alternating with the septa of the camerated shell. Chambers of the siphuncle empty, as are also the camerae. Quebec group." No species was ever named. Hyatt's material has never been illustrated or described beyond the above quotation.* It would be rather a sad mistake at this time to revive this genus. The present status of the Rules of Zoological Nomenclature on the possibility of such a procedure is rather nebulous. Indeed, there seems to be general bewilderment on the matter on the part of those who have attempted to conform with rumors and speculation as to what the rules will ultimately be, for the rumors and reports alone have gone through about five revisions since 1950. Under former rules a genus thus described without species can be validated by selection of a type from among the first species assigned to it.† In the present instance, it would be possible to describe a species having the above characters, assign it to the genus, name it as the genotype, and thus validate the genus. In such an event, however, it is extremely likely that such a genus would only be identical with one subsequently described and now quite generally known. As the genus *Diphragmoceras* would have priority dating from 1900, the procedure would probably result, in conformation to the rules, in the revival of this name, not used in cephalopod taxonomy except in Hyatt, 1900, and the suppression as a synonym of some generic name already familiar. This procedure would serve no good purpose except that the perpetrator of such a deed could perhaps add one more paper to his bibliography; if, indeed, that can be construed as a good purpose.

Two possible courses are open to remove the danger of this future difficulty: (1) a petition to the International Commission to have *Diphragmoceras* placed upon the list of invalid and suppressed generic names and (2) attributing to *Diphragmoceras* as its first species a species which is a typical member of a previously proposed genus. Unfortunately, experience indicates that presenting a petition to the commission is cumbersome and time-consuming, and one is never certain how it will turn out. The petition of Flower and Teichert concerning *Westonoceras* versus *Westenoceras* involved in the end a misprint resulting in the request for the commission to validate not the Westonoceratidae but the ffestonoceratidae. As more than one petition to the commission in previous years has stemmed from a misprint, it is uncertain how this will be decided. The second course is limited in scope, because most of the generic names employed in the Ellesmeroceratidae were proposed after 1900. However, *Eremoceras* Hyatt was proposed in 1883, and while *Eremoceras syphax*, the genotype, is known only from one specimen from the Levis conglomerate, and this specimen has not been sectioned and is not therefore known to possess diaphragms, a species in the present study, *Eremoceras multiseptatum*, has been sectioned, shows diaphragms, and therefore falls within the rather broad limits of Hyatt's genus and is suitable as a genotype. That species is here designated as the genotype of *Diphragmoceras* Hyatt, 1900. As it is a typical *Eremoceras*, *Diphragmoceras* Hyatt, 1900 becomes a synonym of *Eremoceras* Hyatt, 1883.

Ulrich and Foerste (1933) called attention to the presence of diaphragms, but the monographic treatment of the Ozarkian and Canadian cephalopods, completed by Miller and various coworkers after the deaths of both Ulrich and Foerste, record these structures for only a very few species and genera. Indeed, these monographs seemed to regard with suspicion any other than the orthodox structures of shell wall, septa, and siphuncle, and regarded the taxonomic significance of diaphragms or other structures not at that time sanctioned in elementary textbooks as highly uncertain. Endocones were recognized, but the taxonomic validity of the widely varying patterns within the cones, the blades, and presence or absence of diaphragms in the central tube, was not.

Actually, the present descriptions and figures show considerably more evidence of the occurrence of diaphragms in the Ellesmeroceratidae than has been recognized. Much of the previously described material consists of specimens which have been replaced in one way or another by chert. (*See* Text Fig. 7.) It is interesting to note that silicification has, in most of this material, been a replacement of matrix filling the cavity of the shell, rather than replacement of the original calcareous shell structures. Instead, the original calcareous shell parts are commonly not silicified, and in typical material have been dissolved away by weathering. With them has been lost inorganic calcareous material deposited in closed parts of the shell which matrix could not penetrate. Such parts include closed camerae and also the apical part of the siphuncle which was sealed off effectively from its anterior end and the connected living chamber by diaphragms. Chert-replaced fillings of the anterior ends of the siphuncles commonly show a regular,

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*Inquiry and search of the collections of the Museum of Comparative Zoology failed to bring this material to light; curiously, after just having been refused the loan of type specimens, I learned that his material had been on loan elsewhere for about fifteen years.

†The new rules which appeared since this was written leave this situation essentially unchanged.

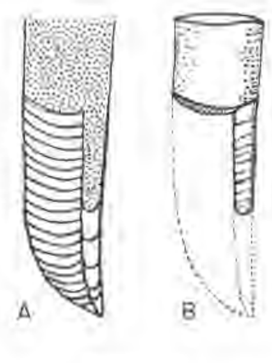

Figure 7

PRESERVATION OF DIAPHRAGMS

A. A sagittal section through an *Ellesmeroceras* in which matrix has invaded the living chamber and the anterior part of the siphuncle, but further penetration is stopped by the last diaphragm. Calcite occupies the true shell parts and also the camerae and the apical closed part of the siphuncle. B. External view of the same specimen after (1) silicification of the matrix and (2) solution of calcitic parts. The remaining internal mold represents the living chamber and part of the siphuncle; the preserved tip of the siphonal filling retains the rounded contours of the last diaphragm.

smoothly curved surface which marks the contact of the invading matrix with the diaphragm. Such apices of matrix in the siphuncle have been figured by Ulrich, Foerste, and Miller (1943) for several species of *Burenoceras* (notably their pl. 37, fig. 34-5, and probably fig. 18), *Clarkeoceras* (pl. 47, fig. 4), *Cumberloceras* (pl. 54, fig. 1-6), *Oneotoceras* (pl. 68, fig. 1-2); later Ulrich, Foerste, Miller, and Unklesbay (1944) figured a subconical diaphragm of *Pachendoceras* as an endocone (their pl. 64, fig. 1). The present work illustrates diaphragms in *Paradakeoceras*, *Ectenolites*, *Ellesmeroceras*, *Annoceras*, and *Boreoceras*. Clarke (1897, p. 768) figured them long ago for *Piloceras newton-winchelli*, now the genotype of *Clarkeoceras*. The Ozarkian–Canadian monographs include recognized diaphragms in *Robsonoceras*, *Stemtonoceras*, and *Levisoceras*.

There is evidently considerable variation in the proximity of the development of diaphragms to the base of the living chamber. In some genera, notably *Cumberloceras*, there is only a short adoral interval of siphuncle lacking diaphragms; in other forms, the secretion of diaphragms is so delayed that there is a long interval of siphuncle without them. In some genera, and, of course, in many species, diaphragms are not known. Are they merely so retarded in their development that they occupy only adapical parts of the phragmocones which have not yet been observed? This interpretation is consistent with the known specimens, so many of which are sadly fragmentary. It must be noted that the possibility remains that there may be species in which the development of diaphragms is suppressed completely. There is scarcely a species known from specimens complete enough to demonstrate real absence of diaphragms in mature individuals. Certainly, diaphragms are a prevalent feature of the Ellesmeroceratidae and are found also in the ancestral Plectronoceratidae, indicating that they are an archaic feature in cephalopods. They are lost in most descendants of the Ellesmeroceratidae but are clearly retained within the Protocycloceratidae.

The present work contains descriptions of two species of *Ectenolites*, the first of the true Ellesmeroceratidae to be found in beds of certain Upper Cambrian age. *Ruthenoceras* Korde[*] is clearly a member of the Ellesmeroceratidae (Flower, 1954), though the genotype is known from a chance-oriented section, leaving its precise features somewhat doubtful. Curiously, a somewhat similar form was found in sections, again chance-oriented, from the Threadgill limestone of the Llano uplift and is figured in the present work. It may further be noted that the assertion that Korde's material came from beds of Upper Cambrian age is as yet unsubstantiated by any associated fauna, and if, as the Llano uplift occurrence suggests, it really occurs in beds of Lower Canadian age, this will not be the first time that earliest Canadian has been confused with Upper Cambrian. Sun's (1937) *Shantungendoceras* is a good member of the *Ellesmeroceratidae*, but includes both slender shells suggestive of *Ellesmeroceras* and *Ectenolites* and slender curved forms suggestive of *Stemtonoceras* and *Dakeoceras*, but it now appears that the beds from which these forms came are Lower Canadian and not Upper Cambrian.

It is in the Lower Canadian that the great expansion of the Ellesmeroceratidae occurs. We know them at present mainly from North America, but this situation is not without its subjective elements; Ulrich made a special effort to bring together American materials, which ultimately received monographic treatment. Dr. Giovanni Cecioni (*fide litt.*) has some significant Canadian cephalopods from South America, in which are apparently included some Ellesmeroceratidae. A few species, inadequately known because they are flattened in shales, occur in the British Tremadoc, but they are consistent with known genera of the family. Kobayashi's work has made known a number of significant forms from eastern Asia, but Troedsson's *Protobaltoceras*, which seems probably a synonym of *Ectenoceras*, is from Chinese Turkestan, and there is hope that current Russian work will add materially to our knowledge of these forms in northern Asia. *Loxochoanella* of Teichert and Glenister (1954) is, from its broad cross section, high stratigraphic position, and apparent absence of diaphragms, a member of the Baltoceratidae, and its assignment to the Ellesmeroceratidae was a mistake. No true Ellesmeroceratidae are yet known from Australia or Tasmania.

Survivors of the Ellesmeroceratidae beyond the close of the Early Canadian are relatively rare; possibly future study will increase the known specimens, species, and even the genera, but they are overshadowed by the larger and more abundant Endoceratida and Tarphyceratida, and also by the Baltoceratidae and Protocycloceratidae. *Cumberloceras* is a genus characteristic of the Middle Canadian. *Copiceras* and *Clelandoceras* are Cassinian. The inadequatley known *Beekmanoceras* of the Middle Canadian of the Champlain Valley and *Oelandoceras* of the Glauconite limestone of the Baltic region are strongly curved, possibly both are gyroconic; such deviation in form seems insufficient for the recognition of a separate family, as it is found also in *Woosteroceras*.

Relationships Within the Ellesmeroceratidae

Relationships of the genera in the Ellesmeroceratidae are close, in some instances to the point of intergradation. It remains, however, difficult to say with any certainty what the archaic members of the family were like. Present evidence shows only one member of the family, *Ectenolites*, certainly

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[*] The name has also been transliterated as Cordé.

present in the Upper Cambrian, with the doubtful addition of the slender curved *Ruthenoceras;* but, as noted above, corroboration of the Cambrian age of that genus seems to require confirmation from associated fossils, particularly since Lower Canadian and Upper Cambrian have so often been confused before. It seems possible, but is far from certain, that *Ectenolites* is the primitive radicle of the family. In the Gasconadian, differentiation of lower and upper faunas has been possible only in a few instances and in a few regions. In Missouri, the Van Buren, which was differentiated from the Gasconade, contains *Burenoceras, Dakeoceras,* and *Ectenolites.* An early Lower Canadian assemblage occurs in eastern New York in the Baldwin Corners formation. The cephalopods of that formation are fairly large straight shells of the aspect of *Ellesmeroceras* and *Eremoceras,* but the marginal parts of the shells were lost through solution, their boundaries are styliolitic, and no specimens have been found showing siphuncles; for all evidence to the contrary, these forms could be allied rather to *Sinoeremoceras* and *Multicameroceras* of the Plectronoceratidae. In the Llano uplift, cephalopods have not been studied from the basal beds of the Canadian, but the limestones of the Threadgill member have yielded the forms here described, representing the genera *Ellesmeroceras, Llanoceras, Muriceras, Burenoceras, Barnesoceras, Woosteroceras,* and *Levisoceras.* It is, however, uncertain whether this occurrence represents the equivalent of the lower half of the Gasconadian, possibly equivalent to the Van Buren and Baldwin Corners formation, or whether it is to be considered as the lower half of the Gasconade in a restricted sense. As yet, other than the obvious fact that there are some obviously specialized genera, notably those with contracted apertures, in the upper part of the Gasconadian, not known in the lower part, there is no clear stratigraphic evidence of a definite sequence of genera in the Lower Canadian.

Morphology alone is something of a guide. Ignoring, for the moment, the genera which are obviously specialized, the simpler genera intergrade to a considerable extent. Figure 8 is an attempt to arrange the Lower Canadian forms in terms of the features in which they vary most prominently, curvature and rate of expansion. Here a rectilinear plane is used, one side of which represents straight shells, the opposite side strongly curved shells. In the other dimension, one side represents slender shells, the opposite side stout shells, rapidly expanding. Theoretically, this rectangle may be considered a plane of infinite extent, with the present limits arbitrary. However, this is not strictly necessary. Shells perfectly straight, except for the short, rapidly expanding apex, represent a limit beyond which it is not possible to pass, except in the sense that exogastric shells would possibly be a further extension of this limit; there are, however, no exogastric shells in the Ellesmeroceratidae, nor for that matter in any shells of the Lower Canadian, except for *Ectenolites extensus,* a species variable in form and having some faintly exogastric as well as endogastric and straight individuals. Likewise, shells which are essentially tubular set a definite limit, another boundary of the plane. The opposite boundary is not the real potential limit in terms of rapid rate of expansion; there is, properly, no such limit on theoretical grounds. It has, however, been taken at a point beyond which the apical angle is not known to increase in Lower Canadian forms. This is not the known limit for nautiloids; *Hipparionoceras* of the Devonian and a few brevicones, unplaced generically, in the Middle Silurian exceed this limit, but such forms are few, highly specialized, and not of immediate concern to the present problem. The limit of strong curvature is again arbitrary, but the simpler genera of the Ellesmeroceratidae are never more than cyrtoconic. On such a plane, the various known species could be placed as loci, and they would form a pattern

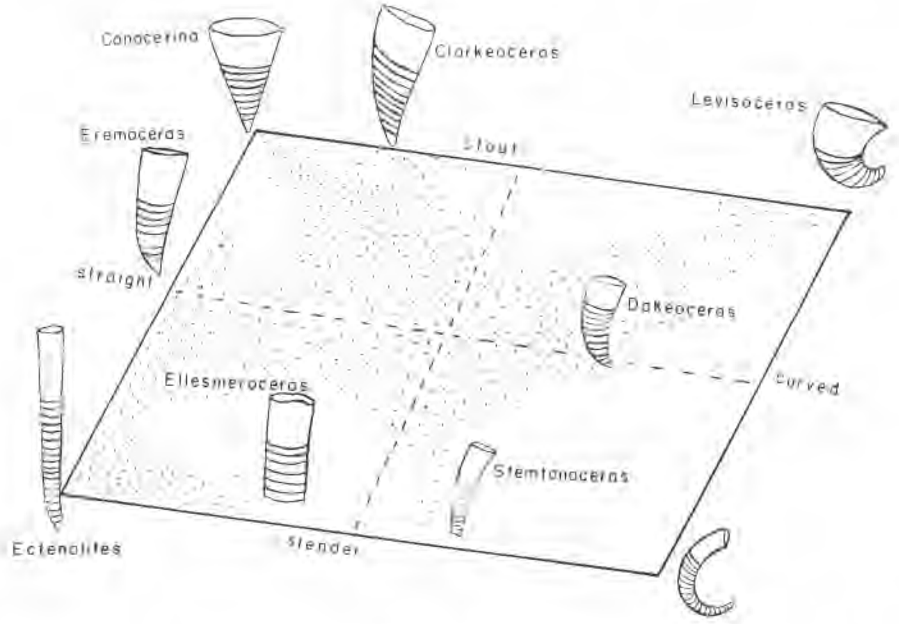

Figure 8

Diagrammatic arrangement of the simple Ellesmeroceratidae of the Lower Canadian in terms of rate of expansion and degree of curvature. The dots represent the distribution of species and show the points of intergradation of the defined form-genera, an indication of the rapid evolutionary expansion of the group.

much as indicated in Figure 8. Gradation exists but is not everywhere perfect. To the left of the diagram, there is gradation from the extremely slender shells of *Ectenolites* through the more gradually expanding shells of *Ellesmeroceras* and *Eremoceras*. *Ectenolites* grades into faintly curved types, but there is no complete unity with *Stemtonoceras*, the most strongly curved of the moderate-sized slender shells. In the simpler genera of the Ellesmeroceratidae, no slender shells attain the degree of curvature represented by the corner of the plane shown in the lower right; however, forms which belong in the upper right are typical of *Levisoceras*. There appears to be perfect gradation from *Levisoceras* into *Dakeoceras*, and from that genus into *Stemtonoceras* on one hand and *Clarkeoceras* and *Conocerina* on the other. Clear gradation exists also between *Dakeoceras* and *Conocerina* and the straight *Ellesmeroceras* and *Eremoceras*. If gradation is vexing in leaving generic boundaries poorly defined, the situation reveals significant evidence that the Ellesmeroceratidae is a single stock, showing wide variation and gradation, both indicative of a rapidly evolving single lineage.

Figure 9 shows again the plane in which the variations in form of the simpler genera of the Lower Canadian are plotted, but two new features are added; first, a similar plane showing the form relationship of our one known Upper Cambrian member of the Ellesmeroceratidae, a matter already mentioned which need not be repeated here. Second, the genera which are specialized in one way or another, but which certainly depart from the generalized pattern of straight to endogastric shells with simple surfaces, compressed sections, and sutures with lateral lobes are indicated; further, lines indicate the position which they occupy in terms of curvature and rate of expansion, and at the same time their probable derivation from the simpler genera.

Some of these departures from the generalized pattern have been mentioned already, as they are departures from any definition built on the basis of the dominant generalized members of the family. *Anguloceras* is a genus in which sutures first become strongly oblique, so that lateral lobes, as such, disappear; species vary from the typical compressed cross section to circular and even depressed cross sections.*

Strong annuli are developed in the slender straight *Walcottoceras*, which is little more than an *Ectenolites* with annuli; matters of definition make it expedient to include this genus, transitional between the Ellesmeroceratidae and the Protocycloceratidae, in the latter family, but because it is so transitional it is included in the present diagram. *Annoceras* is essentially an *Eremoceras* which has developed low annuli. Broad cross sections are attained in *Robsonoceras*, circular in section; *Pachendoceras*, depressed and elliptical in section, and again in *Paradakeoceras* where the section becomes quite wide, but the venter is narrowly rounded and commonly subangular. *Woosteroceras*, another genus in which the cross section broadens, is further specialized in combining strong curvature with an almost tubular shell, by which it would fall at the lower right corner of our rectangle.

Three genera which show some intergradation are charac-

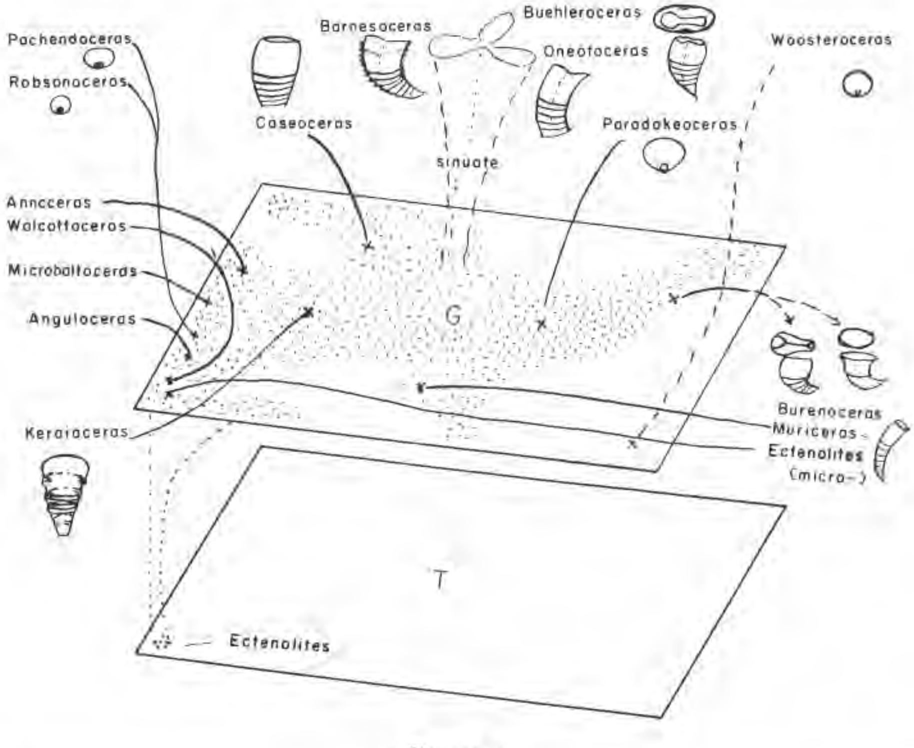

Figure 9

Further elaboration of the evolution of the Ellesmeroceratidae up to the close of the Lower Canadian. The upper rectangle (G) shows by the distribution of dots the form patterns of the simpler genera of Figure 8. The lower rectangle (T) shows a similar treatment of the one known Upper Cambrian Trempealeauan form. Specialized form deviations of the Gasconadian are indicated, with similar types of deviations imperfectly grouped together, their probable points of origin among the simpler genera indicated.

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*It should, however, be noted that it is not impossible that folding of strata may have produced distortion responsible for the apparent broadening in this genus. Other material from the same source, the Chepultapec of Virginia, suggests this is a very real possibility.

terized by growth lines with prominent lateral crests or sinuses; also, the cross section tends to be slightly concave laterally. Here belong the slender cyrtoconic *Oneotoceras*, the more rapidly expanding, more curved *Barnesoceras*, and the nearly straight *Buehloeroceras* in which the contraction of the sides develops late, and a keyhole-shaped aperture develops. Shells assigned to *Burenoceras* have been rearranged in the present work; large forms with flaring apertures are assigned to *Levisoceras* instead. The remaining forms are tiny shells, but even here there is a contrast between two groups, those with wide apertures, flaring slightly at maturity, and those with contracted apertures. Some species are so poorly known that one cannot assign them to either group until more complete living chambers have been found; unfortunately, the genotype is among these species, so for the present it has seemed not so much wise as necessary to leave these two disparate species groups under the generic name *Burenoceras*.

Burenoceras with contracted apertures are almost exact duplicates in miniature of the Silurian *Phragmoceras* and the Devonian *Bolloceras*, both in form of shell and outline of aperture. Unquestionably, the three genera are homeomorphs, and one might conclude that they occupied similar ecological niches; it is not at present possible to go farther for there is some question whether these forms were crawlers, swimmers, or floaters.

Burenoceras is one of several genera characterized by tiny size; other are the slender curved *Muriceras*, and most if not all of *Ectenolites* is represented by shells which are tiny in relation to the more typical Lower Canadian forms. These are grouped together artifically as microellesmeroceroids. Though treated for the purposes of this diagram as specialized, it should be noted that these forms may well be primitive, for all the known Upper Cambrian cephalopods agree with them in their very small size. *Caseoceras* is, in its general features, close to *Clarkeoceras* and *Conocerina* but differs from both genera in the contraction of the aperture. Figure 8 shows the suggested development of the Lower Canadian Ellesmeroceratidae of generalized aspect, shown in more detail in the preceding figure, from *Ectenolites* (though it is realized that this origin suggested by the present factual evidence may be rejected later), and the derivation of the obviously specialized genera from those of simpler aspect.

Figure 10 is an attempt to show the stratigraphic relationships; here features indicated in detail in the two preceding figures are generalized. The basal plane (Tr.) shows the form type of the one Upper Cambrian (Trempealeauan) member of the family, which is assigned to *Ectenolites*. The second plane (G) indicates variation in terms of curvature and rate of expansion developed in the Gasconade; further specializations, shown in Figure 9, are necessarily omitted. The succeeding planes show, again in relation to curvature and rate of expansion, the genera known in the later Canadian (D), the Demingian is characterized by *Cumberloceras*, a short, rapidly expanding shell much like *Levisoceras* and some "*Burenoceras*," a form specialized by costae and a remarkably widely expanding siphuncle. Here also belongs the little-known genus *Beekmanoceras*, atypical in its gyroconic form and circular cross sections. The Jeffersonian, represented by the next plane (J) has no indigenous genera; probably this is an indication of our incomplete knowledge, for in the Cassinian (C) three genera are known.

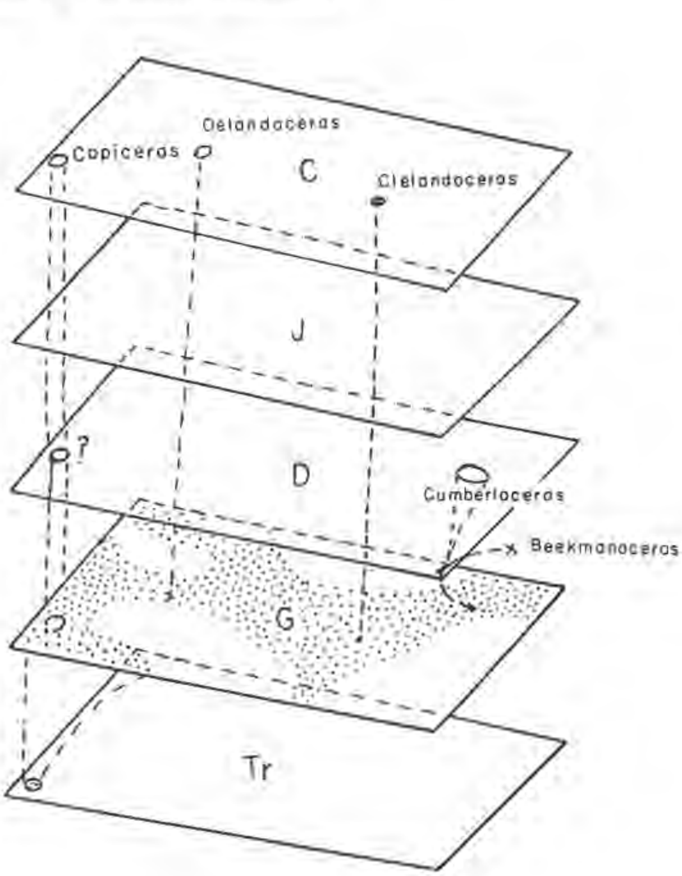

Figure 10
POST-GASCONADE DEVELOPMENT OF THE ELLESMEROCERATIDAE

Here the general form of the genera is indicated by loci on quadrangles, as in the previous Figures 8 and 9, but more ages are indicated.
Tr.—Trempealeauan, Upper Cambrian
G.—Gasconadian, Lower Canadian
D.—Demingian, Middle Canadian
J.—Jeffersonian
C.—Cassinian

Beekmanoceras, being a gyrocone of circular section, lies outside the generalized form-types indicated in the area of the plane of the Demingian. Others are simpler in form, though *Clelandoceras* is seemingly specialized also in the contracted aperture and faintly expanded segments of the siphuncle.

Survivors of the Ellesmeroceratidae beyond the close of the Lower Canadian are accommodated in several genera, few of which are adequately known morphologically. *Cumberloceras*, characteristic of the Middle Canadian is a costate cyrtocone, both shell and siphuncle quite rapidly expanding. The monotypic *Beekmanoceras* is a small gyroconic shell, its morphology most inadequately known, of the *Lecanospira* beds of the northern Champlain Valley. *Oelandoceras* is known only from the glauconitic limestone, of Canadian age, possibly Cassinian, of the Baltic region. This genus is also quite strongly curved and possibly gyroconic. As *Woosteroceras* of the lower Canadian shares such strong curvature, separation of these younger forms into a separate family seems unwarranted. *Copiceras*, known only from the Cassinian, appears in gross features as a rather large *Ellesmeroceras* with a relatively small siphuncle. Details of the siphuncle structure are unknown. *Clelandoceras* of the Cassinian was first known from only silicified bits of phragmocones. A new species, C. *rarum* of the Cassinian of the El Paso group, shows a living chamber with a contracted aperture and siphuncle segments very faintly expanded in the camerae. Both features were unexpected but are possibly shared by the previously described species. Anomalously, another species was found in the Demingian which lies outside the stratigraphic range of the genus but shows a simple conical living chamber, and the siphuncle segments are apparently perfectly tubular. This form, however, seems better referred to the dominantly Lower Canadian genus *Muriceras*.

Doubtlessly, future work will increase the post-Gasconade members of the Ellesmeroceratidae, but they are nowhere abundant and are overshadowed by the larger Endoceratida and Tarphyceratida.

Proportions

A fact not generally recognized is that the shells of the Ellesmeroceratidae are more limited in length than those of more advanced cephalopods. Commonly, the entire shell is two to four times the length of the mature living chamber. It has been evident for some time that some of the genera had very short phragmocones; indeed, *Burenoceras* was defined (UF&M) as having phragmocones shorter than the living chambers. In *Levisoceras* and some *Conocerina*, it is evident that the phragmocones, while a little longer, were not commonly twice the length of the living chamber, and that the same is possibly true of such rapidly expanding shells as *Clarkeoceras*, *Caseoceras*, and *Buehleroceras*. However, it was believed that such of the genera as show a more gentle rate of expansion may have had shells tapering to a long, slender apex. In practice, no support for this natural belief was found. Curiously, no small, slender, apical portions assignable to *Ellesmeroceras* which could be confused with *Ectenolites* were found. In studying the ellesmeroceroids of the Threadgill member of the Tanyard formation, one association on Threadgill Creek yielded some relatively large Ellesmeroceratidae and also associations of numerous tiny shells. It was believed at first that such thanatocenose associations would contain immature individuals and broken apical portions of the large species. Close study showed that this was not the case. Instead, these associations were made up of shells representing tiny species, commonly less than an inch in length and attaining a maximum shell height of usually not more than a quarter of an inch. Adoral modifications of the shell wall and, though less commonly, anterior modifications of the last septa indicated that these shells were mature representatives of tiny species. Commensurate portions of large species in terms of length from the apex or in shell cross section proved to be blunt, rapidly expanding apices, and the groups of large and of tiny species would not, for this reason, have commensurate portions which were similar enough to result in any confusion in identification.

The significance of size became more evident when it was realized that the large and the tiny species, of which a considerable number were actually known, were for the most part well set off from one another, without the gradation which one might well expect. One exception only was found: a few forms transitional between the large *Ellesmeroceras* and the relatively small *Ectenolites*. Several possible explanations for such size discrepancy may be suggested. It is not impossible that all-or-none types of changes, genetic in nature, might be involved. One may also suggest that such wide size discrepancies might be explained by sexual dimorphism. Such extreme size differences as are involved find some parallel in certain organisms, as for example the Rotifera, in which the tiny males cannot ordinarily be identified as conspecific with the larger females, and taxonomy rests essentially on identification of the female specimens. However, no parallel for such extreme sexual differences is known in the Cephalopoda, or indeed, as far as the writer is aware, anywhere in the Mollusca. Sexual dimorphism cannot be disproved in a group of extinct animals so remote as to shell structure from their nearest living relatives, but without supporting evidence the explanation is most unconvincing. Support would be found for such an interpretation if somewhat similar large and small species were found in association, but in the rather extensive collections made from a limited horizon in the Threadgill member of the Tanyard formation on Threadgill Creek, Gillespie County, Texas, no such parallelism could be found. The large shells consisted largely of species of *Barnesoceras*, and large and small representatives of slender endogastric shells of the aspect of *Dakeoceras*, *Stemtonoceras*, and *Levisoceras* simply were not found; material was too abundant for such absence to be attributed convincingly to the results of chance sampling in collecting.

The possibility that sudden gaps in size, genetically triggered differences, might result in species widely disparate in size but actually closely related genetically was considered. It was rejected because the Threadgill association evidently contained a number of tiny shells so similar that close relationship could hardly be denied; they were more similar to each other than to any associated larger shells of the same general conformation. The tiny shells constituted well-defined species groups, which it is convenient to designate as genera. The grouping together of the genera is a matter of convenience, however, for insofar as any conclusions can be reached from the shells alone, it seems probable that there is a close relationship between much of *Burenoceras* and the materially larger *Levisoceras*, while *Muriceras* is more allied to *Dakeoceras* and *Stemtonoceras*.

The correlation of size discrepancy with generic groups is further accentuated in the present work by the rearrangement of some species among the genera *Burenoceras* and *Levisoceras*, a change suggested first by the wide discrepancy in proportions of some relatively large species previously placed in *Burenoceras* and the typical small species. Such large species are, actually, inconsistent with the previous definitions by which the genera have been distinguished.

The general situation as to size discrepancies is shown in Figure 11. Moderate-sized endogastric cyrtocones are shown in Figure 11A, such as are assigned to *Dakeoceras*. Figure 11B shows similar tiny shells assigned to *Muriceras*. Shells of *Muriceras* are from a quarter to half the size of those assigned to *Dakeoceras*. In both genera, however, shell proportions are relatively similar. A short apical region, *a*, is so rapidly expanding that the shell height at its adoral end, *b*, is roughly equal to *a*. There follows a slender portion, *c*, which may be four to seven times the length of *a*, in which the increase in the cross section of the shell from *b* to *f* remains relatively slight. Here the living chamber, is a length *e* usually less than half the height at the base, *d*, is increased to *f*, which is only slightly greater than *d*. The living chamber is commonly one third the length of the entire mature shell.

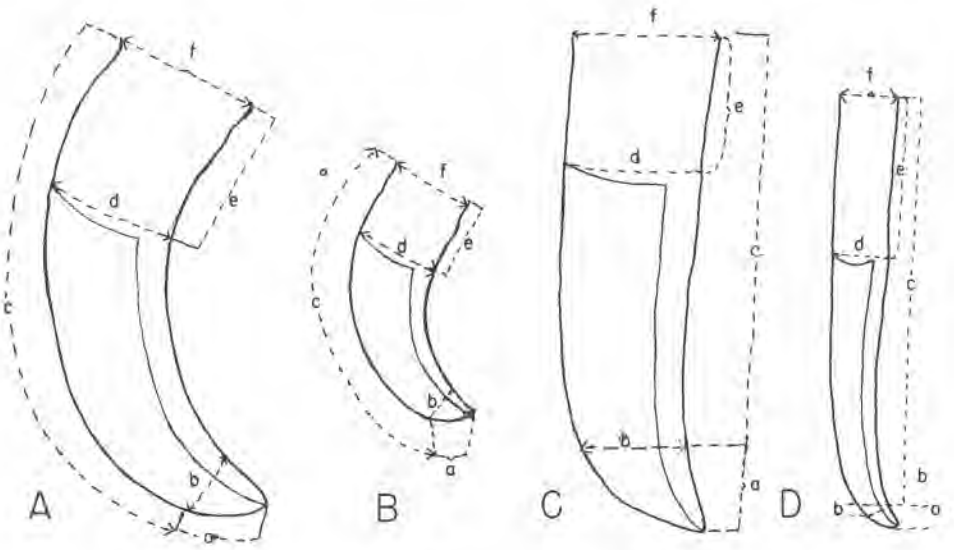

Figure 11

PROPORTIONS OF ELLESMEROCEROIDS AND MICROELLESMEROCEROIDS

A. *Dakeoceras;* B. *Muriceras,* the miniature edition of *Dakeoceras.* C. *Ellesmeroceras.* D. *Ectenolites,* a miniature form of *Ellesmeroceras* but with specialization in that both phragmocone and living chamber have become greatly elongated.

Various measurements are indicated by letters indicating homologous regions.

a.—Rapidly expanding initial portion.
b.—Shell height at anterior end of rapidly expanding initial part.
c.—Length of shell beyond rapidly expanding apex.
d.—Shell height at base of living chamber.
e.—Length of mature living chamber.
f.—Shell height at mature aperture.

The proportions of regions in A and B are similar; in C and D the similarity is less marked, for in D the lengths of c and e are proportionately greater than in C.

It can be seen from the size relationships that the rapidly expanding initial portion of *Dakeoceras,* shown in 11A, could never be confused with the much smaller corresponding part of *Muriceras* and that this portion of *Dakeoceras* may attain a shell height in the extreme base of the shell of that genus which is attained in *Muriceras* only in relatively anterior parts of mature shells, where the rate of expansion is relatively slight.

In *Ellesmeroceras* and *Eremoceras,* portions of phragmocones are abundant, but they show only a relatively slight range in terms of shell diameter. Curiously, where the relatively tiny *Ectenolites* is associated, the species of the genera are never confused. The reason for this is that in these larger, essentially straight genera, there is a relatively short, rapidly expanding apex, such as is illustrated here for *Eremoceras multicameratum* (pl. 6, fig. 1, 2; pl. 8, fig. 14; pl. 28, fig. 7). Such an apical portion, if found alone and unattached to the slender anterior part of the shell, would be regarded as neither *Eremoceras* nor *Ectenoceras* but would be assigned more probably to *Levisoceras* or, not being quite strongly enough curved for that genus, possibly to *Conocerina. Ectenolites* (fig. 11D) shows, however, further specializations in proportions, for the phragmocone and living chamber are both relatively long in proportion to the cross section of the shell, not only in relation to the similar straight *Ellesmeroceras* and *Eremoceras* but also in relation to most of the other Ellesmeroceratidae.

Of large species with exceptionally long phragmocones, only one genus is certainly known, *Pachendoceras.* The present available material fails to indicate a similarly extensive phragmocone, but the Upper Canadian *Copiceras,* which is actually known from less than a half dozen fragmentary specimens, might prove to be similarly exceptionally elongated.

Twenty-eight valid genera are here assigned to the Ellesmeroceratidae. In addition, *Diphragmoceras* is here made a synonym of *Eremoceras; Protobactrites* is regarded as a synonym of *Ectenolites; Ruthenoceras* is so little known that it is not certain whether it should be considered a valid genus of the microellesmeroceroids or whether it should be treated as a synonym of *Stemtonoceras. Shantungendoceras* was based upon a series of poorly known Ellesmeroceratidae which would embrace the simpler orthoconic and slender cyrtoconic genera.

Of these genera, only one, *Ectenolites,* is definitely known in beds of Upper Cambrian age, the reputed Upper Cambrian age of *Ruthenoceras* requiring substantiation as it now does. Both of these genera are found in the Lower Canadian, where 19 others are added. Ultimately, revision of *Burenoceras,* not now possible in view of the incompleteness of information on the living chambers of the described species, may add another genus to this lot. The development of only relatively short phragmocones in the Ellesmeroceratidae is in strong contrast to the very long phragmocones generally prevailing throughout the Michelinoceratida, Endoceratida, Actinoceratida, and Tarphyceratida. Comparably long phragmocones persist in derived Ellesmeroceratida, the Balkoceratidae, Protocycloceratidae, and in the Eothinoceratida and Bathmoceratidae of the Cyrtocerinina. Extremely long phragmocones have been found only in one genus of the Ellesmeroceratidae, *Pachendoceras.*

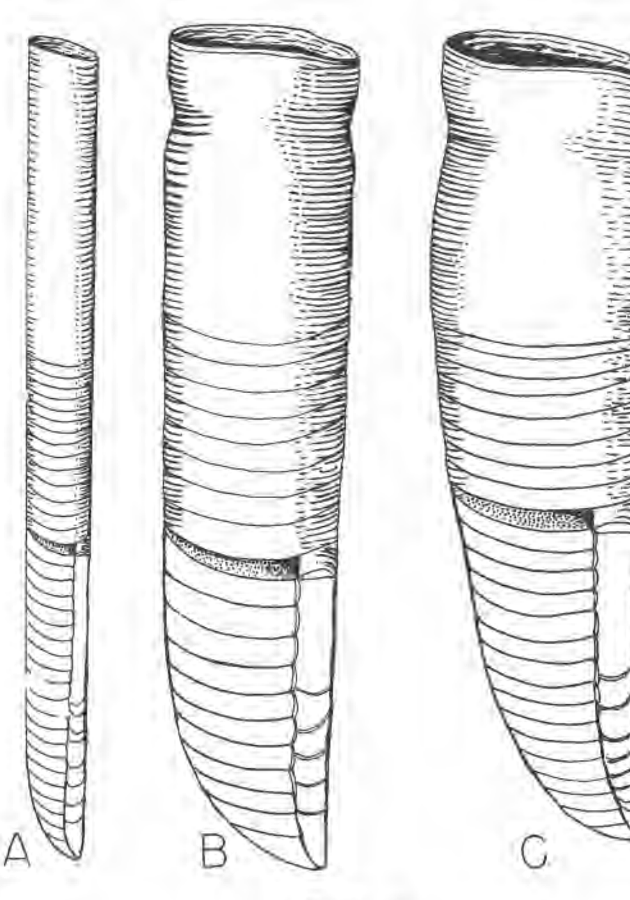

Figure 12
General features of simple orthoconic Ellesmeroceratidae. A. *Ectenolites*, B. *Ellesmeroceras*. C. *Eremoceras*.

ORTHOCONIC GENERA

Genus ELLESMEROCERAS Foerste

Genotype: *Ellesmeroceras scheii* Foerste

Figure 12B

Ellesmeroceras Foerste, 1921, Dennison Univ. Bull., Sci. Lab., Jour., vol. 19, p. 265.
——— Kobayashi, 1933, Tokyo Imp. Univ., Fac. Sci., Jour., sec. 2, vol. 3, p. 267.
——— Ulrich and Foerste, 1935, Denison Univ. Bull., Sci. Lab., Jour., vol. 30, p. 9.
——— Flower, 1941, Bull. Amer. Paleont., vol. 27, no. 102, p. 4.
——— Flower, 1941, Pal. Amer., vol. 2, no. 13.
——— Ulrich, Foerste, Miller, and Unklesbay, 1944, Geol. Soc. Amer., Special Papers, no. 58, p. 66.
——— *(Metaellesmeroceras)* Flower, 1956, Jour. Paleont., vol. 30, p. 78.

Ellesmeroceras contains moderate-sized, compressed, orthoconic shells, showing lateral lobes, a ventral siphuncle of tubular or concave segments, thick rings, diaphragms, and septal necks which are typically short, aneuchoanitic. Rings show layered structure in *E. bridgei*, but most known specimens show such alteration that the original structure is gone. Long, essentially hemichoanitic necks, pointing slightly inward and thus "loxochoanitic," are known in *Ellesmeroceras (Metaellesmeroceras) anomalum*, but in no other species as yet.

One would expect that there would be considerable confusion in separation of early growth stages of *Ellesmeroceras* from *Ectenolites*, but in extensive collecting, I have found no such specimens. The obvious explanation is that *Ellesmeroceras*, like *Eremoceras*, and indeed, most of the moderate-sized Ellesmeroceratidae, possesses rarely found early stages which are rapidly expanding and quite probably endogastric, and that such a condition is replaced by straight, nearly tubular, shells only when a cross section materially larger than that of *Ectenolites* is attained. With some rearrangement of species, the genera are now distinct. Less satisfactory is the generic boundary between *Ellesmeroceras* and *Eremoceras*, but by rearrangement of species, *Eremoceras* is now treated as confined to shells showing more marked modification of the living chamber and more obviously endogastric in the generally slightly greater convexity of the dorsal outline.

It is odd and perhaps unfortunate that *Ellesmeroceras*, from which genus is derived the name of a family and order, is based upon *E. scheii*, a small species from Ellesmereland known only from a single specimen. Fortunately, it was possible to study the type and to ascertain that the siphuncle wall structure is essentially that attributed to the genus from the study of other species.

The previous recognition of *Metaellesmeroceras* as a subgenus is unfortunate in that the resultant nomenclature is unwieldy. Recognition of such long necks as this species presents is desirable, and recognition at the generic level is somewhat embarrassing in view of the impossibility of assigning species known from chert steinkerns. The subgenus is therefore suppressed here.

SPECIES

Some differences of opinion have surrounded the scope of this genus; Kobayashi (1933) assigned a number of Asiatic species to the genus which show somewhat greater expansion than is known in the genotype, and which seem comparable to some species which UF&M, 1943, included in *Eremoceras*. While admittedly *Ellesmeroceras* and *Eremoceras* are so closely similar that if both genera are to be recognized, a course that seems desirable inasmuch as the alternative would result in the suppression of the younger name *Ellesmeroceras* and higher categories based upon that generic name, the standards must be somewhat arbitrary, but they must also be selected with some regard to definition and the placing together of similar species. The present result is a concept more in accord with the usage of Kobayashi than that of UF&M, 1943, and UFM&U, 1944. Similarly some rearrangements of species between *Ellesmeroceras* and *Ectenolites* as used here (= *Ectenoceras* of UF&M, 1943) has been necessary.

The species are listed below, arranged roughly geographically.

ARCTIC NORTH AMERICA

E. scheii Foerste, 1921; Victoria Head, Basche Peninsula, Ellesmereland. The species is here refigured and redescribed.
E. bridgei Flower, 1941; Seward Peninsula, Alaska.
E. expansum Flower, 1941; same occurrence.

WANWANIAN, MANCHURIA

E. elongatum Kobayashi, 1931.
E. subcirculare Kobayashi, 1931.
E. foerstei Kobayashi, 1933.
E. abruptum Kobayashi, 1933.

TEMPERATE NORTH AMERICA

a. Described previously as *Ellesmeroceras*

E. higdonense UFM&U, 1944, a rather small tubular shell, Gasconade of Missouri.

E. hotchkissi UFM&U, 1944, a rather small, slender form, known only from most fragmentary material. Oneota of Wisconsin.

E. luthei UFM&U, 1944, a rather large, gently conical species with a large siphuncle, Oneota of Iowa.

E. anomalum Flower, 1956, Chepultapec of Maryland.

b. Previously assigned to *Endoceras*

E. sansabaense (UFM&U, 1944) Known only from a siphuncle. Tanyard of Texas.

E. calvini (UFM&U, 1944) A large species with very close septa. Oneota of Iowa.

E. sp. (UFM&U, 1944) A moderate-sized, essentially tubular form known from a specimen showing a longitudinal section. Tribes Hill of New York.

c. Previously assigned to *Eremoceras*

E. difficile (UF&M, 1943) A fairly large, very gently expanding form. Oneota of Wisconsin.

E. vernonense (UFM&U, 1943) Somewhat more rapidly expanding vertically. Oneota of Wisconsin.

E. marylandicum (UF&M, 1943) Known only from a somewhat distorted shell, but definitely very slender. Chepultapec of Maryland.

E. teres (UF&M, 1943) A species very slender and straight anteriorly, showing early stages slightly endogastric and quite rapidly expanding. Oneota of the northern Mississippi Valley.

E. vernonense (UF&M, 1943) Same occurrence.

d. Previously assigned to *Ectenoceras*

E. chepultapecense (UFM&U, 1944) Anomalously large and rapidly expanding for *Ectenolites*. Chepultapec of Maryland. Unklesbay and Young (1956, p. 151, fig. 8) have assigned a fragment to this species.

e. Previously assigned to *Clarkeoceras*

E. clelandi (UF&M, 1943) A little-known form, but essentially straight and slender. Tribes Hill of New York.

f. Forms dubious at the specific level

The following are certainly *Ellesmeroceras*, but inadequate for critical comparison at the specific level, and are here designated as *Ellesmeroceras* sp.:

Dakeoceras perretorsum Unklesbay, 1954, p. 638, pl. 70, fig. 1. Tanyard of Texas. Close to *E. vernonense* but with a proportionately smaller siphuncle.

Burenoceras compressum Unklesbay, 1954, pl. 68, fig. 5-6. This is a small, straight, nearly tubular living chamber of very strongly compressed section. It is certainly not *Burenoceras* and is one of the very few species which seems intermediate between *Ellesmeroceras* and *Ectenolites*. Tanyard of Texas.

g. Species removed to other genera

Ellesmeroceras thomasi UFM&U, 1944, from its small size and tubular form is removed to *Ectenolites*. Oneota of Iowa.

Cyrtoceras winonicum Sardesson, 1896, placed in *Ellesmeroceras* by Ulrich, Foerste, Miller, and Unklesbay, 1944, is a small tubular shell here assigned to *Ectenolites*.

h. Doubtful species

Ellesmeroceras amplum Kobayashi. This species is discussed in the systematic appendix. Its features are not typical of *Ellesmeroceras*, and it lies outside the range of the genus, occurring in the Upper Canadian Wolungian of Korea and southern Manchuria.

SPECIES DESCRIBED AND ILLUSTRATED

Ellesmeroceras scheii Foerste

Pl. 25, fig. 2-8

Ellesmeroceras scheii Foerste, 1921, Denison Univ. Bull., Sci. Lab., Jour., vol. 19, p. 265, pl. 27, fig. 3A-C; pl. 33, fig. 3.
——— Foerste, 1925, *ibid.*, vol. 25, p. 9.
——— Ulrich and Foerste, 1935, *ibid.*, vol. 30, p. 275.
——— Flower, 1941, Bull. Amer. Paleont., vol. 27, no. 102, p. 4.
——— Ulrich, Foerste, Miller, and Unklesbay, 1944, Geol. Soc. Amer., Special Papers, no. 58, p. 66, pl. 28, fig. 8, 9.

This species is apparently known solely from the holotype, a specimen 24 mm long, with a width of 9.5 mm and an apparent height of 11 mm at about midlength. Thirteen camerae are visible ventrally; they average four in a length of 5 mm, but the last is slightly shorter, 0.9 mm, and may or may not indicate maturity. Sutures form a good saddle on the venter, interrupted on the surface of the internal mold by the siphuncle. Lateral lobes are developed, but there is not a clear indication of a dorsal saddle, the dorsal side of the specimen being very poorly preserved, but such saddles are a logical inference. A transverse section ground across the apical portion of the siphuncle reveals the siphuncle wall. Segments are faintly and rather variably concave externally, but the interior is very nearly tubular, and concavity of segments is not clearly evident. Though the wall is somewhat replaced, it is evident that septal necks are short, pointing in obliquely to the siphuncle axis, rings are developed that are thickened somewhat at their tips which lie broadly against the apical septal necks. Alteration has occurred, as can be seen from irregular texture of the rings, and it is evident that any original differentiation of materials and textures has been lost. The specimen shows no evidence of diaphragms, but the known portion of the phragmocone has only 13 adoral camerae, and diaphragms are commonly confined to more apical portions of the siphuncle than that retained here.

Discussion. It is of particular importance, in view of the variation already noted among specimens of the aspect of *Ellesmeroceras*, to establish the shortness of the necks in this species; such a condition was generally assumed to be universal and was, indeed, shown by sectioned specimens from Manchuria, Alaska, and eastern North America, but the discovery of lengthening of the necks in *Ellesmeroceras anomalum* of the Chepultapec of Maryland made it desirable to ascertain the condition in the unique genotype for stabilization of the subgeneric groups *Ellesmeroceras* and *Metaellesmeroceras*.

Foerste's description of the genotype is accurate and detailed in all matters except the nature of the siphuncle wall; Foerste figured the specimen as an internal mold, and no section was made at that time nor was such an investigation then recognized as important. Foerste's earlier descriptions involve the assumption that the siphuncle walls of the earlier cephalopods were holochoanitic. This logic seems to have originated in the not unnatural assumption, first voiced by Ruedemann (1905, 1906) that a siphuncle wall of one substance, the septal neck, was simpler and more primitive than one composed of a short neck supplemented by connecting rings. This concept we have had to abandon in the light of extensive evidence to the contrary, but it has taken careful study of numerous sections from better than average material in terms of preservation to establish the matter beyond doubt.

The holotype is from the Lower Canadian of Victoria Head, Basche Peninsula, Ellesmereland, collected by Per Schei in 1899, no. A10430 Paleontologisk Museum, Oslo. Apparently, only this single specimen is known.

Ellesmeroceras indomitum Flower, n. sp.

Pl. 6, fig. 13; pl. 7, fig. 21-22

This is a generalized *Ellesmeroceras*, known from a portion of the shell extending from a height of 16 and a width of 12 mm through a length of 50 mm to an estimated height of 28 mm and a known width of 21 mm. The shell is straight, uniformly expanded throughout the known portion. The siphuncle is relatively large and slender; if, as in associated species, there is a stage in which it expands very rapidly, it is in an earlier portion than that preserved in the holotype. In the 25 mm of the phragmocone, the siphuncle increases from only 4 to 5 mm, though the phragmocone increases in height from 16 to 21 mm. Sutures have lateral lobes, symmetrically rising on dorsum and venter as viewed from the side. The dorsal sutures are obscure, but it is evident that this species lacks the extremely elevated ventral saddles of some of its associates, and it appears that dorsal and ventral saddles are nearly equal in height. The siphuncle wall is composed of short, inward pointing, septal necks supplemented by connecting rings which are considerably inflated at their tip, rounded, and showing a differentiation of structure which, as in so many associated forms, is too extensively replaced to permit a proper analysis of its structure. No diaphragms are visible in the type. The camerae are very closely and uniformly spaced. Ten camerae occur in the adoral 12.5 mm of the phragmocone.

Holotype. Collection of the writer; No. 178.

Occurrence. From the Smith Basin limestone, section just just east of Smith Basin, New York.

Ellesmeroceras imbricatum Flower, n. sp.

Pl. 7, fig. 13

This species is quite generalized in cross section and sutures. The known portion is straight, gently expanding, moderately compressed, the venter only slightly more narrowly rounded than the dorsum, the siphuncle uniformly expanding throughout the known portion. The holotype expands from 11 and 12 mm to 16 and 18 mm in 30 mm. Five camerae occur in a length of 6 mm throughout the chambered portion. Lateral lobes are moderate, evenly and equally elevated as they approach dorsum and venter, though the ventral saddle is higher as it passes over the siphuncle, whereas the dorsal saddle is flattened centrally. The siphuncle expands from 4 to only 5 mm in the length of the specimen.

The exfoliated shell on one side of the specimen shows numerous imbrications, irregularly crenulate, pointing forward on the shell. It would appear that the imbrications are part of the shell wall, as shown in the section of *Eremoceras magnum* (pl. 25, fig. 1). They are very characteristic of this form, and in our illustration obscure the septal pattern completely.

Holotype. Collection of the writer; No. 171.

Occurrence. Smith Basin limestone, section east of Smith Basin, New York.

Ellesmeroceras fusiforme Flower, n. sp.

Pl. 6, fig. 14-15

This is an *Ellesmeroceras* in which the dorsal profile is very slightly convex throughout life, the venter is essentially straight, faintly concave adapically. Cross section is oval, venter slightly more narrowly rounded than dorsum, but without any ventrolateral flattening and not markedly narrowly rounded as in some allied forms. The known portion of the shell is 65 mm in length, expanding from a point at which the shell is 14 mm high and 12 mm wide, to the aperture of an apparently mature shell where the width is estimated at 21 mm and the height at 24 mm.

Expansion is rapid initially, the shell increasing from 12 and 14 mm to 16 and 19 mm in the basal 20 mm; in the next 20 mm, the shell increases to a height of 18 mm, and then to 19 and 23 mm in the succeeding 10 mm, orad of which the shell is incomplete, but 20 mm farther the aperture is attained which is not more than 21 mm wide and perhaps 24 mm high, compression of the shell increasing with the growth stage.

The siphuncle enlarges from 3 to 6 mm in the basal 20 mm, beyond which it increases only to 7 mm in the remaining 20 mm. The sutures exhibit lateral lobes, the greatest depth of the lobe being slightly ventrad of midheight, so that the dorsal and ventral saddles are about equally conspicuous in typical specimens when viewed laterally. The dorsal saddle flattens in its center, while the ventral saddle rises high, though it can be traced only obscurely in typical specimens across the annulations on the siphuncle.

Discussion. The slightly convex dorsal profile gives this species a fusiform appearance by which it can be readily distinguished. The suture pattern is distinct from that of *E. angulatum* or *E. progressum*. The proportions of the siphuncle resemble those of *E. progressum*. The internal structure of this form was not examined.

Holotype. Collection of the writer; No. 177.

Occurrence. Smith Basin limestone, from the section just east of Smith Basin, New York.

Ellesmeroceras progressum

Pl. 6, fig. 5-7

This *Ellesmeroceras* is known from a stage 13 mm wide and 14 mm high to the aperture of an apparently mature individual 22 mm wide and 25 mm high. The known portion occupies a length of 65 mm. Presumably, the unknown apical portion was 25 mm or less in length, as the early stage is very faintly curved and quite rapidly expanding. The ventral profile is essentially straight, with a slight swelling near the midlength of the living chamber. The dorsal profile is slightly convex apically, becomes subparallel to the venter in the middle portion, and faintly concave on the living chamber, the aperture tending to flare very slightly on the dorsal side.

In the apical 18 mm, the shell increases from 13 to 14 mm to 14 and 19 mm. In this portion, the siphuncle increases in diameter from 3 to 6 mm. Adorally, both the siphuncle and the whole shell become much more slender. In the adoral 20 mm of the phragmocone the shell increases to 19 and 22 mm, bringing the shell to the lateral portion of the last septum. The living chamber, 22 mm long laterally, attains a width of 22 mm and a height of 25 mm.

In lateral view, the sutures show only faint lateral lobes. Apically, the suture is inclined slightly forward on the venter and scarcely so on the dorsum. At the adoral end of the phragmocone a more prominent dorsal saddle is developed, clearly seen in lateral view. This saddle is broad and low, and the suture appears essentially transverse when viewed from the dorsal side. The ventral suture swings forward increasingly on the venter as growth progresses, and at the base of the living chamber the marks of the septa on the siphuncle extend 7 mm farther orad than the lateral lobe of the last suture. Camerae are uniformly shallow and average five in a length of 6 mm, both adapically and adorally.

A section of the basal 18 mm of the phragmocone reveals that the apical part of the siphuncle is shut off by a diaphragm which slopes strongly forward on the ventral side. The septal necks are very short and terminate pointing obliquely inward and apicad. The connecting rings are not clearly preserved, but there is clear evidence of a nonhomogeneous structure, consistent with what is known of *E. bridgei*.

It is not evident whether the slight swelling on the ventral side of the living chamber and the slight flaring of the dorsal margin as it approaches the aperture are typical features, but it seems highly probable that they may be. The characteristic ventrolateral flattening of the cross section, evident on the adoral but not on the adapical end of the type, is clearly a distinctive feature, as is the increasing steepness and prominence of the ventral saddles, the apical slight curvature, and the sharp change from rapid to very gentle expansion as the shell grows.

Holotype. Collection of the writer; No. 170.

Occurrence. Smith Basin limestone, east of Smith Basin, New York.

Ellesmeroceras angulatum Flower, n. sp.

Pl. 6, fig. 3-4

Shell straight, moderately expanding; cross section with venter strongly rounded, ventrolateral areas slightly flattened; greatest width just dorsad of midheight. The type expands in the 20 mm of the phragmocone from 10 to 12 mm to 15 and 18 mm. In this length the siphuncle increases in width from 2.5 to 4.0 mm. The living chamber, 25 mm in length laterally, attains 20 and 22 mm at the aperture.

Sutures with high, well-marked, ventral saddles, which occupy the ventral fourth of the shell as seen in lateral view. The saddles rise to a height equal to the depth of between four and five camerae. The greatest length of the lateral lobes is just dorsad of the beginning of the ventral saddles. There is a low, inconspicuous saddle on the dorsum. Adorally, eight camerae occupy a length of 10 mm.

Discussion. The fairly rapid and uniform expansion of the shell, the slight flattening of the ventrolateral areas in cross section, and the prominent ventral saddles characterize this species.

Holotype. Collection of the author; No. 169.

Occurrence. From the Smith Basin limestone, from the section just east of Smith Basin, Fort Ann quadrangle, New York.

Ellesmeroceras sp.

Pl. 11, fig. 1, 2 (pars.)

Quite curiously, the Threadgill member of the Tanyard has yielded very few straight cephalopods, and only this one fragmentary specimen of an *Ellesmeroceras*. The specimen is straight, slightly compressed, and elliptical in cross section, expanding laterally from 14 to 20 mm in 18 mm. The height is estimated at 20 mm where the width is 14 mm. The siphuncle, exposed in a natural horizontal section, is tubular, increasing from 4 to 5 mm in 12 mm; the phragmocone contains four camerae in a length of 5 mm.

Only this one specimen, found in the living chamber of a paratype of *Barnesoceras lentiexpansum*, has been observed. It is here illustrated only as it appears in conjunction with that specimen. It was cut out and a cross section made to obtain the above-noted proportions. Unfortunately what can be learned from this specimen, incomplete both dorsally and ventrally, is insufficient for a proper specific comparison.

Figured specimen. Collection of the writer, No. 252, in living chamber of paratype of *Barnesoceras lentiexpansum*.

Occurrence. Threadgill Member, Tanyard formation, from Threadgill Creek, Gillespie County, Texas.

Ellesmeroceras sp.

Pl. 26, fig. 1

This is a poorly preserved fragment, showing a naturally weathered longitudinal section. The fragment is 22 mm long, tubular, 10 mm high, showing four camerae at the base in a length of 7 mm and a siphuncle which is 2 mm high adorally.

Discussion. This specimen is of note as the only orthoconic ellesmeroceroid so far found in the Gasconadian portion of the El Paso limestone. Its dimensions suggest assignment to *Ellesmeroceras* rather than to *Ectenolites*, though its apparently tubular form gives it more the aspect of the latter genus.

The figured specimen is No. 320 in the collection of the writer, from the Sierrite portion of the El Paso, at Mud Springs Mountain, New Mexico.

Ellesmeroceras sp.

Pl. 26, fig. 12; pl. 27, fig. 8

Material from the York District, Seward Peninsula of Alaska, yielded some compressed orthoconic shells typical of *Ellesmeroceras* in aspect and proportions. They were only fragmentary and are not adequate for comparison at the specific level, as they are too incomplete to show the proportions upon which recognition of the species depends. The material is apparently not conspecific with *E. bridgei* or *E. expansum* Flower (1941A). One, here figured, yielded a thinsection, though retaining only the ventral part of the phragmocone, which is here illustrated. The section shows the ventral shell wall as apparently homogeneous and composed of irregular calcite crystals. Septa springing from this wall show only vestigial development of a buttress, such as is shown in our material of *Eremoceras magnum*, but the extent of the mural part of the septum orad of the suture is definitely short, though somewhat longer in the adoral than in the adapical part of the section. Septal necks are moderately developed, longer than in some other species of the genus, pointing slightly obliquely centrad and apicad. Rings are thicker than those observed in any other species of the genus in thin-section, show definite layering, with both the inner and outer surfaces composed of dense, amorphous material. The inner surfaces of the rings are convex; on the venter the rings are so widened that, adorally, they lie on and engulf the whole apical surface of the septal necks; apically, they are thickened and lie against essentially the whole width of the free part of the septum, as well as on the anterior oblique face of the necks, extending to the tip of the neck and touching the next adapical ring. In the apical part of the section the rings are apparently so broad that they touch the mural wall of the camera on the venter. On the dorsal side, the rings are somewhat similar, the inner surface convex and more curved than the concave outer surface. Adoral ends of the rings extend along the outside of the septal necks but do not extend farther; their broad apical ends terminate against the whole length of the septal neck but do not extend onto the free part of the septum.

Within the siphuncle are diaphragms; only the anterior one is seen in Plate 26, Figure 12, but in Plate 27, Figure 8, near the base of the specimen, and separating an apical region of clear calcite from an adoral region of darker calcite, there is a second diaphragm, sloping strongly orad from venter to dorsum, the reverse of the position of the anterior diaphragm, and showing two surfaces of the diaphragm as thin, dark lines. The anterior ring, which seems less replaced than the other, suggests continuity of material of the rings across the siphuncle as the diaphragm.

The length of the necks and the extreme thickness of the rings here shown are unusual; possibly one could see in this a beginning of the tendency of the ring to thicken, so oddly developed in the Cyrtocerinina.

Figured specimen. U. S. National Museum (from U. S. Geological Survey material). Evidently Lower Canadian, from the York district, Seward Peninsula, Alaska. It is from 1.4 miles east of the site of Lost River Mines, on the crest of a divide separating a tributary of Cassiterite Creek, the head of Tin Creek, and easterly drainage, altitude 1475 feet. Universal Mercator grid, zone 3: E 402,330m; N7,263,630m. Teller (B-5) quadrangle, Alaska. Data from Dr. C. L. Sainsbury, supplied through Dr. Reuben Ross.

Genus EREMOCERAS Hyatt

Genotype: *Cyrtoceras syphax* Billings, 1865
Text Figures 12C, 13

Eremoceras Hyatt, 1884, Boston Soc. Nat. Hist., Proc., vol. 22, p. 282.
——— Hyatt, 1900, Cephalopoda, *in* Zittel-Eastmann Textb. Paleont., vol. 1, p. 530; reprinted with varying pagination in later editions.
——— Foerste, 1921, Denison Univ. Bull., Sci. Lab., Jour., vol. 19, p. 263.
Ulrich and Foerste, 1935, Denison Univ. Bull., Sci. Lab., Jour., vol. 30, p. 276.
Ulrich, Foerste, and Miller, 1943, Geol. Soc. Amer., Special Papers, no. 49, p. 126.
Diphragmoceras Hyatt, 1900, Cephalopoda, *in* Zittel-Eastmann Textb. Paleontology, vol. 1, 1st. ed., p. 514; reprinted with varying pagination in later editions.

Eremoceras is here restricted to nearly straight compressed shells differing from *Ellesmeroceras* in showing more definite traces of the primitive endogastric condition, not only in the young stage but also in maturity, particularly in the slight convexity of the dorsum on the mature living chamber. *E. syphax* is essentially straight ventrally, with the faintest suggestion of concavity in the profile, convex dorsally, most convex in the lower part of the mature living chamber, sides moderately expanding, showing a pronounced preoral constriction, sutures with lateral lobes vestigial, a siphuncle expanding laterally at least more rapidly than the phragmocone. Its siphuncle wall has not been studied. While there is certainly room for difference of opinion as to what species should be grouped with this one, it is plain that if *Ellesmeroceras* and *Eremoceras* are to be recognized, a course desirable in view of the higher categories based on *Ellesmeroceras*, which is the younger name, a number of the more slender species previously placed in *Eremoceras* must be placed in *Ellesmeroceras*.

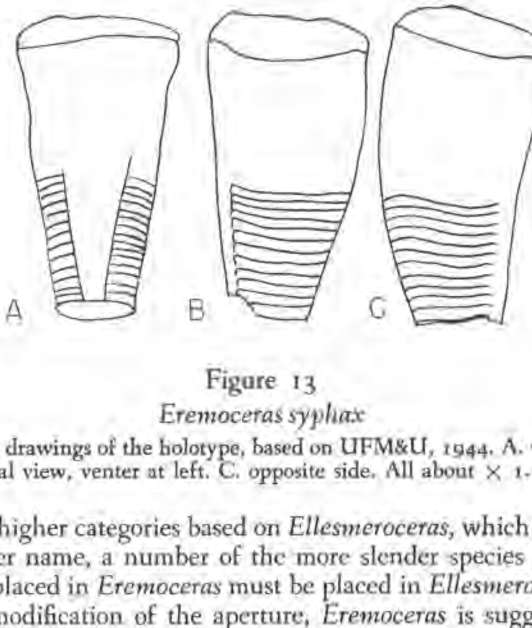

Figure 13
Eremoceras syphax

Outline drawings of the holotype, based on UFM&U, 1944. A. venter; B. lateral view, venter at left. C. opposite side. All about × 1.

In modification of the aperture, *Eremoceras* is suggestive of *Beloitoceras* of the Oncoceratida, and the two may well have occupied similar ecological niches. The species described below supply evidence of the siphuncle wall structure and presence of diaphragms, and one shows an indication of the rapidly expanding initial portion of the shell.

PREVIOUSLY DESCRIBED SPECIES

Previously described species retained in the genus are *E. syphax* (Billings) from Levis boulders of Quebec, *E. conoidale* UF&M, 1943, a conically expanding form (possibly the type is not mature), from the Gasconade of Missouri, and the following:

E. subrectum UF&M, 1943; a species rapidly expanding in the young with slight contraction of the mature living chamber; Gasconade of Missouri.

- *E. gasconadense* UF&M, 1943; typical in contraction of the mature living chamber. Gasconade of Missouri.
- *E. perdilatatum* UF&M, 1943; this is a puzzling species known from two fragments, rather rapidly expanding; possibly it should be transferred to *Conocerina*.
- *E. sansabaense* Unklesbay, 1954. Tanyard of Texas, typical of the genus.

SPECIES REMOVED TO OTHER GENERA

To *Ellesmeroceras*:
  E. marylandicum UFM&U, 1943.
  E. teres UFM&U, 1943.
  E.? difficile UFM&U, 1943.
  E. vernonense UFM&U, 1943.
To *Anguloceras*:
  E.? luthei UFM&U, 1943.

Unklesbay (1954) has identified from the Tanyard of Texas one living chamber as *Eremoceras subrectum*, which may well belong to that species (his pl. 71, fig. 11), but he included also (pl. 71, fig. 12-13) a much larger portion of a phragmocone which is better placed in *Ellesmeroceras*. His *Conocerina cloudi* is here removed to *Eremoceras*, being typical in the slender, nearly orthoconic shell.

NEW SPECIES

Eremoceras multicameratum Flower, n. sp.

Pl. 6, fig. 1, 2; pl. 10, fig. 14; pl. 28, fig. 7

The holotype and only known specimen is a shell which retains the apex and extends to an incomplete aperture. Apparently this shell represents a mature individual. One side, that embedded in the matrix as shown in our illustration, is largely missing. The cross section cannot therefore be adequately determined. It is, however, evident that at the base of the specimen, the dorsum and venter are about equally rounded, and at midlength the sides become rather broadly rounded. Apparently, the cross section is more evenly rounded and probably broader than in most ellesmeroceroids.

The ventral profile is nearly straight, faintly convex at midlength, faintly concave on the living chamber. The dorsal profile expands rapidly, turning away from the apex of the straight ventral siphuncle, so that 15 mm from the apex the shell is 15 mm high. The dorsum is convex, though decreasing adorally in curvature, over the entire phragmocone, essentially straight on the living chamber.

The shell increases in the first 15 mm from a height of 1.5 mm, the height of the siphuncle where the phragmocone is vestigial, to 14 mm and an estimated width of 10 mm. In the remaining 32 mm of the phragmocone, the height increases to 32 mm, and in the 18 mm of the living chamber to 22.5 mm.

The septa are very closely spaced throughout. The basal 15 mm contains an estimated 18 septa; at the adoral end of the phragmocone, 11 camerae occur in a length of 10 mm. The sutures are transverse, with very faint broad lateral lobes. The saddles of both the dorsum and venter are low and inconspicuous.

The apex of the shell shows a straight ventral siphuncle which expands in 15 mm from 1.5 near the very bluntly rounded apex to a height of 2 mm. It is circular and not depressed as in some associated forms. The siphuncle wall is not clearly preserved, but there are evidently aneuchoanitic septal necks and rather thick connecting rings, though the structure of the ring is not clear. Within the siphuncle are several diaphragms. Those near the apex are irregularly crowded, curved unevenly apicad, the point of greatest depth being ventrad of the center of the siphuncle. The two adoral diaphragms are evenly curved and normal to the axis of the siphuncle. The clear termination of the siphuncle by a thick wall indicates that this represents the apical end of the shell. The shell wall is very imperfectly preserved over the dorsum, but the shell outline evidently expands very rapidly in this region. The greatest depth of the septum is at midheight of the shell, and the curve is essentially symmetrical as seen in vertical section.

Discussion. This species is extremely easy to recognize because it has the septa much more closely spaced than does any other orthoconic American ellesmeroceroid. Indeed, the only shell of comparable aspect in this regard is *Multicameroceras multicameratum* Kobayashi of the Wan-Wan-Kou limestone of Manchuria. *Multicameroceras* has the connecting rings expanded in the earlier camerae into siphuncular bulbs, of which no trace is found in the present species. In form and suture pattern, our species is typical of the genus *Eremoceras*. It is notable as the first of the typical ellesmeroceroids to yield the earliest growth stages. Further, it is significant in showing the presence of diaphragms which are confined to the extreme early part of the shell. As such early parts of the shell are only very rarely found, it is easy to see why diaphragms have remained unobserved in many of the ellesmeroceroids.

Holotype. Collection of the writer; No. 167.

Occurrence. From the Smith Basin limestone in the section east of Smith Basin, Fort Ann quadrangle, New York.

Eremoceras perseptatum Flower, n. sp.

Pl. 6, fig. 8, 9

This *Eremoceras* has extremely closely spaced septa and a siphuncle which is removed from the venter by slightly more than its own diameter. The type preserves a maximum of 21 mm of the phragmocone and the basal part of an incomplete living chamber. The cross section of the shell is compressed, the sides strongly flattened, dorsum and venter broadly and about equally well rounded. The ventral profile is slightly concave apically, nearly straight adorally; the dorsum is very faintly convex over the adoral part of the phragmocone, nearly straight over the extant part of the living chamber.

The sutures are imperfectly known; evidently lateral lobes are developed. In vertical section, the septa are transverse and normal to the axis of the shell; in depth, a septum is about one third the shell height and equal to about five camerae in length. Basally there are five camerae in a length of 5 mm, but adorally the septa are markedly crowded and ten occupy a similar length. The siphuncle is essentially tubular, enlarging in the length of the phragmocone from 1.0 to 1.5 mm, and is located 1.4 mm apically and 2.0 mm adorally from the venter. Septa pass strongly obliquely from the venter to the siphuncle; apically, they are almost straight there; adorally, their obliquity is decreased, but curvature remains negligible. The tips of the septa are here curved only faintly apicad, forming very short septal necks parallel to the shell axis. On the dorsum, the septum is very gently and broadly recurved, its tip points in obliquely toward the center of the siphuncle, and only the very tip of this broadly recurved part of the septum is enclosed in the siphuncle. The rings are thick, though only faintly differentiated in color from the matrix. There is a faint suggestion of a layered structure, but color differentiation within the ring is not clear. The apical third of the siphuncle is occupied by calcite, and the anterior border of this region is a very deeply curved diaphragm. There is indication of some additional diaphragms within the calcite, but recrystallization has obscured the original structures here, and these traces are faint and inconclusive.

Discussion. This form has the septa even more closely spaced than those of the species which I had already named *Eremoceras multiseptatum*. Its most remarkable feature is the relatively small siphuncle which is appreciably removed from the venter; in many *Eremoceras* and *Ellesmeroceras* the siphuncle is so close to the venter that it is commonly exposed by exfoliation, and, indeed, the septal necks are not demonstrable there in typical material.

The extremely close septa give this form the aspect of such of the Plectronoceratidae as *Sinoeremoceras* and *Multicameroceras*, but there is no indication of either siphuncular bulbs in the young or of long septal necks in the adult, features found in both of these genera.

Holotype. Collection of the writer, No. 168.

Occurrence. Smith Basin limestone, from the section east of Smith Basin, Fort Ann quadrangle, New York.

Eremoceras magnum Flower, n. sp.

Pl. 10, fig. 1; pl. 25, fig. 1

This form is represented by an unusually large phragmocone, 52 mm long and increasing in height from 17 to 25 mm, the venter straight, with the faintest suggestion of concavity, the dorsum faintly convex, expansion being greater apically than adorally, and faintly sinuate. The cross section, not now preserved, is compressed without marked narrowing of the venter, the width very slightly more than two thirds of the height. The siphuncle is ventral, increasing from 4 to 6 mm in diameter, circular in cross section. Alteration has destroyed most of the details of wall structure, but adorally a short neck is evident; the figured section is eccentric apically and shows the connecting rings extended as exaggerated lobes into the siphuncle, a feature which shows the length of the segments there where septa are destroyed.

Discussion. The proportions of this species and the faintly convex dorsum are distinctive. It is on the basis of the latter feature that the species is assigned to *Eremoceras*. The specimen when found was a nearly vertical natural section. All that now remains is a vertical thinsection.

Most of the specimen shows advanced replacement. Astonishingly, the adoral portion of the dorsal shell wall has escaped alteration and shows differentiation of layers which is clearly original. There are (pl. 25, fig. 1) thin bands of dark material which slope strongly forward from the inner to the outer surface, separated by wider bands of light calcite; within the light calcite, two slightly different areas can be made out. The structure is totally different from what one would expect from the shell of *Nautilus*, but it supplies a possible explanation for the type of exfoliation observed in *Ellesmeroceras imbricatum*, and a more remote comparison with *Ecdyceras* (Flower, 1962) is also possible. Most of the Lower Canadian material of Ellesmeroceratidae studied in thinsection shows the wall so replaced that original fine textures are lost. However, it is clear that *Ectenolites primus* shows no comparable structure, while Llano uplift material of Gasconade age shows advanced replacement of shell structures; it should be noted that the minute frills of *Barnesoceras* suggest an imbricating structure like that of the present species.

Type and occurrence. Collection of the writer, No. 189, Smith Basin limestone, section just east of Smith Basin, New York.

Eremoceras (?) sp., cf. *magnum*

Pl. 7, fig. 14

Under this designation is figured a natural, essentially sagittal, section of a phragmocone. It is 22 mm long; the venter is straight, and in the section the siphuncle is exposed except in the basal quarter, where it apparently passes above the plane of the section. At the anterior end, the phragmocone is 22 mm high; anteriorly, camerae are close, well curved, 8 in the anterior 10 mm, and 10 in the apical 10 mm. In the remaining apical part camerae are shorter and the septa faint. The dorsum enlarges rapidly in the initial quarter and is markedly convex, but curvature of the dorsum and rate of vertical expansion both decrease adorally, and the anterior part suggests that the shell may ultimately become quite slender. The specimen is comparable to the apical portion of *Eremoceras multicameratum*; hence, the tentative generic assignment. It should be noted, however, that without demonstration of the orthoconic later portion, the generic assignment must remain tentative. If this is an *Eremoceras* and the general law of proportions holds which seems to persist throughout most of the family, this should, when complete, be a considerably larger species than the *Eremoceras* here described. *Eremoceras magnum* comes close in size requirements and spacing of septa, but the identification of this form with *magnum*, in which septa slope forward more strongly on the dorsum, seems questionable.

Figured specimen. No. 331, from the Smith Basin limestone, from the section east of Smith Basin, New York.

Eremoceras? expansum

Pl. 6, fig. 21-22

This is a straight, rapidly expanding, compressed shell which in form lies so close to the boundary separating *Eremoceras* and *Conocerina* that it could be placed in either genus. The shell has a vertical apical angle of 25 degrees. The type, with a maximum length of 30 mm, has an estimated height at the very base, incomplete dorsally, of 12 mm but expands in the basal 5 mm to 15 mm. In the succeeding 15 mm, to the end of the phragmocone, the height increases to 21 mm. The corresponding widths are estimated at 10 and 16 mm. Lateral expansion is more gentle than vertical expansion. The living chamber is incomplete, only 5 mm being preserved. At the adoral end, the type is 22.5 mm high and 20.0 mm wide.

The sutures are straight and transverse dorsally and laterally. On the extreme ventral side they rise to a high, narrow saddle which is obscured in the type by exfoliation of the shell, exposing the obliquely annulated siphuncle. The ventral saddles are confined to the portion of the shell immediately adjacent to the siphuncle, so that when the siphuncle is exposed, the saddles as such are lost. Adorally, 11 camerae occupy a length of 10 mm. The siphuncle enlarges more gradually than does the rest of the shell. It is 3.5 mm broad at the base where the shell height is 12 mm, and 6 mm adorally where the height of the shell is 22.5 mm and the width is 20.0 mm.

The internal mold bears numerous, low, rounded, longitudinal markings. A portion of the surface shows faint, low, closely spaced, gently rounded, transverse ridges separated by equally broad interspaces.

Discussion. This rapidly expanding shell has a suture pattern very close to that of *Eremoceras* but lacks the faint endogastric curvature and the more slender adoral end which characterizes most species of that genus. However, there are some species already placed in the genus, as *E. subrectum*, which are close to the present species in straightness and rate of expansion. This does not mean, of course, that either *E. subrectum* or *E. expansum* are very satisfactory as species of *Eremoceras*. *Conocerina*, another possible resting place, has in general included shells which are even more rapidly expanding, though they grade into the rapidly expanding *Eremoceras* on one hand and the more compressed and more markedly curved forms seem to grade into the more generalized species assigned to *Clarkeoceras* on the other hand.

Holotype. Collection of the writer; No. 179.

Occurrence. From the Smith Basin limestone, in the section just east of Smith Basin, Fort Ann quadrangle, New York.

Genus ECTENOCERAS Kobayashi

Genotype: *Ectenoceras ruedemanni* Kobayashi

Ectenoceras Kobayashi, 1933, Tokyo Imperial Univ., Fac. Sci., Jour., ser. 2, vol. 3, p. 269.

——— Ulrich and Foerste, 1935, Denison Univ. Bull., Sci. Lab., Jour., vol. 30, p. 274.

——— Ulrich, Foerste, and Miller, 1943, Geol. Soc. Amer., Special Papers, no. 49, p. 116.

Ulrich and Foerste, 1935, defined *Ectenoceras* as having recurved septal necks. Quite probably they had in mind specimens described by Kobayashi which are currently placed in the Plectronoceratidae, some of which Kobayashi had referred earlier to other genera. Though subsequently *Ectenoceras* was used for small, slender shells, many of which certainly have tubular siphuncles, there is some uncertainty inasmuch as the genotype, *E. ruedemanni*, has never had the form of the siphuncle segments made known; since the species is from the Wanwanian of Manchuria where associated Plectronoceratidae have been found, there remains uncertainty on this matter, and it seems safer to use *Ectenolites* with essentially the scope for which *Ectenoceras* was employed by UF&M, 1943, for species with known tubular siphuncles of the pattern found in other Ellesmeroceratidae. Oddly, *Palaeoceras* shows the features which Ulrich and Foerste attributed to *Ectenoceras*, but it has not been possible to find any material of that genus in material collected at the time this description was written, in 1935.

As noted under *Ectenolites*, the generic group is rather perplexingly broad, including slender shells, some straight, some showing rather general endogastric curvature, some with very short and others with very long living chambers. Division seems impossible now in view of the extremely fragmentary nature of the specimens from which many species are known.

That the possibility of confusing Plectronoceratidae and Ellesmeroceratidae is very real, is shown by the present material described from the Trempealeauan of the Llano uplift; without recourse to sections, *Palaeoceras* would certainly be mistaken for *Ectenolites* (*Ectenoceras* of previous usage), and an *Ectenolites* was found in the association.

To add to the perplexity, it seems doubtful whether the two specimens on which Kobayashi based his *Ectenoceras ruedemanni* are conspecific. The original of his pl. 5, fig. 2a-d, designated as the holotype, has a short, straight living chamber. A fragment regarded as belonging to the same specimen shows close septation and slight endogastric curvature. A second specimen, however (Kobayashi, 1933, pl. 2, fig. 11a-b), is a shell much broader in cross section, somewhat more rapidly expanding, sutures sinuate but with poor development of lateral lobes. In size of cross section, this specimen exceeds the holotype, so the simpler sutures are not attributable to an earlier growth stage. It is necessary to conclude that from uncertainty as to the structure of its genotype, *Ectenoceras* cannot be used generally for small slender Ellesmeroceratidae; such species can, however, be referred to *Ectenolites*.

Genus ECTENOLITES Ulrich and Foerste

Genotype: *Ectenolites subgracilis* Ulrich and Foerste

Text Fig. 12A

Ectenolites Ulrich and Foerste, 1935, Denison Univ. Bull., Sci. Lab., Jour., vol. 30, p. 272.

Ectenoceras Ulrich, Foerste, and Miller, 1943, Geol. Soc. Amer., Special Papers, no. 49, p. 116.

Protobaltoceras Troedsson, 1937, Palaeontologica Sinica, Ser. B, no. 2, p. 16.

See also *Ectenoceras*, above.

This genus is employed for very small, very slender, essentially tubular shells of compressed section, ventral tubular siphuncle, sutures with lateral lobes. The species included show variation, some are othoconic, some are definitely endogastric over an appreciable length of the phragmocone. Living chambers are extremely short in one group of species, long and tubular in another, and are inadequately known in a third group. Where siphuncles are known, they are composed of short septal necks and connecting rings; diaphragms are known, being best shown in *E. primus*, described below. *E. extensus* is anomalous in showing specimens erratic in curvature, straight, faintly endogastric and, most anomalously, faintly exogastric.

Future work may show the advisability of restricting the genus on the basis of curvature and length of the living chamber, but such a course is not feasible at present, largely because so many of the species are known from short fragments showing only limited portions of length. Presumably all apices were rapidly expanding and endogastric, but such stages are scarcely known. *Ectenolites* is here employed for most of the species formerly placed in *Ectenoceras*.

Troedsson (1937) erected *Protobaltoceras* for two species, *P. qurquense* the genotype, and *P. holmi*, from Lower Canadian of western Quruq Tagh, Chinese Turkestan. The species are described as circular rather than compressed in cross section but show lateral lobes, and the figures suggest a compressed section such as is typical of *Ectenolites*. I regard it as a synonym of *Ectenolites*, inasmuch as clear separation of the genera, which rests only on the doubtfully circular section of *Protobaltoceras*, is not possible. *Protobaltoceras* was not compared with *Ectenoceras* or *Ectenolites*: possibly the work was in press when the descriptions of Ulrich and Foerste appeared.

Silicified specimens in dolomite, which constitute the bulk of the known material from the Gasconadian, offer only poor indications of the morphology. Details of siphuncle wall structure are obscured in such material, and the small tubular siphuncles, often poorly penetrated by matrix, commonly fail to show good evidence of diaphragms. It is the more surprising and satisfying to find in *E. pimus* of the Upper Cambrian exceptionally fortuitous preservation of both siphuncle wall and diaphragms.

Two Cambrian forms, *E. primus* and *E.* cf. *primus* are the only known Upper Cambrian members of the genus and also, for that matter, of the family Ellesmeroceratidae. They are described below.

The remainder of the known species are Gasconadian in age. Probably understanding at the specific level is still rather too general; in such minute shells, relatively small differences in cross section, septal spacing, and suture pattern must be considered, but we have poor evidence on which to judge variation within the species.

Short but apparently complete living chambers occur in *E. laqueatus* (UF&M, 1943), a species of the Van Buren of Missouri, and in *E.* sp. figured by Unklesbay (1954, pl. 68, fig. 5-6) as *Burenoceras compressum*. Possibly short living chambers are to be found in *E. subgracilis*, *E. arcuosutus*, *E. compressus*, and *E. ellipticus* (described as *Ectenoceras* by Ulrich, Foerste, Miller, and Unklesbay, 1943) but it may be questioned whether the living chambers are actually complete. *Ectenolites subgracilis* is based upon two specimens; one, the holotype, shows an incomplete living chamber with relatively transverse sutures; the second, a paratype, shows what appears to be part of the aperture of a short, complete living chamber, but its specific determination is questionable; the sutures show high ventral saddles not evident on the holotype. Both specimens are from the Gasconade of Missouri.

Living chambers are obviously incomplete or unknown in *E. higdonensis* of the Gasconade of Missouri, *E. arbucklensis* of the Gasconade portion of the Arbuckle limestone, *E. gracilis* (Cleland) of the Tribes Hill of New York, *E. exilis* of the Gasconade of Missouri, *E. millsi* of the Chepultapec of Tennessee, and *E. obliquus* of the Oneota of Wisconsin.

Long, slender, living chambers are found in *E. elongatum* and *E. longus* of the Tanyard of Texas, *E. pergracilis* of the same horizon and region, and in the new species described below, *E. penecilin*, *E. curviseptatus*, and *E. sinuatus*. To these may be added *Ectenolites thomasi*, which UFM&U, 1944, described as a species of *Ellesmeroceras*. *E. extensus* probably belongs here also, a slender form from the Chepultapec of Maryland remarkable in erratic curvature, species ranging from faintly endogastric to straight and to faintly exogastric. The exogastric form, if not due to tectonic distortion, gives an indication of how the exogastric Bassleroceratidae may have been derived from the dominantly endogastric Ellesmeroceratidae, though probably the *Bassleroceras* did not arise actually from the small tubular *Ectenolites*.

Two additional occurrences of the genus are worth noting, though the fragments do not permit close analysis, and without siphuncle structure one cannot be certain that they do not represent instead *Palaeoceras*. Dr. C. L. Balk has shown me one specimen from the type section of the Deadwood "formation" of South Dakota, from 0.5 foot above the base of the Aladdin formation of Gasconade age. Another was shown me at Harvard, collected by Stone from the Clarendon Springs dolomite, a "formation" which, farther south, I have found to be composed of two discrete elements, lower dolomites of Franconian age and upper dolomites of late Gasconade age. At Fort Ann, the Trempealeauan Whitehall formation and the Dewey Bridge formation of early Gasconade age intervene, but they disappear to the north between Whitehall, N. Y., and East Shoreham, Vt. Oddly, while *Ectenolites* is one of the commonest of the Gasconadian cephalopods, it is evident that such specimens are not proof of Gasconadian age for (1) we now have *Ectenolites* in the Trempealeauan and (2) until the siphuncle outline is known, such specimens are not certainly distinguishable from *Palaeoceras*. However, no *Palaeoceras* is known in the Franconian, and in the Champlain Valley the assignment seems beyond serious question.

Unklesbay (1954, pl. 70, fig. 11) has identified as *E. laqueatus* a specimen from the Tanyard of central Texas. Unklesbay and Young have identified several species in the Chepultapec of Virginia. *E. longus* is certainly correctly identified. *E. exilis* seems doubtful, *E. compressus* fails to show the deep lateral lobes of the type, and *E. chepultapecense*, here assigned to *Ellesmeroceras*, is represented by a fragment indecisive as to species or genus.

The species now recognized are as follows:

TREMPEALEAUAN

E. primus n. sp.
E. cf. *primus*

Both from the Trempealeauan, San Saba limestone of central Texas.

GASCONADIAN

E. laqueatus (UF&M, 1943) Van Buren, Missouri.
E. ellipticus (UF&M, 1943) Van Buren, Missouri.
E. subgracilis (U&F, 1935) Gasconade, Missouri.
E. compressus (UF&M, 1943) Gasconade, Missouri; doubtful in the Chepultapec of Virginia.
E. higdonensis (UF&M, 1943) Gasconade, Missouri.
E. pergracilis (UF&M, 1943) Tanyard, Texas.
E. longus (UF&M, 1943) Tanyard, Texas; Chepultapec, Virginia (Unklesbay and Young, 1956).
E. arcuosutus (UF&M, 1943) Chepultapec, Tennessee.
E. arbucklensis (UF&M, 1943) Gasconade equivalent in Arbuckle limestone, Oklahoma.
E. millsi (UF&M, 1943) Chepultapec, Tennessee.
E. obliquus (UF&M, 1943) Oneota, northern Mississippi Valley.
E. gracilis (Cleland) Tribes Hill, New York. A species somewhat doubtful, known only from a small fragment.
E. primigenium (Vanuxem, 1842), tentatively placed in *Endoceras* by UFM&U, 1944) Tribes Hill, New York.
E. exilis (UF&M, 1943) Gasconade, Missouri.
E. sp. (*Burenoceras compressum* of Unklesbay, 1954, pl. 68, fig. 5-6) Tanyard of Texas.

E? sp. Basal Aladdin, South Dakota.
E? sp. "Clarendon Springs formation," northwest Vermont.
E. sp. (Unklesbay and Young as *Ectenoceras compressum* and *exile)* Chepultapec, Virginia.

Gasconadian forms described below include
E. penecilin, from the Smith Basin limestone of New York;
E. curviseptatus, same occurrence;
E. simplex, same occurrence;
E. sinuatus, same occurrence; and
E. extensus, from the Chepultapec of Virginia.

Ectenoceras chepultapecense is here removed to *Ellesmeroceras* because of its somewhat larger size and greater rate of expansion.

Ectenolites primus Flower, n. sp.

Pl. 5, fig. 3, 5, 6

This cephalopod, from the cephalopod bed of the San Saba limestone of Threadgill Creek, is represented by a single specimen in our collection; when first seen it was a bit of phragmocone, poorly preserved externally and peculiar in the rather marked depth of the septa in lateral curvature and the rather thick shell wall and septa, which set it apart from all the others of the association. A thinsection was made in sagittal section, which shows the siphuncle to be tubular and traversed by diaphragms. The shell expands vertically from 4.0 to 5.5 mm in a length of 9 mm, and retains 9.5 camerae.

On the dorsal side of the siphuncle, the septal necks are short and bent rather abruptly to a course parallel with the siphuncle axis; basally, the necks are extremely short and can be made out with difficulty; adorally, they are more conspicuous, slightly longer, about one fifth the length of the segment. Connecting rings are straight and rather variable in thickness, but fail to show more than a suggestion, expressed differently in different segments, of layered structure. On the ventral side of the siphuncle, there is for the most part only a thin band of calcite, darker and thinner than that representing the shell wall, but in the middle of the section there is a suggestion of extremely steep septa, in which further steepening to form a septal neck is only most faintly developed. Quite possibly this part of the section is slightly eccentric in relation to the siphuncle; siphuncles may, upon occasion, depart slightly from a perfect plane of symmetry.

The apical half of the siphuncle is traversed by diaphragms, ten in the type, the anterior ones the clearest, the apical ones not so clearly differentiated from calcite in the spaces between them. They curve forward at their edges, joining with the connecting ring, with which they are continuous and with which they agree in texture of material.

Discussion. This form is unique in showing a tubular siphuncle with well-defined walls and good diaphragms in the Upper Cambrian. Other forms either have siphunclar bulbs, the rings wanting, or are extremely poorly defined. The structure of the siphuncle proclaims this form to be a true member of the family Ellesmeroceratida; by its form, it is allied to the genera *Ellesmeroceras* and *Ectenolites*. Curiously, these genera are distinguished primarily on the basis of size, and this species would be assignable to *Ectenolites*. We have had as yet no *Ectenolites* showing such diaphragms, but this lack may be a preservation phenomenon; most of the known material of that genus from the Gasconade is silicified, and the few calcitic specimens studied have shown such recrystallization that septa and connecting rings cannot be differentiated in thinsection, and any inorganic calcite within the siphuncle would be united with diaphragms so that the latter are indistinguishable and cannot be recognized certainly as organic structures. It may well be that when this form is better known it will be separated from *Ectenolites* generically; at the present time the observed differences, the thickness of the shell, the deep lateral curvature of the septa, and the presence of diaphragms, are hardly a conclusive basis for such a taxonomic step. We must, then, at least temporarily extend the range of *Ectenolites*, from this species, into the Upper Cambrian.

Holotype. Collection of the writer; No. 298.

Occurrence. From the cephalopod bed in the San Saba limestone, originally regarded as 67 feet below the top of the San Saba limestone.

Ectenolites sp. aff. *primus*

Pl. 5, fig. 4

Here is described a specimen which has been observed only in sagittal section, a small part of a phragmocone of a straight cephalopod, similar in general to *Ectenolites primus*, but a slightly more slender shell, the camerae deeper, septa more deeply curved, septal necks longer, straight, but their entire length is not incorporated into the siphuncle.

The fragment, 12 mm long, 3.5 mm high at the base, contains three complete camerae and portions of five incomplete adoral camerae. Three and a half camerae occupy a length equal to the adoral shell height, in contrast to four and half in *primus;* the depth of the septum, hardly measurable because of uncertainty as to its ventral termination, owing to the presence of the siphuncle and no septal structures on its ventral side, is appreciably deeper than that in *E. primus*, as can be seen plainly from the illustrations. On the dorsal side of the siphuncle the septal necks are long, as much as one third the length of the segment, bent abruptly, perfectly straight and parallel to the siphuncle axis. The siphuncle is occupied by material slightly finer-grained and lighter than that filling the camerae; mixed irregularly with lighter, obscurely crystalline material, evidently calcitic. Of the three visible segments, the central one shows the filling of the siphuncle extended slightly into the camerae, but the other two show the boundaries straight, and the lightest of the calcitic material is apparently a connecting ring, with possibly part of a transverse diaphragm at the extreme anterior end of the siphuncle. Oolites complicate the present structures. On the dorsal side, a moderately thick shell wall is represented by clear calcite; similar calcite forms the septa; where the septum joins the dorsal wall it is extended forward, suggestive of an extremely short mural part of a septum.

Discussion. This specimen is sufficiently commensurate with the type of *Ectenolites primus* that when the two are superimposed, two camerae of this specimen lie apicad of the broken apex of *E. primus*. This concordance serves to emphasize the differences, deeper camerae, more strongly curved septa, and slightly smaller apical angle. Unless variation is extremely wild here, these are two different species. I refrain from giving this form a name only because it seems too small a scrap to ask later workers to consider as a type and use for later comparison. Its surface has not been observed, nor has its cross section or suture pattern.

Figured specimen. Collection of the writer; No. 299.

Occurrence. Upper part of the San Saba limestone, Threadgill Creek section, Gillespie County, Texas.

Ectenolites penecilin Flower, n. sp.

Pl. 7, fig. 10-12

This *Ectenolites* is strongly compressed in cross section, has sutures with high dorsal and low ventral saddles, has the venter and dorsum both very narrowly rounded, the venter the narrower of the two. The type is a shell with a maximum length of 44 mm. It expands from 5 and 7 mm to 6 and 8.5 mm in the basal 20 mm, and in the next 16 mm attains 7 and 10 mm. Both dorsum and venter are more narrowly rounded than in *E. sinuatus* or *curviseptatus*, the venter being slightly more narrowly rounded than the dorsum. The siphuncle is a small, circular in section, and 1 mm across where the shell increases from 7 to 8.5 mm in height. This part of the shell has been sectioned and shows the siphuncle to have very short, straight, septal necks and connecting rings which are thickened, the inner surface slightly darker than the remainder, the thick rings producing segments which are slightly concave internally though straight externally. Though there is calcite in the anterior part of the siphuncle (pl. 7, fig. 12), it appears to be inorganic and there is no evidence of diaphragms.

The camerae are spaced five in 6 mm basally, five in 6.5 mm adorally. The break at the anterior end of the sectioned part of the specimen shows that the septa are strongly convex in a horizontal plane, the curvature being about equal to the length of two camerae. Vertical curvature of the septum is equal to three and a half camerae. The sutures show broad lateral lobes, rising gently to the venter, where the saddle is equal to slightly less than one camera, and more steeply toward the dorsum, where the saddle is equal to one and a half camerae. The preserved part of the living chamber is 13 mm long, but it is not certain that its anterior end is really attained.

Discussion. This form is distinctive in the combination of the strongly compressed section, the narrowly rounded venter, and the sutures which form only low ventral saddles but are strongly inclined forward dorsally.

Holotype. Collection of the writer; No. 181.

Occurrence. From the Smith Basin limestone, from the Fort Ann quadrangle. The holotype is from the section just east of Smith Basin, New York, but the species is a widespread one and has been recognized in the equivalent Shelburne Marble in sections north of East Shoreham, Vermont.

Ectenolites curviseptatus Flower, n. sp.

Pl. 7, fig. 8

This is an *Ectenolites* with moderately spaced sutures, symmetrical lateral lobes, and an unusually large siphuncle. The type, a specimen 27 mm long, shows at the base a cross section in which dorsum and venter are both rather broadly rounded, the venter slightly more so than the dorsum, the sides much less convex than dorsum or venter. Here the shell is 6 mm wide, 7.5 mm high, and the siphuncle, broadly in contact with the venter, is 2.4 mm wide and 1.5 mm high. The septum is strongly curved laterally, its depth being greatest at midheight, where it is slightly greater than the length of a camera. The nine camerae of the type occupy a length of 9.5 mm. The last is slightly shorter than the others, but not so markedly as is usual in gerontic camerae; the others are subequal in length. Lateral lobes of the sutures are deep, equal to the length of two camerae, the deepest part of the lobe at the center of the shell, as seen in lateral view, the sides symmetrical. Sutures appear to be no higher on the venter than on the dorsum, but their course is not always clear across the very large siphuncle.

The living chamber is incomplete, 20 mm from the apex of the shell the height has increased to 9 mm, the width to 6.5 mm.

Discussion. The very deep symmetrical lateral lobes and the large siphuncle of depressed cross section serve to characterize this species.

Holotype. Collection of the writer; No. 180.

Occurrence. From the Smith Basin limestone, from the section just east of Smith Basin, New York.

Ectenolites extensus Flower, n. sp.

Pl. 7, fig. 1-6

Cross section oval, more narrowly rounded dorsally than ventrally, greatest width ventrad of center of cross section. The species is known from fragments of phragmocones up to a height of 9 mm and a width of 7 mm. Apparently the height is 2 mm greater than the width throughout, though loss of the venter and the siphuncle in many fragments makes close study of the proportions difficult, particularly in the earliest stages. The siphuncle is circular in cross section, moderately large, 2 mm in diameter at the adoral end of the holotype, where the height is 7.5 mm and the width 5.5 mm. The siphuncle is tubular, empty of any evidence of internal organic structures. The septum is deeply curved vertically, shallow horizontally. The sutures have rather broad shallow lateral lobes between high ventral and low dorsal saddles, so that the course of the sutures appears to be rather strongly oblique. The camerae are closely spaced. Four camerae occur in a length of 3 mm where the shell height is 6 mm, and six in 5 mm. An earlier stage shows eight camerae in a length of 5 mm.

The holotype is a portion of a phragmocone 30 mm in length, increasing from 6.5 and 4.5 mm to 8 and 6 mm. This specimen shows slight but definite endogastric curvature. Another specimen 42 mm in length shows slight but definite exogastric curvature, but there is no other difference and curvature is apparently slightly erratic in this species.

Discussion. No described species seems to be particularly close to this one. *E. exilis* is more răpidly expanding in the initial portion and the sutures are less oblique. *E. pergracilis* has very different dorsal sutures. *E. perobliquus* from the Chepultapec limestone of Maryland is based upon a distorted fragment and probably cannot be recognized again. Here the sutures are more strongly oblique and the lateral lobes less evident. *E. laqueatus* is perhaps closer in proportion than the other described forms, but the ventral saddles are lower. In *E. arcuosutus*, the dorsal saddles are sharper and narrower.

Holotype and paratypes. Collection of the writer; No. 188.

Occurrence. From the Chepultapec limestone, near Roanoke, Virginia.

Ectenolites sinuatus Flower, n. sp.

Pl. 7, fig. 7

This is a small, slender *Ectenolites* notable for the deep asymmetric lateral lobes and the very closely spaced septa. The cross section is compressed, with sides slightly rounded, dorsum and venter subequally rounded. The type is 6.5 mm wide and 7.5 mm high at the base, with the vertical expansion 0.5 mm in 10 mm, attaining a height of 9.5 mm, 20 mm from the apical end. The camerae are very shallow; 18 occur in the basal 14 mm of the type. Sutures show rounded lateral lobes which attain their greatest depth just dorsad of the center. They rise strongly but evenly toward the dorsum. Toward the venter, they rise even more strongly, the ventrolateral side of the lobe being much more strongly rounded than its dorsolateral part; the slope does not remain uniform as the suture is traced ventrad, but rather bcomes sinuous and more transverse, then steepens again as the venter is approached. The type is a specimen 30 mm long, of which the basal 18 mm is occupied by the camerae, the remainder being an incomplete living chamber.

Discussion. The oval section, close septa, and the sinuous sutures serve to characterize this species. The siphuncle, obscure on the type, is small and in contact with the venter. *E. pergracilis* is a comparable species, having a somewhat similar suture pattern but with deeper camerae and more abrupt dorsal saddles.

Holotype. Collection of the writer; No. 182. From the Smith Basin limestone, from the section just east of Smith Basin, New York.

Ectenolites simplex Flower, n. sp.

Pl. 7, fig. 9

This is a small straight *Ectenolites* with a generalized elliptical cross section, dorsum and venter equally rounded, sides convex, not markedly flattened. The type is a shell 34 mm in length, increasing in the basal 8 mm from a height of 4 mm and a width of 3.4 mm to a height of 5.4 mm and a width of 5 mm. At the adoral end, a height of 7 mm is attained.

The lateral surface of the aperture is very well preserved; it shows the aperture to be straight, nearly transverse, scarcely sloping apicad from dorsum to venter. The surface is fine, smooth, with extremely narrow, fine, raised lines separated by broad, flat interspaces. The lines occur spaced from 1.5 mm to 0.8 mm apart.

Calcite fills the apical 12 mm of the specimen. Here can be seen only traces of sutures which are transverse and which develop only shallow lateral lobes and camerae averaging 1 mm deep.

This is an extremely slender form of generalized cross section and rather deep camerae. It is the only form so far encountered showing the surface of the shell clearly and exhibiting a transverse aperture in which there is no development of a hyponomic sinus. Apparently the surface features of the species are unique, for fragments of shell on other known species show obscure but coarser and larger and more closely spaced growth lines. The siphuncle has not been observed in detail. There is indication that the segments are tubular.

Holotype. Collection of the writer; No. 190.

Occurrence. From the Smith Basin limestone, from the section east of Smith Basin, New York.

Genus ANNOCERAS Flower, n. gen.

Genotype: *Annoceras costatum* Flower, n. sp.

This genus is erected for ellesmeroceroids which are slightly curved initially and moderately expanded, straight adorally and marked there by a reduction in the rate of expansion. The sutures have shallow lateral lobes separating a very low, inconspicuous dorsal and a higher ventral saddle. The siphuncle, tiny in the initial part, expands at first more rapidly than does the shell, becomes broader than high in cross section, but later becomes more tubular, and consequently tends to reduce proportionately in size in the later part of the phragmocone. The septal necks are vestigial, the connecting rings thick. There are diaphragms in the early portion of the siphuncle. The surface bears broad costae which are oblique, sloping evenly apicad from dorsum to venter. Evidently this indicates the course of the aperture.

Discussion. This genus is erected for the reception of three species from the Smith Basin limestone which differ from most other ellesmeroceroids in the strong oblique costae of the surface. *Bridgeoceras* has even stronger markings, which are strong enough to be called annuli, but the shell in that genus is straight and rapidly expanding. The large curved *Quebecoceras* is not comparable, as it has no such costae and bears lateral sinuses on the aperture. In form, aside from the surface features, *Annoceras* is perhaps closer to *Eremoceras* and the intergrading *Ellesmeroceras* than to any other genera. A strongly costate but more rapidly expanding representative of this genus has been found in the Bliss sandstone of the Van Horn region of Texas. This material could not be located for description, when needed, but was shown the writer by the late Dr. Josiah Bridge in 1951.

Annoceras costatum Flower, n. sp.

Pl. 6, fig. 10, 17, 18; pl. 7, fig. 19, 20, 23

Shell slightly curved endogastrically in the apical portion, where the cross section is compressed, and more narrowly rounded ventrally than dorsally. Adorally, as curvature decreases the venter becomes more broadly and gently rounded. The shell becomes straight, the initial rather rapid rate of expansion decreases and the adoral part of the shell is essentially tubular. The sutures, as in most ellesmeroceroids, have lateral lobes, the ventral saddle being higher than that of the dorsum. The siphuncle is small initially, expands rapidly in the early part of the shell, where it is disproportionately large for the shell, then becomes tubular when the shell is still increasing in size. Septal necks very short, connecting rings thick. A possible diaphragm has been noted in one section. The shell surface is marked by obscure, transverse, broad, thickened costae alternating with thinner constricted regions. In the later part of the shell, the costae are to be seen on the internal mold; in the young stages they are purely external.

This species is based upon three specimens. The smaller, a paratype (pl. 6, fig. 10; pl. 7, fig. 19, 20), shows a slight initial curvature, the shell expanding from 6.5 and 8 mm, where the venter is very narrowly rounded in cross section and the siphuncle very small and obscure, to a height of 14 mm and a width of 12 mm in a dorsal length of 20 and a ventral length of 17 mm. In this part of the shell the siphuncle attains a width of 4 mm and a height of 3.2 mm, being more rapidly expanding than the shell. There are five camerae in a length of 4 mm. There are shallow lateral lobes, an inconspicuous ventral saddle, and over a large part of the lateral surface the sutures slope gently forward on the dorsum where a broad, rounded saddle is developed. The living chamber, 20 mm in length increases to 19 and 15.5 mm. Comparison with other specimens suggests that the great height is perhaps due to slight lateral compression. The surface bears faint thickenings of the shell alternating with thinner regions, but these markings are not clearly reflected upon the internal mold. They are slightly oblique, sloping apicad slightly from dorsum to venter. The early portion of this specimen was sectioned vertically, but the structure of the siphuncle wall was not preserved.

The holotype (pl. 7, fig. 23) represents an individual 50 mm long showing stages which initially overlap those shown at the adoral end of the paratype. The phragmocone is 30 mm in length. At its base, the shell is 9 mm wide and 10 mm high, the venter only faintly more narrowly rounded than the dorsum. At the adoral end the shell has increased to 18 and 20 mm. The living chamber, retaining part of the aperture, is 17 mm in length, with an estimated height of 22 and a width of 20 mm at the adoral end. The camerae are shallow; four occur in a length of 5 mm at the adoral end of the phragmocone. The siphuncle is slightly broader than high in section. In the basal 17 mm of the type, it increases vertically from 3.0 to 5.5 mm in height. The thick connecting rings and very short septal necks are similar to those known in *Ellesmeroceras*. At the base of the sectioned portion is a calcite filling representing the space closed adorally by a diaphragm. Structures of the shell wall, not as yet thoroughly understood, produce transverse irregular rugosities on the internal mold that are deceptively suggestive of the septa. The sutures are not well displayed but agree with those of the paratype in having only a low ventral saddle and a still fainter one on the dorsum. The shell bears rather irregularly spaced coarse costae which slope apicad from dorsum to venter. In this part of the shell they appear as slight alternating constrictions and inflated zones on the internal mold. A second paratype (pl. 6, fig. 16, 17) retains most of a living chamber expanding from 19 and 22 mm to 20 and 24 mm in the length of 23 mm, with 17 mm of phragmocone containing 14 camerae, measuring 17 and 18 mm at the base.

Discussion. The surface features which characterize the genus will serve to distinguish this species from all the associated ellesmerceroids except the following one. That species is more rapidly expanding vertically to the aperture and has high, conspicuous ventral saddles.

Types. Holotype and paratypes, collection of the writer, Nos. 175-177.

Occurrence. From the Smith Basin limestone, from the section east of Smith Basin, Fort Ann quadrangle, New York.

Annoceras perobliquum Flower, n. sp.

Pl. 6, fig. 11; pl. 12, fig. 6, 7

This is a small shell, the known part nearly straight, the type consisting of the entire length of a living chamber and four camerae. The shell is 9.5 mm wide and 10.5 mm high at the base, increasing in 10 mm to 12 and 15 mm, measured in a ventral length of 15 mm (increased to 20 mm on the dorsum). The cross section is compressed, elliptical, dorsum and venter equally rounded. At the base of the specimen are four camerae in a length of 5 mm, the last two shorter than the first two. The suture describes a broad dorsal saddle, which gives way to shallow lobes which are definitely ventrad of the center of the sides, and these in turn give way to a ventral saddle, more conspicuous than the dorsal one because it is narrower, not higher. There is indication of a ventral siphuncle, but internally the septa are not preserved. The shell surface is not preserved. The internal mold of the shell shows, however, very broad, shallow, annular expansions, with faint constrictions between. Four are present on the specimen, and from crest to crest the distance is 5 mm. They are oblique, sloping strongly forward from venter to dorsum. One side of the shell shows a definite limit of the shell. The aperture is oblique as are the annuli, and the living chamber extends forward from the last septum, which is essentially transverse, 14 mm on the dorsum and 10 mm on the venter.

The shell shows only a very faint trace of endogastric curvature, the dorsum showing the faintest convexity, the venter correspondingly concave. The shell expands at an apical angle of about 22 degrees vertically, about 12 degrees horizontally.

Discussion. This is a small species, the type apparently representing a mature individual. In comparison to other forms, this one is generalized in cross section but notable for the strongly oblique aperture and the oblique, extremely low and distant annuli.

Holotype. Collection of the writer; No. 200.

Occurrence. From the Smith Basin limestone, from the section just east of Smith Basin, New York.

Annoceras elevatum Flower, n. sp.

Pl. 6, fig. 12, 16

This species differs from the preceding in the high ventral saddles and the greater rate of expansion of the shell. The type, a specimen 60 mm long, has one side lost by weathering. The cross section throughout apparently has the dorsum and venter equally rounded. The shell increases from a height of 15 mm to one of 23 mm in the 32 mm of the phragmocone. The shell expands vertically more rapidly in the early than in the late portion, increasing to 20 mm in the basal 12 mm and to only 23 in the adoral 15 mm. Adapically, the shell is very faintly endogastric. The living chamber has a maximum length of 20 mm and an adoral height of 24 mm. The corresponding width is estimated at 20 mm. The camerae occur eight in a length of 10 mm throughout the known portion. The sutures show broad, shallow lobes on the lateral surface, a low dorsal saddle, and an extremely high saddle on the venter. The adapical part of the shell was sectioned vertically, revealing a siphuncle which expands only gradually, increasing in height from 4 to 5 mm in 20 mm. The septal necks are vestigial, the connecting rings thick. No organic diaphragms were observed; judging from other forms, they would not be expected in this specimen in a portion of the phragmocone so close to the living chamber. The shell surface is missing, but the surface of the steinkern shows the slightly oblique costae which characterize the genus. The costae are extremely low and broad and fail to show clearly on Plate 6, Figure 16.

There are four expansions in the length of the specimen; crests are 15-18 mm apart.

Discussion. Assuming that the type is a complete mature shell, this species attained a length of probably 70 mm, assuming a slightly greater rate of expansion in the initial portion as was found in *A. costatum.* It may be that the specimen was not fully mature, as suggested by the failure of the adoral part of the shell to expand more gradually; if so, the species was even larger. No specimens have been found indicating a larger size, however.

Holotype. Collection of the writer.

Occurrence. From the Smith Basin limestone, in the section about three quarters of a mile east of Smith Basin, New York.

Genus LLANOCERAS Flower, n. gen.

Genotype: *Llanoceras gracile* Flower, n. sp.

This genus is erected for a single species, a moderately expanding conical shell, faintly endogastrically curved. It is comparable in size to species of *Ectenolites* but is relatively rapidly expanding in contrast to species of that genus, which are almost tubular rather than conical. *Ellesmeroceras* and *Eremoceras* are separated from *Llanoceras* by their much larger size; in commensurate portions of those genera, there is a short, very rapidly expanding, apical region which soon outstrips *Llanoceras* in dimensions before it gives way to the neanic part of the shell, which is typically much more slender, most gently expanding, or tubular.

Only the one species, described below, is yet known. As the present work goes to press, an opportunity for more collecting in the Llano region resulted in some additional material, which suggests that the living chambers of this genus were longer than the type material indicated, and also that the species had extremely long living chambers comparable to those of the Chazyan genus *Graciloceras*; such living chambers are more than twice as long as those indicated by the type material.

Llanoceras gracile Flower, n. sp.

Pl. 11, fig. 10

This is a small conical shell, very faintly endogastrically curved. The type is a naturally weathered, essentially vertical, section of a shell 34 mm long. The phragmocone increases from 2 to 3.5 mm in the basal 10 mm, and to 5.5 mm in the remaining 9 mm of its length. The living chamber is 13 mm long attaining an adoral shell height of 8 mm. At midlength of the phragmocone, a camera is 1.2 mm long where the shell height is 3.5 mm. Here the siphuncle is tubular, ventral, 0.6 mm across. The septum in vertical section is deeply curved, but swings forward only 0.4 mm on the venter but 1.2 mm on the dorsum. The cross section of the shell and the suture pattern cannot be ascertained; clearly, the shell cross section was compressed, and the sutures sloped forward from venter to dorsum, probably with some development of lateral lobes.

Discussion. This small shell is unique among the known ellesmeroceroids in its form. Strangely, it is not strictly typical of any known genus. *Ectenolites* is typically a much more slender shell, one, indeed, which is almost tubular rather than conically expanding. *Ellesmeroceras,* which may approach the present form in rate of expansion, is represented generally by shells which are not only more slender but attain a much larger shell height, presumably as the result of a short, rapidly expanding apex. *Dakeoceras* is typically a larger shell, one that is more curved and more rapidly expanding. There is no previously described form with which this ellesmeroceroid can be easily confused.

Holotype. Collection of the writer; No. 262.

Occurrence. From the Threadgill member of the Tanyard formation, from Threadgill Creek, Gillespie County, Llano uplift, central Texas.

Genus ALBERTOCERAS Ulrich and Foerste

Genotype: *Albertoceras walcotti* Ulrich and Foerste

Albertoceras Ulrich and Foerste, 1935, Denison Univ. Bull., Sci. Lab., Jour., vol. 30, p. 261.

——— Ulrich, Foerste, Miller, and Unklesbay, 1944, Geol. Soc. Amer., Special Papers, no. 58, p. 61.

Shell small, slender, cross section strongly compressed, sutures with lateral lobes, siphuncle close to venter, septal necks short, connecting rings thick. No diaphragms have been observed. The early part of the shell resembles that of *Ectenolites* very closely. Shells are straight or very slightly endogastrically curved. The feature which distinguishes this genus from *Ectenolites* is the short living chamber which is somewhat contracted adorally. In this contraction, the ventral profile of the living chamber remains essentially straight, the dorsal profile becomes slightly convex.

All species are from the equivalents of the Gasconade, Lower Canadian.

The genotype, *A. walcotti,* of the Mons formation of Alberta is a tiny shell. It is quite adequately known, and the siphuncle has been described and figured. The associated *A. gracillimum* is typical of the genus. *A. minimum* of the Gasconade part of the Arbuckle limestone is again a tiny, slender shell, for which the fusiformly contracted living chamber is known. *A. staufferi* of the Tanyard formation of the Llano uplift is a shell very close to *Ectenolites.* This form has a larger, longer, straight, gently expanding living chamber, with only a faint preoral constriction which may have been a purely internal feature. A specimen tentatively identified with this species is from the Mons formation of Alberta.

Ulrich, Foerste, Miller, and Unklesbay described a species of *Bassleroceras, B. clelandi,* a shell which is typical of *Albertoceras* in form and is singular mainly in that it is larger than the other forms. The siphuncle was not known. If it is on the convex side, the authors say, the species is a *Bassleroceras.* However, they did not state that if the siphuncle was on the concave side, the species was an equally typical *Albertoceras.* As the septum is well preserved on the convex side, well enough to preserve a siphuncle if it were there, the endogastric nature of this shell, its affinities with the contemporaneous ellesmeroceroids, and its position in *Albertoceras* are quite evident.

The known species of the genus are as follows:

Albertoceras walcotti Ulrich and Foerste, 1935, Mons formation, Alberta.

A. gracillimum UFM&U, 1944, Mons formation, Alberta.

A. staufferi UFM&U, 1944, Tanyard formation, Texas.

A. clelandi (UFM&U) 1944, Tribes Hill limestone, New York.

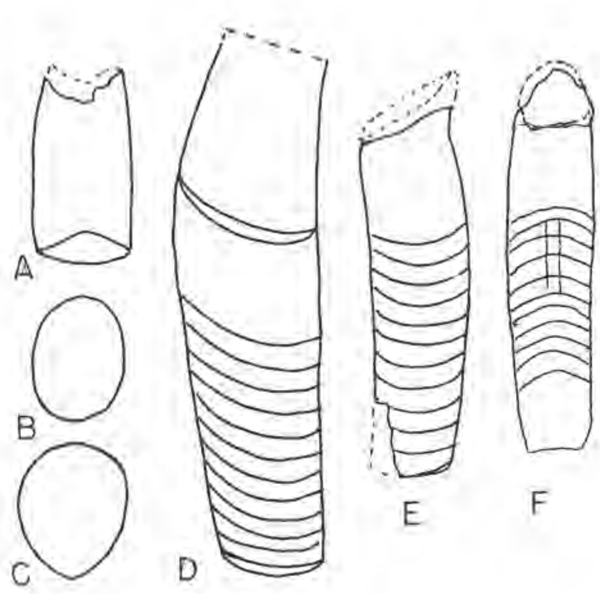

Figure 14
GENERAL ASPECT OF *Albertoceras*

A. Dorsal view of living chamber of *A. walcotti*.
B, C. Septal views attributed to the same species, showing variation in cross section.
D. Restoration, based upon an isolated living chamber and a portion of phragmocone; venter to right.
E. *A. gracillimum* UFM&U, lateral, venter on left.
F. Ventral view of the same form. All about × 4.

Genus ANGULOCERAS Unklesbay and Young

Genotype: *Anguloceras ovatum* Unklesbay and Young

Anguloceras Unklesbay and Young, 1956, Jour. Paleont., vol. 30, p. 488.

Shell straight adorally, apex possibly endogastric, siphuncle close to venter, its segments tubular or faintly concave; sutures slope strongly forward on venter, being strongly oblique in lateral view, but with little or no curvature. Cross sections vary in the genus from compressed to circular and depressed.

Unklesbay and Young assigned to this genus three species from the Chepultapec of Virginia: *A. ovatum*, the genotype with a compressed cross section, *A. rotundum*, in which the cross section is round, and *A. depressum*, in which the cross section is depressed.

Eremoceras? luthei UF&M of the Oneota dolomite of Wisconsin must be included here rather than in *Eremoceras;* the sutures are strongly oblique, but the species differs in that obliquity is reduced as the sutures approach the dorsum, so that sutures are slightly curved in lateral view. *Orthoceras sericeum* Salter, as represented by Blake (1882, p. 138, pl. 13, fig. 1, 2) of the British Tremadoc is certainly an *Anguloceras*, though it is known only from shells flattened in shales.

The inclusion in one genus of species which vary widely in the nature of the cross section of the shell, is unusual in the dominantly compressed Ellesmeroceratidae, but the appearance of the species justifies the conclusion that they are closely related. One is tempted to suggest that the broadening of the section might be produced by distortion, but this is a possibility which Unklesbay and Young certainly took into account.

Conocerina? bassleri UF&M, 1943, is, from its slender form and oblique sutures, assignable to *Anguloceras* rather than to *Conocerina*. It is from the Chepultapec of Maryland.

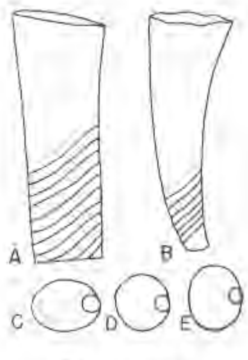

Figure 15
GENERAL FEATURES OF *Anguloceras*

A.—Lateral view, somewhat restored, of *A. luthei* (UF&M, 1943), venter on right.
B.—*Anguloceras rotundum* Unklesbay and Young, venter on right, showing more rapid expansion and apical curvature.
C, D, E.—show variation in cross section from compressed to circular and depressed. About × 1.

Genus PACHENDOCERAS Ulrich and Foerste

Genotype: *Cameroceras huzzahense* Ulrich and Foerste *in* Bridge, 1930

Pachendoceras Ulrich and Foerste, 1935, Denison Univ. Bull., Sci. Lab., Jour., vol. 30, p. 283.
——— Ulrich, Foerste, Miller, and Unklesbay, 1945, Geol. Soc. Amer., Special Papers, no. 58, p. 120.
——— Flower, 1946, Bull. Amer. Paleont., vol. 29, no. 116, p. 79.
——— Flower, 1947, Ohio Jour. Sci., vol. 47, p. 159, 169.
——— Flower and Kummel, 1950, Jour. Paleontology, vol. 24, p. 608.
——— Flower, 1955, Jour. Paleontology, vol. 29, p. 337, 338, 351.

Shell straight, slender, almost tubular over most of the length, depressed in cross section, sutures straight and transverse, a rather large ventral siphuncle of tubular or faintly concave segments. The early stage is blunt, both siphuncle and shell quite rapidly expanding and apparently faintly endogastric. Diaphragms in the siphuncle may be greatly retarded and present only apically. Shell apparently essentially smooth, aperture without clear evidence of a hyponomic sinus.

This shell is relatively large for the Ellesmeroceratidae, departing from the general pattern of the family in the broad cross section and loss of lateral lobes of the sutures. It is a vexing form inasmuch as in general aspect it is more similar to Endoceratida of the Middle and Upper Canadian than to associated Ellesmeroceratidae of the Gasconadian. It is unusual in the exceptional length of the phragmocone.

Thus far, only silicified material has been found, which is not suitable for a study of the siphuncle wall. The reported holochoanitic condition rests upon superficial observation coupled with the now exploded premise that such wall structure prevailed among the older, slender endoceroids.

In depressed section and straight sutures, this genus is more similar to the Baltoceratidae than to typical Ellesmeroceratidae, and was placed in that family by Flower *in* Flower and Kummel, 1950. However, in reviewing the Baltoceratidae, it becomes evident that diaphragms, known in *Pachendoceras*

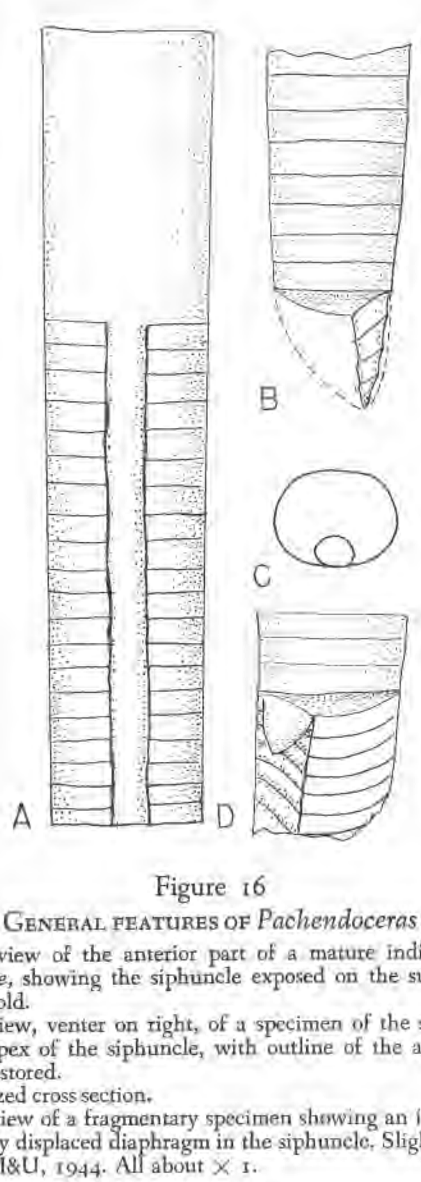

Figure 16

GENERAL FEATURES OF *Pachendoceras*

A.—Ventral view of the anterior part of a mature individual of *P. huzzahense*, showing the siphuncle exposed on the surface of the internal mold.

B.—Lateral view, venter on right, of a specimen of the same species, showing apex of the siphuncle, with outline of the apical part of the shell restored.

C.—Generalized cross section.

D.—Lateral view of a fragmentary specimen showing an internal mold of a slightly displaced diaphragm in the siphuncle. Slightly modified from UFM&U, 1944. All about × 1.

from Ulrich, Foerste, Miller, and Unklesbay, 1944, pl. 64, fig. 1, are not developed in the Baltoceratidae. *Pachendoceras* is of Gasconadian age, older than most Baltoceratidae, and associated with Ellesmeroceratidae with which it agrees in the development of the diaphragms. It seems wiser to refer the genus to the Ellesmeroceratidae. One may suggest that it is possibly the stock from which the Baltoceratidae developed, but of this one cannot be certain, especially as we have in the Lower Canadian *Microbaltoceras*, tentatively placed in the Baltoceratidae, which is equally suitable as the ancestral radicle of the family in the Lower Canadian.

One may suggest that inasmuch as *Pachendoceras* has much the gross aspect of the oldest and quite possibly the simplest of the Endoceratida, the genus *Proendoceras*, that the beginning of the Endoceratida is marked by transition from the one genus to the other, the main change involved being the suppression of diaphragms and the development of the endoceroid endosiphuncle. Indeed, on this basis, the theory may be proposed that diaphragms and endocones may be modifications of the same type of structure, but the best evidence suggests that diaphragms are extensions of the connecting ring, while the endosiphuncle is apparently a new structure and one secreted within the tissues of the siphonal strand, and always is quite distinct from the connecting ring in habit; we may infer that it was distinct in composition.

As restricted, *Pachendoceras* is confined to the Gasconadian. The following species are recognized (UFM&U, 1944) U&F (*in* Bridge, 1930):

P. huzzahense (U&F), Gasconade of Missouri.
P. confertum UFM&U, 1944, Gasconade of Missouri.
P. tardum UFM&U, 1944, Gasconade of Missouri, identified (Unklesbay and Young, 1956) in the Chepultapec of Virginia.
P.? sp. UFM&U, 1944, p. 123, pl. 64, fig. 1, is a fragmentary specimen showing a slightly displaced diaphragm in the siphuncle.
P. brevicameratum Unklesbay and Young, 1956, Chepultapec of Virginia.

It should be noted that *P. huzzahense*, UFM&U, 1944, pl. 61, fig. 4, is interpreted as representing an early growth stage rather than a specimen showing an endocone. The true apex of the siphuncle is shown here, protruding from a series of camerae. Necessary restoration of shell outlines will show a profile very slightly convex ventrally, more strongly convex dorsally, and thus showing a faintly endogastric condition.

Flower (1955) has noted that two Middle Canadian species assigned to *Pachendoceras* are probably referable to *Proendoceras*. These are *Proendoceras? newsportense* UFM&U, 1944, of the Longview limestone of Virginia and *P. sayi* Billings of the Hastings Creek formation of the Phillipsburg region of Quebec. Neither species is very adequately known.

Genus ROBSONOCERAS Ulrich and Foerste

Genotype: *Ellesmeroceras robsonensis* Walcott

Robsonoceras Ulrich and Foerste, 1935, Denison Univ. Bull., Sci. Lab., Jour., vol. 30, p. 285.
——— Ulrich, Foerste, Miller, and Unklesbay, 1944, Geol. Soc. Amer., Special Papers, No. 58, p. 73.
——— Flower, 1947, Ohio Jour. Sci., vol. 47, p. 160, 161.
———Flower and Kummel, 1950, Jour. Paleont., vol. 24, p. 606.

This genus contains small, slender, essentially tubular, straight cephalopods of circular section, straight transverse sutures, a ventral siphuncle of the ellesmeroceroid pattern, short necks, thick rings with a suggestion of layering, and diaphragms developed in the siphuncle.

UFM&U assigned two species to the genus, *R. robsonensis* and *R. manitouense*. The former is known to have diaphragms and has been studied from a number of sectioned specimens. The latter is known from only a single specimen and has not been sectioned. I regard its assignment as most doubtful. It may as easily belong to *Rioceras*.

Assignment to the Ellesmeroceratidae is indicated by the siphuncle wall and diaphragms. The genus departs from the general pattern of the family in the circular rather than compressed cross section and the loss of lateral lobes of the sutures.

The age of *Robsonoceras* is somewhat doubtful from the present evidence. The genotype is indicated as coming from the *Leiostegium* zone, regarded as Lower Canadian. However, it is certain that in the El Paso limestone *Leiostegium* occupies a considerable interval in the Middle Canadian part of the section, possibly appearing in the latest Lower Canadian with *Kainella*, certainly extending through the first endoceroid and first piloceroid zones, extremely abundant in the overlying oolite, and specimens have been found from the thin-bedded layers above the "*Orospira*" reef in the Cooks Range. The *Leiostegium* in question is either very close to *L. manitouense* or may be identical with it. The faunal succession in the Manitou limestone has not yet been recorded in adequate detail, but it is fairly certain that the *Leiostegium manitouense* must have come from beds which are equivalent to the Demingian rather than to the Gasconadian, equivalents of the first endoceroid or first piloceroid zones of the El Paso. These horizons in the El Paso succession have yielded some small, straight cephalopods which at first seemed referable to *Robsonoceras*, but there was enough material to show that they lack diaphragms, and they are here described under the new genus *Rioceras*, assigned to the Baltoceratidae.

On the other hand, Ross (1951) and Hintze (1952) have both recognized *Leiostegium manitouense* in their equivalent zones D in the Garden City and Pogonip successions, respectively. This zone the writer regards as late Gasconadian, and it is possible that this is a horizon deposited in western North America at a time when the Gasconade beds of most of eastern North America were uplifted and subjected to minor erosion. However, the question of the age of *Robsonoceras* and also of the stratigraphic range of *Leiostegium* will both profit from further study. It is worthy of note that *Robsonoceras* has not been recognized in typical Gasconadian cephalopod assemblages of eastern North America, nor in Demingian associations there. Kobayashi (1955) cites *Robsonoceras* from the *Apatokephalus–Peltura* fauna of the McKay group of British Columbia. His identification is logical, but the single available specimen does not permit the demonstration of diaphragms. It would appear, however, that this fauna is quite possibly equivalent to zone D of Ross and Hintze.

Robsonoceras robsonense (Walcott)

Pl. 15, fig. 17-24

Ellesmeroceras robsonensis Walcott, 1924, Smithsonian Misc. Coll., vol. 67, no. 9, p. 527, pl. 126, fig. 5-9a.

Robsonoceras robsonense Ulrich and Foerste, 1935, Denison Univ. Bull., Sci. Lab., Jour., vol. 30, p. 285.

——— Miller, 1943, Biological Reviews, vol. 18, p. 101-2, text fig. 2B.

——— Ulrich, Foerste, Miller, and Unklesbay, 1944, Geol. Soc. Amer., Special Papers, no. 58, p. 73, pl. 2, fig. 1-10.

This is a small, slender orthocone, circular in section, only most gently expanding, with straight transverse sutures and a ventral siphuncle. The ellesmeroceroid rather than baltoceroid affinities are shown by diaphragms, which are developed in exceptional abundance and clarity in this species; in gross aspect, the species could be mistaken for a *Rioceras*. The gross aspects of the species need not be redescribed here. The present illustrations are particularly designed to show the siphuncle wall, with thick rings of ellesmeroceroid aspect, and the diaphragms. The thinsection (pl. 15, fig. 17) was made from a specimen cut from the matrix of one of the types, and orientation could not be selected as desired. The plane of the section is essentially transverse but is oblique to the axis of the shell and passes below through the ventral wall. It shows necks of moderate length, pointing slightly inward, and rings of moderate thickness, with a broad, light, outer portion and a thin, darker band on the siphonal surface.

Types. U.S. National Museum, from the *Leiostegium* zone, Billings Butte, east of Robson Peak, northwest of Yellowhead Pass, Robson Park, Cariboo County, British Columbia.

SIMPLE CYRTOCONIC GENERA

Genus DAKEOCERAS Ulrich and Foerste

Genotype: *Dakeoceras normale* Ulrich and Foerste

Dakeoceras Ulrich and Foerste, 1931, in Bridge, Missouri Bur. Mines, ser. 2, vol. 24, p. 21.

——— Ulrich and Foerste, 1935, Denison Univ. Bull., Sci. Lab., Jour., vol. 30, p. 271.

——— Ulrich, Foerste, and Miller, 1943, Geol. Soc. Amer., Special Papers, no. 49, p. 108.

Dakeoceras is here restricted to moderately small compressed endogastric cyrtocones, moderately expanded and curved in the young, and with a variable tendency for reduction of curvature and rate of expansion on the living chamber, which is commonly not greater in length, and usually less, than twice the height across the base. Forms in which the cross section is so broadened that the width is equal to the height, and the section is strongly triangular, are separated as *Paradakeoceras*. *Stemtonoceras* is similar, but is uniformly more slender and more uniformly and quite gently curved. *Levisoceras* is more expanded, particularly in the vertical plane. Typical *Conocerina* is much more rapidly expanded. *Eremoceras* shows apical curvature which is relatively slight, and the anterior essentially straight portion occupies most of the length of the shell.

The known species are all from the Gasconadian of North America. Ten of the known species are from the Van Buren formation of Missouri. These include *D. normale*, *D. corniculum*, *D. magnisiphonatum*, *D. dilatatum*, *D. subcurvatum*, *D. retrorsum*, *D. perretrorsum*, *D. undulatum*, and *D. divergens*.

Other species of Gasconade age listed by Ulrich, Forerste, and Miller are

D. separatum UF&M, Gasconade of Missouri
D. reversum UF&M, Gasconade of Missouri
D. vernonense UF&M, Oneota in northern Mississippi Valley
D., 3 specimens, Tanyard, central Texas.

New material described below adds the following species:

D. harrisi, Tribes Hill of New York
D. (?) *mutabile*, Tanyard of Texas
D., 2 specimens, Gasconsade portion of the El Paso of New Mexico

Unklesbay (1954) identified *D.* cf. *normale* and *D.* cf. *perretrorsum* from the Tanyard of central Texas.

Two species from the Llano uplift assigned to *Levisoceras* by Unklesbay are anomalous in their gentle vertical expansion. They are *L. magnum* Unklesbay (1954) and a specimen which Unklesbay identified as *L. complanatum*. Both are rather anomalous in their relatively broad cross sections, but fit into *Dakeoceras* far better than in *Levisoceras*. Likewise, specimens from the Chepultapec of Virginia identified by Unklesbay and Young (1956) as *Levisoceras ellipticum* and *L. instabile* are tiny portions of phragmocones showing gentle curvature and expansion typical of *Dakeoceras*, and most foreign to commensurate parts of any known *Levisoceras,* which at such early stages are most rapidly expanding.

D. corniculum approaches *Levisoceras* in rapid early vertical expansion, but remains relatively broad. Though suggestive of a relationship between the two genera, it may well be assigned in *Dakeoceras.* It was originally referred to *Clarkeoceras* (UF&M, 1943).

Likewise *D. mohawkense* (UF&M, 1943) was described as a *Clarkeoceras* but is anomalous for that genus and typical of *Dakeoceras* in the gentle expansion and small size of the shell. Part of *Clarkeoceras clelandi* is a *Dakeoceras,* but the holotype is an *Ellesmeroceras.*

Dakeoceras harrisi Flower, n. sp.

Pl. 8, fig. 8, 13, 14

Although specimens of *Dakeoceras* are not uncommon in the Tribes Hill limestone, all the specimens I have encountered, except one, are found as natural sections on surfaces, and phragmocones are filled with coarse calcite. It is impossible to obtain surfaces or good cross sections, and the internal structure is usually lost. There remains one fine portion of a phragmocone from the riberirid layer which is adequate as a basis for description.

Holotype a portion of a phragmocone with a maximum length of 19 mm. Cross section compressed, venter somewhat flattened, dorsum more narrowly rounded. The shell expands from a width of 6.5 and an estimated height of 8.5 mm at the base to 7 and 9 mm in a length of seven camerae with a lateral length of 5 mm. It increases in a ventral length of 14 and a dorsal length of 18 mm to 8 and 10.5 mm at the adoral end. There are 16 camerae in this interval. The sutures describe broad, shallow, lateral lobes separated by a low, broad, ventral saddle and a slightly higher, narrower dorsal saddle which is, however, obscurely shown on the surface of the type.

A vertical section through the middle portion of the type (pl. 8, fig. 8) shows the siphuncle to be tubular, ventral, 1.5 mm in diameter at a shell height of 8.3 mm. The septal necks are aneuchoanitic; the connecting rings thick and show obscure traces of layering, though the color differentiation is too poor to make out the details. The shell surface was apparently smooth.

Discussion. This is an extremely slender form, and projection of the type to a reasonable apex indicates a length of at least 40 and probably 50 mm. More complete shells are known, but the interior is occupied by coarse calcite, totally obscuring the internal structure, and it is impossible to obtain surfaces showing the course of the sutures. One such specimen increases from 6 to 13 mm in height in the phragmocone, with a dorsal length of 35 mm, and has a living chamber 22 mm long. Although it is reasonable to believe that this and other similarly preserved specimens are conspecific with *D. harrisi,* their preservation is such that actually they are unidentifiable specifically. (*See* pl. 8, fig. 10, upper left.)

Holotype. Collection of the writer; No. 203.

Occurrence. From the Tribes Hill limestone, along the Erie Canal just east of Fort Hunter, New York. By lithology and association, the type is from the riberirid zone.

Dakeoceras (?) mutabile Flower, n. sp.

Pl. 15, fig. 8-11

This is a rather remarkable species in which the shell is apparently strongly curved and rapidly expanding in early stages, but this stage gives way to another in which the shell is very slender and only gently curved. Sutures are extremely

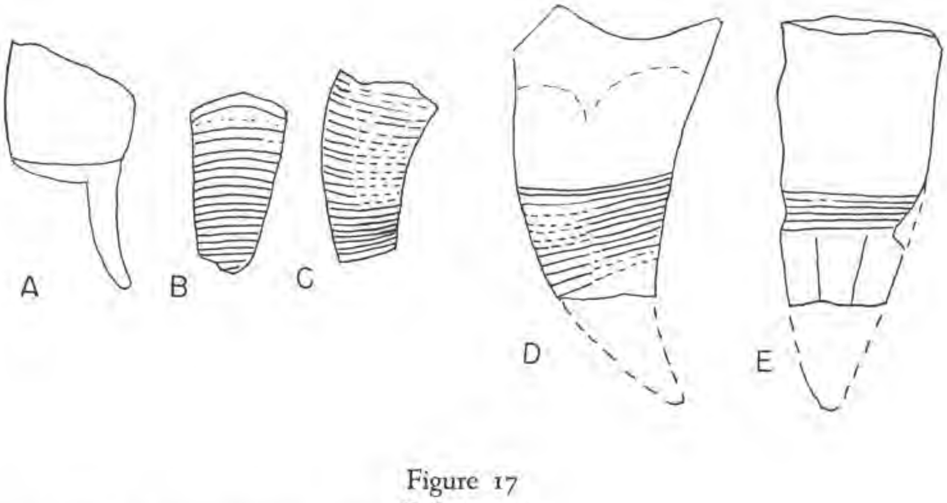

Figure 17

Dakeoceras

A.—*D. normale,* holotype, lateral view, venter at right.
B.—Dorsal view of a portion of phragmocone of the same species.
C.—Lateral view of the specimen figured in B, dorsum on left.
D.—*Dakeoceras* sp., lateral view, venter at right.
E.—Ventral view of the same specimen.
All × 1.5; after UF&M, 1943, pl. 55.

closely spaced, show lateral lobes which slope forward strongly on the dorsum. The siphuncle, not clearly shown in the early rapidly expanding stage of the shell, is presumably slender there, but becomes rapidly expanding where the shell first becomes slender, and then is slender, nearly tubular, in the later slender part of the phragmocone. In the adult, and apparently in the young also, the cross section of the shell is strongly compressed. In the adult, at least, the greatest width is attained well dorsad of the center, but the extreme dorsal part is quite narrowly rounded. Unusually flat diaphragms occur in the siphuncle. Siphuncle segments are nearly straight, faintly concave, as in most Ellesmeroceratidae.

The type is a rather small shell, showing only part of a phragmocone, 21 mm in length. In the anterior part of the phragmocone, 14 mm long ventrally and 19 mm dorsally, the shell height increases from 13 to 14 mm. Curvature is not clearly determinable but is evidently slight here; the slope of the sutures increases forward on the dorsum, and the difference in the angle of the early and later sutures here is between 30 and 40 degrees. Curvature, however, is clearly less than 20 degrees. In an earlier portion the phragmocone is too incomplete for measurement, but curvature is evidently very strong, for the siphuncle described a turn of 50 degrees in a short interval, 3.8 mm ventrally, 5 mm dorsally, in which it increases from 2 and 4 mm to 2.5 and 5.0 mm. In a succeeding interval of 4.8 mm, the width of the siphuncle remains unchanged, but its height increases to 6.5 mm in an interval in which the phragmocone is slender. The siphuncle shows short, faintly concave segments. Two breaks in it expose two diaphragms, both only very faintly convex, nearly flat. A cross section at a break in the middle of the specimen shows the greatest width of the shell to lie well dorsad of the center, the slightly convex sides diverging gently from the narrowly rounded venter to this point, and then converging toward a rather more narrowly rounded dorsum than one would expect. Where the section in the plane of the septum was 14 mm high, the shell width was 9 mm.

Septa are very closely spaced. At the base of the specimen, seven to eight septa occur in a length of 5 mm; adorally, there are thirteen to fourteen in a length of 10 mm.

Discussion. This shell is peculiar in the early rapid curvature followed by a very gently cyrtoconic adult portion, a siphuncle which expands rapidly initially and continues such rapid expansion into the early part of the slender part of the phragmocone, the strongly inclined and very close septa, and the strong compression of the cross section. It is not typical of any genus. The very close septa recall *Oneotoceras* and its allies, but there is certainly no pair of lateral furrows, and the specimen fails to show growth lines, so it is not even demonstrable that it belongs in the small group of genera with lateral modification of the growth lines. Without such evidence, the only proper course seems to be a tentative assignment of the species to *Dakeoceras*, placing reliance on the anterior, relatively slender, part of the phragmocone, rather than on the more strongly curved and more rapidly expanding early portion.

Holotype. Texas Bureau of Economic Geology.

Occurrence. Originally from the Standebach member, Tanyard formation; actually from cherts in Cretaceous conglomerates, Hensell Sand member, Shingle Hills formation, Trinity group, Lower Cretaceous; Blanco County, Johnson City area (Cage Ranch) 4½ miles southwest of Cypress Mills, 1¼ miles northwest of Pedernales River, Llano uplift, central Texas.

Dakeoceras sp.

Pl. 26, fig. 2, 7

A small fragment from the Sierrite limestone of Mud Springs Mountain shows two natural sections of obvious *Dakeoceras*. They are largely replaced by fine yellow dolmite, show as scarcely more than shadows on the weathered surface, and, while both are essentially vertical sections, there is no assurance that the exposed surfaces are central or that they are not oblique to the median plane, which would be necessary to show the exact rate of expansion.

One specimen, shown on Plate 26, figure 7, shows a phragmocone 11 mm long expanding in apparent height from 3 to 5 mm, and an incomplete living chamber which extends 7 mm farther on the venter.

The other specimen (pl. 26, fig. 2) has a phragmocone expanding from 3 to 5.5 mm in a length of 11 mm and a living chamber increasing in height to 6 mm in a length of 7 mm. The living chamber is incomplete, the dorsal length extending 3.5 mm farther.

The slight curvature and moderate instead of extremely slow vertical expansion indicate that these specimens belong to *Dakeoceras* and not to *Ectenoceras*. Though early stages of *Ectenoceras* are known which are slightly curved, they are always much more slender.

Figured specimens. No. 319, both specimens on one piece.

Occurrence. Loose, from the Sierrite limestone of Mud Springs Mountain, New Mexico.

Dakeoceras sp.

Pl. 15, fig. 6

This is a small *Dakeoceras* represented by a specimen weathered from one side but obviously crushed, a matter which forbids close analysis at the specific level. The specimen shows a phragmocone extending 8 mm on the dorsum, increasing in height from 8 to 10 mm, showing a small ventral tubular siphuncle. It is impossible to judge the spacing of septa, as the camerae are filled solid with silica. At the base, the strong compression of the shell leaves a width of 3 mm, but irregularity of the right surface, embedded in the matrix but partially exposed by etching, shows the shell to be flattened, and such extreme compression is clearly not original. The living chamber extends 13 mm on the dorsum, attaining a height of 12 mm adorally. At the extreme adoral end, weathering exposes part of the far side of the shell, producing the false impression in our photograph of a contracted aperture.

Discussion. This specimen is noteworthy as the best one so far found in the Gasconade part of the El Paso, even though weathering and distortion forbid close comparison at the specific level.

Figured specimen. Collection of the writer; No. 227.

From the lower 15 feet of the El Paso at Pierce Canyon, on the southern end of the Black Range, on the east side, about five miles northwest of Lake Valley, New Mexico.

Genus PARADAKEOCERAS Flower, n. gen.

Genotype: *Paradakeoceras planiventrum* Flower, n. sp.

Dakeoceras is a moderately small, gently curved cyrtocone, the adoral part of which is either nearly tubular or slightly contracted; the early portion is moderately rapidly expanding. It is a typical ellesmeroceroid in the compressed section, lateral lobes, and the moderately large siphuncle close to the concave ventral side.

The new genus *Paradakeoceras* is erected for species which differ from *Dakeoceras* in that the cross section of the shell is broadened, with consequent loss of the lateral lobes. In this respect, indeed, these species depart from the general pattern of the Ellesmeroceratidae. Nevertheless, I include it in the family because it possesses diaphragms, a feature widespread in the contemporary Lower Canadian Ellesmeroceratidae of typical aspect, and a feature not as yet found in the post-Gasconade genera which stem from the Ellesmeroceratidae and which agree with the present genus in the relatively broad cross section and the loss of the lateral lobes.

In addition to the two species described below, *Levisoceras complanatum* of Unklesbay, 1954, Jour. Paleont., vol. 28, 649, pl. 70, fig. 17-18, and part of *Burenoceras barnesi* belong here.

Paradakeoceras planiventrum Flower, n. sp.

Pl. 8, fig. 1-7

This is a small slightly curved species, broad in cross section, the concave ventral side flattened, the dorsum strongly arched. Expansion is moderate in the early stages, but becomes reduced in the adoral part, and the mature living chamber contracts very gently toward the aperture. The sutures are essentially straight and transverse, the septa closely spaced, the siphuncle moderate in size, essentially in contact with the ventral wall. Its segments are subcylindrical; its interior is traversed by diaphragms which present curved surfaces like unperforated septa, concave orad.

The holotype is a small living chamber, 28 mm long, expanding from 11 mm in width and 10 mm in height to 15 and 12 mm in a ventral length of 16 mm. The remaining 12 mm shows a gentle contraction, the shell having a height of 12 mm and an estimated width of 14 mm.

A second specimen, incomplete, retains the siphuncle and the ventral part of the phragmocone. The siphuncle expands from 3 mm at the base, where it is terminated by a diaphragm, to 5 mm at the base of the living chamber; it expands rapidly in the basal third of this distance, and is nearly tubular adorally. Fourteen septa occur in this distance. The living chamber is 18 mm long, incompletely preserved, but evidently the cross section is identical with that of the holotype. On the same piece is a lateral portion of another specimen, which shows growth lines that slope strongly apicad and are strongly oblique over the entire lateral surface. The orientation is uncertain, but it appears that the lines of growth swing forward on the convex dorsal side of the shell. This specimen is very poorly preserved and may not be specific or even congeneric with *P. planiventrum*; indeed, if it is not altered by flattening, the cross section is narrower than high, and this may well be a species of the genus *Dakeoceras*.

Types. Holotype and paratype, collection of the writer; Nos. 185, 186.

Occurrence. From the Smith Basin limestone at Smith Basin and Fort Ann, New York.

Paradakeoceras minor Flower, n. sp.

Pl. 8, fig. 15, 16

This is a small species, as the name implies. The type is a portion of a shell consisting of a living chamber and eight camerae, 13 mm in length. The concave ventral side of the shell is poorly preserved and not exposed. The cross section is wider than high, the shell expanding from a width of 10 and an estimated height of 7 mm to a width of 13 and an estimated height of 9 mm. Dorsal profile convex, sides diverging rapidly initially, the rate of divergence abruptly reduced on the adoral part of the living chamber. Eight camerae occupy a length of 6 mm. The sutures are inclined strongly forward on the convex side of the shell. The ventral side is not exposed, the siphuncle has not been observed. The abrupt adoral decrease in the rate of expansion indicates that the type represents a mature shell, though a small one.

Discussion. The small size, very shallow camerae, and abrupt adoral decrease in the rate of lateral expansion of the shell characterize this species.

Holotype. Collection of the writer; No. 187.

Occurrence. Smith Basin limestone, from the section just east of Smith Basin, New York.

Genus QUEBECOCERAS Foerste

Text Figure 18

Genotype: *Cyrtoceras quebecense* Whiteaves

Quebecoceras Foerste, 1925, Denison Univ. Bull., Sci. Lab., Jour., vol. 21, p. 11.
——— Ulrich, Foerste, Miller, and Unklesbay, 1944, Geol. Soc. Amer., Special Papers, no. 58, p. 136.

Quebecoceras is a cyrtocone with much the rate of expansion and curvature of *Dakeoceras*, but differing in the circular cross section and suppression of lateral lobes, and the aperture shows very slight lateral sinuses. The one species is about half again as large as the largest known *Dakeoceras*. Certainly the genus may be held as distinct from *Dakeoceras* and *Paradakeoceras*; in the latter genus, the cross section shows marked flattening of the venter and the anterior part shows a marked reduction in expansion, but the relationships are certainly close.

Genus STEMTONOCERAS Ulrich and Foerste

Genotype: *Stemtonoceras elongatum* Ulrich and Foerste

Stemtonoceras Ulrich and Foerste, 1935, Denison Univ. Bull., Sci. Lab., Jour., vol. 30, p. 288.
——— Ulrich, Foerste, Miller, and Unklesbay, 1944, Geol. Soc. Amer., Special Papers, no. 58, p. 29.

Shell a slender endogastric cyrtocone, cross section compressed, sutures with lateral lobes, siphuncle close to the concave venter. The nature of the siphuncle wall is not stated in the description nor is it evident from the illustrations. It may safely be assumed to have short necks and thick connecting rings like other ellesmeroceroids. The interior of the siphuncle is traversed by diaphragms. Shell surface with faint and rather rugose growth lines, which slope faintly orad on the convex dorsum and exhibit very faint lateral sinuses.

Discussion. This genus contains only the genotype which is known from only three specimens from the Gasconade

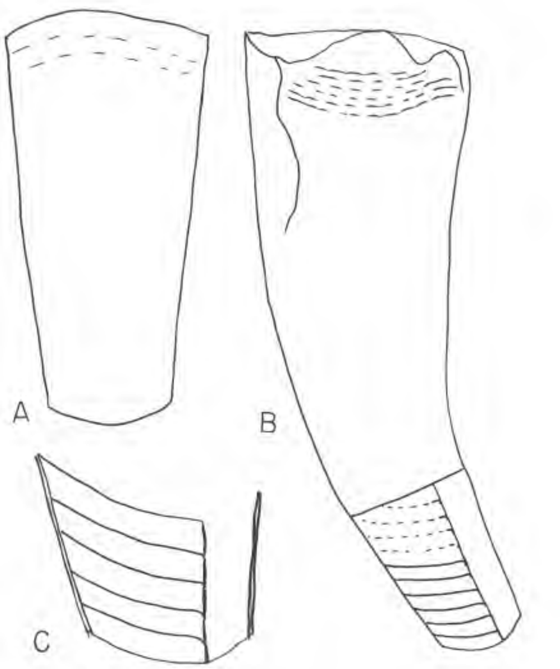

Figure 18

Quebecoceras quebecense

Outline drawings. A. Living chamber, slightly restored, dorsal view. B. Lateral view of holotype; venter at right. Both × 1. C. Enlargement of section from the base of B. After UFM&U, 1944.

equivalent of Stemton, Pennsylvania. It is a typical ellesmeroceroid, but distinctive as a relatively large and extremely slender compressed cyrtocone. *Woosteroceras* is most similar in general aspect but is more curved and the cross section is as broad as high. Diaphragms are certainly not so strongly developed.

Stemtonoceras elongatum Ulrich and Foerste
Text Figure 19

Stemtonoceras elongatum Ulrich and Foerste, 1935, Denison Univ. Bull., Sci. Lab., Jour., vol. 30, p. 289, pl. 38, fig. 3.
——— Ulrich, Foerste, Miller, and Unklesbay, 1944, Geol. Soc. Amer., Special Papers, no. 58, p. 29, pl. 1, fig. 6, 7; pl. 2, fig. 11.

A slender, almost tubular shell, faintly compressed, sutures show lateral lobes. The ventral siphuncle is tubular, an apical section shows unusually numerous and regular diaphragms. It is known only from the holotype from the Lower Canadian, near Stemton, Pennsylvania.

Genus LEVISOCERAS Foerste
Genotype: *Cyrtoceras mercurius* Billings

Levisoceras Foerste, 1925, Denison Univ. Bull., Sci. Lab., Jour., vol. 21, p. 11.
——— Ulrich and Foerste, 1935, Denison Univ. Bull., Sci. Lab., Jour., vol. 30, p. 278.
——— Ulrich, Foerste, and Miller, 1943, Geol. Soc. Amer., Special Papers, no. 49, p. 132.

Levisoceras is distinctive among the Ellesmeroceratidae in the combination of rapid expansion and strong curvature. The section is compressed; indeed, height in general increases more rapidly than the width. Sutures show well-developed

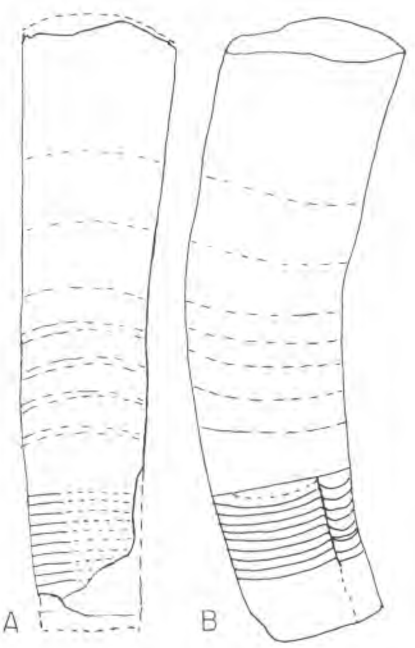

Figure 19

GENERAL FEATURES OF *Stemtonoceras elongatum*

Outline drawings from the holotype. A. Dorsal view, somewhat restored; dotted lines indicate faint annular constrictions. B. Lateral view dorsum on left. Both × 1.

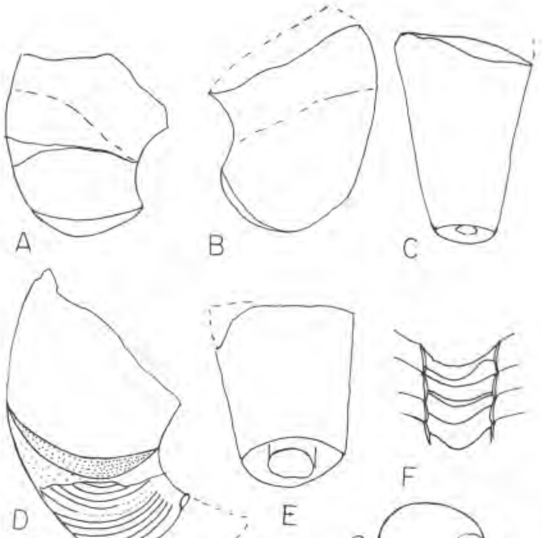

Figure 20

GENERAL FEATURES OF *Leviscoceras*

A-C. *Levisoceras mercurius* (Billings). A and B are opposite lateral views of a type living chamber; C. the ventral view of the same specimen. D. *L. complanatum*, lateral view, venter on right, somewhat restored. E. Ventral view of the living chamber of the same specimen. F. Transverse longitudinal section through the siphuncle of *Levisoceras*, sp. from the Tanyard formation of Texas, showing siphuncle wall and diaphragms, × 4. G. Generalized cross section; venter on right. All except F are × 1.

lateral lobes. The siphuncle may show rapid increase in diameter, particularly in height, comparable to that of the conch. Apertures are incompletely known, but some specimens certainly show an adoral decrease in rate of vertical expansion, but others show a slight flaring at complete maturity.

The species known are all from the Gasconadian; some are reputedly widespread in North America. As in so many members of the Ellesmeroceratidae, the fragmentary remains make difficult critical comparison at the specific level. Also, the more gently expanding and more gently curved species approach the condition of typical *Dakeoceras*. A few such species have been transferred to that genus, largely to simplify generic definitions. Some large species formerly placed in *Burenoceras* are here transferred to *Levisoceras*.

The previously described species are listed below with their reported ranges:

- *L. mercurius* (Billings) Lower Canadian boulder in the Levis conglomerate.
- *L. belli* UF&M. Same occurrence.
- *L. arctedorsatum* UF&M. Chepultapec, Hagarstown, Maryland.
- *L. complanatum* UF&M. Gasconade of Missouri, Chepultapec of Alabama, and Oneota of Wisconsin. The specimen figured by Unklesbay (1954) from the Tanyard of Texas is atypical in the slender living chamber and the broad cross section, and is referred to *Dakeoceras*.
- *L. constrictum* UF&M. Oneota of Wisconsin. The species is peculiar in showing vertical expansion of the living chamber to the adoral end, but the sides are convex, the aperture being contracted laterally.
- *L. curvatum* UF&M. Oneota, northern Mississippi Valley. A smaller species, with similar convexity of lateral profile of the living chamber.
- *L. edwardsi* UF&M. Oneota of Wisconsin; a third species with convex lateral living chamber profiles.
- *L. ellipticum* UF&M. Gasconade of Pennsylvania, Tanyard of Texas, Oneota of Wisconsin. Probably too much has been included under this name, but the forms agree in general in relatively slight curvature and, except the living chamber which is the holotype, show quite close septa. Unklesbay's *L. ellipticum* of the Tanyard is close if not identical, but *L. ellipticum* of Unklesbay and Young of the Chepultapec of Virginia is much too slender and is removed to *Dakeoceras*.
- *L. instabile* UF&M. Gasconade of Missouri, Chepultapec of Alabama and Tennessee, Oneota of Wisconsin. A moderately small species showing marked adoral flattening of the sides, suggesting an approach to the lateral concavity of cross section of *Oneotoceras*.
- *L. obliquatum* UF&M. Reported from the Gasconade of Missouri, Oneota of Wisconsin, Arbuckle of Oklahoma, and Tanyard of Texas (Unklesbay, 1954). Sutures are strongly extended forward on the dorsum. Quite possibly the appearance of greatly increased convexity on the dorsal profile of the living chamber and of a contracted aperture (UF&M, pl. 64, fig. 16) is adventitious, if not the result of retouching.
- *L. percurvatum* UF&M. Gasconade of Missouri. A fragment with the ventral side missing was assigned to this species from the Tanyard of Texas by Unklesbay (1954).
- *L. raaschi* UF&M. Oneota of Wisconsin and, tentatively, Chepultapec of Tennessee. The type is a phragmocone, very rapidly expanding vertically. The living chamber remains unknown. Sutures slope strongly dorsorad, as in *obliquatum*, but proportions differ, and septa are not so closely spaced.
- *L. subgracile* UF&M. Oneota of Minnesota and Tanyard of Texas. Though rather slender, the strongly compressed section gives this the aspect of *Levisoceras* rather than of *Dakeoceras*.
- *L. transitum* UF&M. Chepultapec of Tennessee. Again a species of rather gentle curvature and expansion, but distinct from *Dakeoceras* by the strong compression of the section. The specimen figured as this species by Unklesbay and Young (1956) from the Chepultapec of Virginia is relatively broad in section and shows much closer sutures; it is tentatively considered a *Dakeoceras*.

In addition, apparent gradation between *Burenoceras* and *Levisoceras* is eliminated by the transferral of the following species from *Burenoceras* to *Levisoceras*:

- *L. curticei* (UF&M) Oneota of Wisconsin; the aperture shows very faint flaring and a good hyponomic sinus.
- *L. cornucopiaeforme* (Powell, 1935) Oneota of Minnesota. The extreme margin of the aperture is flared, particularly laterally; before it, sides of the living chamber diverge and are straight.
- *L. dilatatum* (UF&M) Tanyard of Texas. The aperture is not known. This is rather broad for *Levisoceras*, approaching *Dakeoceras subcurvatum* in aspect.
- *L. minor* (UF&M) Known only from a living chamber from the Oneota of Wisconsin; though smaller than typical *Levisoceras*, it is much closer to this genus than to *Burenoceras* in size range and in aspect.

It is proper to note here a few forms transferred to other genera. *Levisoceras magnum* Unklesbay and the specimen Unklesbay (1954) figured as *L. complanatum* from the Llano uplift of Texas are removed to *Dakeoceras*. A similar transfer affects the small bits of phragmocones which Unklesbay and Young figured from the Chepultapec of Virginia as *L. ellipticum* and *L. instabile*. These are based on tiny specimens, obviously early portions of phragmocones. It has been found that such early portions of true *Levisoceras* are apt to be particularly rapidly expanding in the vertical plane, and these slender forms are thus clearly atypical.

Levisoceras contractum Flower, n. sp.

Pl. 11, fig. 4

This is a moderate-sized endogastric cyrtocone, rather strongly curved, rather rapidly expanding to the middle of the living chamber and then gently contracting to the aperture. The type is a specimen exposed in a natural section. Slight obliquity of the section exaggerates the rate of expansion of the strongly endogastric phragmocone, in which 12 camerae are seen, in a ventral length of 10 and a dorsal length of 18 mm. The shell attains a height of 16 mm at the base of the living chamber, where the septum is deeply curved, 3.5 mm deep, nearly one fourth of the shell height. The siphuncle here is 2 mm high and 0.5 mm from the venter. The living chamber, 12 mm long dorsally and 10 mm ventrally, attains a maximum height of 17 mm and contracts to 16 mm at the aperture. On the living chamber the dorsum is convex, curvature increased slightly near the aperture, the venter concave at the extreme base, blending with the concavity of the phragmocone, straight over most of its length, slightly convex near the aperture.

Discussion. It is necessary somewhat to emend the proportions shown by the type, for the section is not in the axial plane but passes below it apically where the rate of expansion of the earlier part of the phragmocone is therefore exaggerated, and above it adorally, increasing the slight contraction of the shell at the aperture. The rapid expansion and rather deep septa supply a combination of characters not duplicated in previously described species.

Holotype. Collection of the writer; No. 245.

Occurrence. From 272-6 feet above the base of the Threadgill member, Tanyard formation, from Threadgill Creek, Gillespie County, Texas.

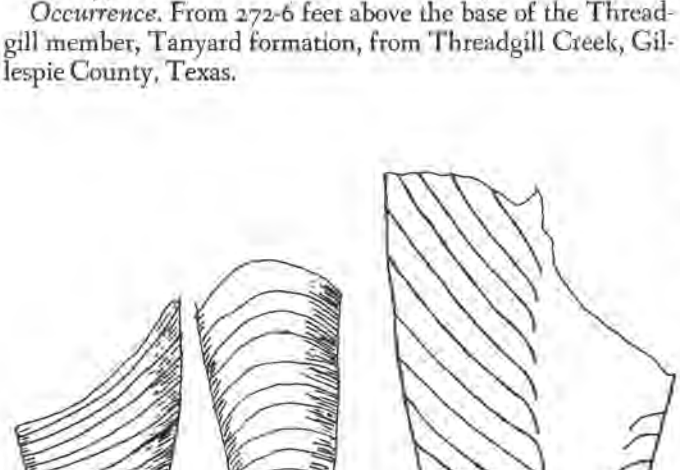

Figure 21

Clarkeoceras newton-winchelli (Clarke)

A. lateral view of a syntype, venter at left; B. dorsal view of the same specimen. C. Vertical section, showing rapidly enlarging siphuncle and moderately long necks; apically rings and necks are not clearly differentiated.

Genus CLARKEOCERAS Ruedemann

Text Figure 21

Genotype: *Piloceras newton-winchelli* Clarke

Clarkeoceras Ruedemann, 1905, New York State Museum, Bull. 80, p. 337.

——— Foerste, 1921, Denison Univ. Bull., Sci. Lab., Jour., vol. 19, p. 261.

——— Foerste, 1924, ibid., vol. 20, p. 204.

——— Ulrich and Foerste, 1935, ibid., vol. 30, p. 267.

——— Ulrich, Foerste, and Miller, 1943, Geol. Soc. Amer., Special Papers, no. 49, p. 79.

Typical *Clarkeoceras* is a shell with only very faint endogastric curvature, in which lateral expansion is slight, vertical expansion much more rapid, so that the section is strongly compressed adorally. Mature living chambers may show a reduction in the rate of expansion but are not commonly contracted. Sutures slope strongly dorsorad; their curvature on the lateral faces is slight or wanting altogether. The aperture slopes forward from venter to dorsum; the slope may be greater than that of the sutures. The ventral siphuncle expands more rapidly vertically than horizontally. There is variation within the genus in the length of the septal necks, which may be short as in typical Ellesmeroceratidae, or long enough to be called hemichoanitic. Diaphragms are developed but are commonly rather markedly confined apically.

Discussion. Clarkeoceras is widespread in the Lower Canadian of eastern North America, being known from the Smith Basin limestone of the Champlain Valley to the Llano uplift of central Texas. One fragment, too poor to merit illustration, has been found in the Gasconadian part of the El Paso limestone, but the genus is not known in more westerly beds. UF&M recognized 34 named species. Some are difficult to evaluate owing to the fragmentary material on which they are based, but the greater number of them are certainly one generic group. At Fort Ann *Clarkeoceras* is rather abundant in the Skene member, but rare in the Vly Summit or the Smith Basin limestone. The material from the Skene member collected by the writer was not available for the present work. It is in the New York State Museum.

In form, *Clarkeoceras* is similar to *Levisoceras,* which is more strongly curved, *Dakeoceras,* which is more slender and about equal in curvature, but shows a much more gentle rate of vertical expansion. One species, *C. menniskiense,* shows a faint concavity of the lateral face, and might possibly be an *Oneotoceras.* The one known specimen is most fragmentary. The Tribes Hill *C. clelandi* is based upon two species, one certainly an *Ellesmeroceras,* one rather poorly preserved and possibly *Ellesmeroceras* or *Dakeoceras;* the type shows slight curvature suggesting the latter genus, but the appearance may be adventitious, from partial weathering beyond the plane of symmetary. *C. mohawkense* is clearly assignable to *Dakeoceras.* The bulk of the species, however, seem to be a single genus, though a few approach *Dakeoceras* or *Levisoceras* in aspect, as noted in the analysis below.

Boreoceras, known only from Arctic North America, seems allied, and at first I thought that the two genera might be better united, but *Boreoceras* is generally broader in section and shows gentle curvature and sutures with strongly developed lateral lobes which are not inclined forward markedly on the dorsum. Possibly future work may show the advantage of transferring to *Boreoceras* some little-known species contained at present in *Clarkeoceras* with relatively transverse sutures, but at present it does not seem that such a transfer would be of any great advantage in clarifying the distinctness of the genera; such species of *Clarkeoceras* as are now known are more typical of *Clarkeoceras* in that the shell is more rapidly expanding vertically or in that the sutures are largely without curvature on the lateral faces.

Phragmocones of *Caseoceras* may be mistaken for *Clarkeoceras,* and indeed, from phragmocones alone the genera are possibly not separable, but *Caseoceras* is probably little more than a *Clarkeoceras* in which the aperture is contracted at maturity.

PREVIOUSLY DESCRIBED SPECIES

The species are listed below with known ranges, and such notes as seem particularly pertinent:

C. newton-winchelli (Clarke 1897), Oneota of the northern Mississippi Valley; Chepultapec, Alabama; Tanyard, Texas; oddly, this often cited species is known from phragmocones, but no living chambers have been recognized; one wonders whether living chambers have been identified under another species.

C. affine UF&M, 1943, Gasconade of Missouri; a large species, septa slightly oblique, nearly straight laterally.

C. arcuatum UF&M, 1943, Oneota, Wisconsin; Gasconade, Missouri; Tanyard, Texas; a large species with very close septa and faint lateral lobes.

C. buttsi UF&M, 1943, Chepultapec, Tennessee; large species, close, nearly transverse, sutures.

C. calvini UF&M, 1943, Oneota of Iowa, Wisconsin, Minnesota; convex dorsal profile of the living chamber suggests a large *Levisoceras*; but change of genus would serve no good purpose.

C. cinctum UF&M, 1943, Gasconade, Missouri; close to *luthei* but with a preoral constriction of the living chamber.

C. clelandi UF&M, 1943, Tribes Hill, New York; the original of UF&M, 1943, pl. 25, fig. 5, is an *Ellesmeroceras*; pl. 45, fig. 12, shows a dolomitized specimen, seemingly faintly endogastric, but specific comparison is not possible. It could be an *Ellesmeroceras*, but only if the concavity of the venter is adventitious; otherwise it is a *Dakeoceras*.

C. confertum UF&M, 1943, Gasconade, Missouri; Tanyard, Texas; typical, rather broad in section, slightly oblique sutures.

C. crassum UF&M, 1943, Gasconade, Missouri; large typical form, oblique slightly curved sutures, preoral constriction.

C. cuneatum UF&M, 1943, Gasconade, Missouri; Tanyard, Texas; large typical species.

C. curvatum UF&M, 1943, Chepultapec, Tennessee; incompletely known, but apparently typical of the genus.

C. expansum UF&M, 1943, Oneota, northern Mississippi Valley; a moderately small species with relatively transverse sutures, suggests *Levisoceras* somewhat but is less curved.

C. gracile UF&M, 1943, Gasconade, Missouri; this suggests *Dakeoceras* but is more compressed in section and shows more oblique sutures.

C. holtedahli Foerste (1921, Denison Univ. Bull., vol. 19, p. 261, pl. 27, fig. 2a-b, pl. 33, fig. 1). With *Ellesmeroceras scheii*, Lower Canadian, Victoria Head, Basche Peninsula, artctic N. A. UF&M, 1943, refer this doubtfully to *Caseoceras*.

C. huzzahense UF&M, 1943, Gasconade, Missouri; slightly compressed, little curved, oblique sutures.

C. inconstans UF&M, 1943, Gasconade, Missouri; Tanyard, Texas; an unusually slender form, suggesting gradation of *Clarkeoceras* into *Dakeoceras*, but best left in the present genus.

C. jasperense UF&M, 1943, Chepultapec, Tennessee; a small form, moderate vertical expansion, sutures anomalously sloping forward on the venter. Typical in form and aspect.

C. lawrensense UF&M, doubtful; possibly *Clitendoceras*.

C. levisense UF&M; doubtful; possibly *Clitendoceras*.

C. luthei (Calvin, 1892) Oneota, northern Mississippi Valley; a good species; convexity of the dorsum on the living chamber gives this much the aspect of an oversized *Levisoceras*.

C. magnisiphonatum UF&M, 1943, Gasconade, Missouri; Tanyard, Texas; a large species with the siphuncle particularly broad adorally and costae on the living chamber.

C. minneiskense UF&M, 1943, Oneota, Wisconsin; known from only a fragment showing the base of a large living chamber and a few camerae. A lateral groove suggests *Oneotoceras*, and the species could pertain to that genus.

C. modestum UF&M, 1943; small, like a relatively straight compressed *Levisoceras* or *Dakeoceras*, best left in present genus.

C. ? mohawkense UF&M, 1943, Tribes Hill, New York; a small species better assigned to *Dakeoceras* but distinct from *D. harrisi*.

C. parvisiphonatum UF&M, 1943, Chepultapec, Tennessee; based upon one poor fragment of a phragmocone, but typical in strongly compressed section, though unusually slender in vertical expansion.

C. rectum UF&M, 1943, Gasconade of Missouri; dubious; straight, slender, compressed, oblique sutures.

C. ruguliferum UF&M, 1943, Tanyard, Texas; a large typical form with a costate living chamber.

C. subarcuatum UF&M, 1943, Gasconade, Missouri; typical species, rapid vertical expansion, strongly compressed, slightly curved.

C. subcrassum UF&M, 1943, Gasconade, Missouri, Tanyard, Texas; a large typical species, early part with very rapid vertical expansion.

C. subrectum UF&M, 1943, Gasconade, Missouri; typical in rapid vertical expansion; nearly straight adorally.

C. vicinum UF&M, 1943, Gasconade, Missouri; small, similar to *Dakeoceras*, but with more rapid vertical expansion, sutures slope dorsorad.

C. whitehallense UF&M, 1943, Great Meadows formation, southern Champlain Valley. Known from adoral portion, unusually straight, rather broad, sutures relatively transverse, with good lobes. Typical of genus.

SPECIES REMOVED FROM *Clarkeoceras*

Two rather inadequately known species from the Levis conglomerate boulders, *C. lawrensense* and *C. levisense*, are known from relatively late growth stages of phragmocones which are orthoconic, slender, subcircular in section, and have oblique sutures. One, *C. lawrensense*, was sectioned, and the septal necks are hemichoanitic. The other was also sectioned, but the preservation left the siphuncle wall apparently of rather uncertain interpretation. Both of these could be anterior parts of phragmocones of *Clitendoceras*, but affinities cannot be determined from the evidence supplied by the present known specimens. The Levis boulders certainly contain elements suggesting Middle as well as Lower Canadian cephalopods. Even more puzzling is *C. rectum* of the Gasconade, known from a single silicified fragment from the anterior part of an orthoconic phragmocone showing similarly oblique sutures, without lateral curvature, but in this form the cross section is compressed, being 43 mm high and 30 mm wide. The Lower Canadian age makes a similar assignment to *Clitendoceras* or to the Endoceratida most unlikely; no Lower Canadian Endoceratida are known. Without more knowledge of its structure, the position of this species cannot be determined. One might suggest assignment to *Anguloceras*, but the fact that this species is a veritable giant in relation to the forms known at present leaves this only a doubtful suggestion.

As noted above, *Clarkeoceras ? clelandi* is based certainly upon one *Ellesmeroceras* and one rather poorly preserved specimen which is either *Ellesmeroceras* or *Dakeoceras*. *C. ? mohawkense* is best transferred to *Dakeoceras*, and the same generic disposition is made of *Clarkeoceras ? corniculum* (Sardesson) of the Oneota of Minnesota.

NEW SPECIES

New species are described below. One specimen from the Smith Basin limestone, not illustrated, was sectioned; it shows essentially hemichoanitic necks. The same condition was figured by UF&M, 1943, on pl. 42, fig. 3, for *Clarkeoceras newton-winchelli*. In the same work, two diaphragms are shown in a small portion of siphuncle for *C. luthei* on pl. 47, fig. 6, 7, and probably the rounded base of fig. 8 and 9 of the same plate represents a diaphragm.

Clarkeoceras ruedemanni Flower, n. sp.

Pl. 10, fig. 2

This is a medium-sized, gently curved *Clarkeoceras* with relatively close transverse sutures lacking clear lateral lobes. The type is a portion of a phragmocone 105 mm long, which expands from 9 to 35 mm in height in the basal 75 mm, in which the radius of curvature of the dorsum is 100 mm; later, the dorsal curvature increases, having a radius of 70 mm. Farther orad the dorsum is incomplete, but there is suggestion of a later decrease in rate of curvature. Apically, the venter is concave; adorally, it becomes perfectly straight, and is, indeed, straight over the anterior 60 mm of the type. Only the adoral 22 mm of the shell represents a part of the incomplete living chamber.

Sutures are obscure in the apical part of the specimen. At midlength, the sutures are seen to be essentially transverse and straight, though slight lateral lobes develop close to the base of the living chamber. At midlength, the camerae average 4 mm in depth, a condition retained to the latest observed part of the phragmocone. Near the midlength of the shell the whorl is 26 mm high and 18 mm wide. Here the siphuncle is 4 mm high, 3 mm wide, and 4 mm from the venter. The septum is deep, the siphuncle occurs 5 mm apicad of the suture of the septum. A section indicates that the siphuncle wall is composed of short septal necks, essentially aneuchoanitic, and not hemichoanitic as in some species of the genus.

Diaphragms have not been observed in the species, but the early part of the type fails to preserve any internal structures.

Discussion. This form is distinctive in combining gentle expansion, gentle curvature of the apex, the straight ventral profile of the anterior part of the shell, the relatively straight and transverse septa. The cross section, though incompletely shown, is evidently unusually strongly compressed.

Holotype. Collection of the writer; No. 199.

Occurrence. From the Smith Basin limestone, from the section east of Smith Basin, New York.

Clarkeoceras trapezoidale Flower, n. sp.

Pl. 10, fig. 10, 13

Only the anterior part of the shell is known of this species. The dorsum and venter are here straight, rapidly diverging, with an apical angle of 25 degrees. The shell height increases from 26 to 37 mm, while the width in the same distance increases from 17 to 20 mm, increases of 11 and 3 mm, respectively. The cross section is strongly compressed, the venter much more narrowly rounded than the dorsum, but with the greatest width attained only slightly dorsad of the center. Sides remain slightly convex. The sutures are inclined forward from venter to dorsum, but show only a faint curvature as they cross the flattened lateral zones. The type contains eight camerae in the basal 18 mm as measured dorsally; the last two are shortened and together occupy 3 mm; earlier ones are subequal in length, six occurring in a length of 15 mm. The siphuncle is close to the venter, 3 mm high, 2 mm wide, 1 mm from the venter, relatively small for the genus in this growth stage where the septum is 29 mm high and 17 mm wide. The living chamber extends 20 mm beyond the last septum, is strongly oblique to the axis of the shell, sloping orad from venter to dorsum, relatively straight laterally, and without a distinct ventral sinus other than that resulting from the general obliquity of the aperture.

Discussion. This species is characterized by the straight rapidly diverging dorsum and venter, though some curvature in the earlier unknown part of the shell is not improbable. It is evident, however, that curvature, if present, was relatively slight. The strongly oblique sutures and aperture give the anterior part of the shell a trapezoidal appearance, quite characteristic, as is the essentially straight course of the sutures laterally. *C. whitehallense* is a form of much broader cross section, the sutures lobed laterally and relatively transverse. Comparable species with rapid expansion, the dorsum sloping much more than the venter, and with the sutures essentially uncurved laterally, are few. *C. luthei* is such a form, but its vertical expansion is more gentle, the camerae are shallower, and compression of the cross section is less extreme than in *C. trapezoidale*.

Holotype. Collection of the writer; No. 201.

Occurrence. From the Smith Basin limestone, from the section just east of Smith Basin, New York.

Clarkeoceras rhomboidale Flower, n. sp.

Pl. 6, fig. 19-20

This is a small, straight, conical compressed shell, the type 25 mm long, retaining the entire length of a living chamber and parts of seven camerae. The shell is compressed in cross section at the base, venter and dorsum equally rounded there, 6 mm wide, 9 mm high, and expands in 22 mm to a width of 16 mm and an estimated height of 19 mm, where the dorsum is somewhat more broadly rounded than the venter. Growth lines and aperture are essentially transverse to the axis of the shell, though there is a slight apical curvature as they approach the venter, which is incomplete here. There are also faint annular expansions of the shell, very low and broad, measuring 6 mm from crest to crest. The sutures outline seven camerae which are subequal and occupy 11 mm on the dorsum. Sutures slope apicad from dorsum to the midlateral region, and from there they appear to become more transverse as they pass to the venter, but the ventral part of the shell is too poorly preserved to show their course there.

Discussion. This is a small shell, and the specimen may not be a mature one. However, it is clearly a *Clarkeoceras* and is clearly distinct from the two other species described from the present association, for *C. trapezoidale* has an oblique aperture and *C. ruedemanni* has more transverse sutures. The costae at such an early growth stage are unusual, and it may be that this species is an essentially mature one, but a dwarf among its congeners. Certainly the straight vertical profiles, strong compression of the cross section, and the sharp rise of the sutures on the dorsum are typical of the genus.

Holotype. Collection of the writer; No. 201.

Occurrence. From the Smith Basin limestone, from the section east of Smith Basin, New York.

Clarkeoceras sp., aff. *luthei*

Pl. 12, fig. 10

The single specimen here described is a portion of a cyrtocone, moderately curved apically, the shell straightening adorally, exposed in a natural section which is nearly vertical and longitudinal. The shell increases in height from 19 to 30 mm in the phragmocone, a length of 16 mm ventrally and 36 mm dorsally. The siphuncle, clearly exposed in a length of 17 mm, increases in height from 4 to 6 mm. Camerae vary in depth rather erratically but average 3 mm. Septa slope forward from venter to dorsum, but in the plane of the siphuncle are relatively shallow and not at all strongly curved as in *Barnesoceras*. The living chamber is very incomplete adorally. It appears to have been crushed in the sediments, and the plane of the natural section passes through the far side of the specimen as it is oriented in our figure. However, the living chamber had a length of 30 mm, its dorsal portion is largely lost, but probably the dorsum was faintly convex, diverging from the venter. The ventral profile becomes essentially straight, and the shell is believed to have had an apertural height of 35 to 40 mm. The earlier part of the specimen shows sutures which are straight, uncurved laterally, sloping forward slightly from venter to dorsum. The growth lines, apparent in the same region, clearly slope forward from venter to dorsum. It is evident that in form, growth lines, and sutures, this species is fairly typical of *Clarkeoceras*. I figure it to show the extreme difficulty in distinguishing, from natural sections or artificial ones, between *Clarkeoceras* and *Barnesoceras*, if specimens fail to supply any information as to the growth lines or apertural features of the shells. This form was probably a moderate-sized *Clarkeoceras* when complete, comparable in general to *C. luthei*. Our form seems to differ in a number of features, however, and particularly in the somewhat longer camerae and more nearly transverse sutures. Should further work and better material show this to be true *luthei*, I should be surprised, but the material does not justify the erection of a distinct species.

Figured specimen. Collection of the writer; No. 201.

Occurrence. From 272 to 276 feet above the base of the Threadgill member of the Tanyard formation, from Threadgill Creek, Gillespie County, Texas.

Clarkeoceras(?) sp.

Pl. 11, fig. 5

Under this name is figured a portion of an ellesmeroceroid with a high cross section and slight curvature, features of *Clarkeoceras*, but inadequate for detailed specific comparison. The specimen is largely remarkable for the presence of the shell, showing a mottled pattern which represents original color markings. The pattern, though probably not the original color, is preserved and is adequately illustrated on our plate. The shell fragment is 40 mm long, shows a maximum shell height of 26 mm at midlength, which is possibly not quite complete dorsally. In the basal part, the opposite lateral side from that one illustrated is preserved in part, showing the shell to be 17 mm wide where the estimated height is 21 to 23 mm. The incomplete cross section at the base shows the venter strongly but not so narrowly rounded as is usual in the genus or in the family, the sides slightly convex, and markedly less flattened than in *C. ruedemanni*. The interior is not preserved.

Discussion. This fragment, though not determinable specifically, is reasonably assigned to *Clarkeoceras*. It is the first Lower Canadian cephalopod to be found showing traces of what is quite evidently a part of the original color pattern.

Figured specimen. Collection of the writer; No. 198.

Occurrence. From the Smith Basin limestone, from the section just east of Comstock, New York.

MODERATELY SPECIALIZED ENDOGASTRIC GENERA LARGELY WITH FAIRLY SIMPLE, SLIGHTLY CONTRACTED APERTURES

Genus CONOCERINA Ulrich and Foerste

Text Figure 22

Genotype: *Conocerina brevis* Ulrich and Foerste

Conocerina Ulrich and Foerste, 1935, Denison Univ. Bull., Sci. Lab., Jour., vol. 30, p. 269.

——— Ulrich, Foerste, and Miller, 1943, Geol. Soc. Amer., Special Papers, no. 49, p. 101.

This genus is erected for short, rapidly expanding shells, typically faintly endogastric and slightly compressed in cross section, but in general broader than most members of the family, and with sutures showing generally rather poor curvature of the lateral lobes on the sides of the internal molds.

Discussion. As usual, some difficulty attends drawing the precise boundaries of this genus. In general, it differs from *Clarkeoceras* in which, where the form may be somewhat similar, sutures are markedly oblique and the section is more strongly compressed. Living chambers may appear nearly straight and rapidly expanding. Slender forms approach *Eremoceras* in aspect, as in *C. beani*, and *C.(?) bassleri*, which should probably never have been named from such a fragmentary specimen, may well be an *Eremoceras*.

The species show extreme size range, from available descriptions. It is, however, questionable whether some of the tiny species are based on mature specimens. Future work may show a division here such as is noted in connection with the microellesmeroceroids, but present evidence seems inconclusive.

The known species, all of Gasconade age, previously described are as follows:

- *C. arrecta* UF&M, 1943, Gasconade of Missouri; Tanyard of Texas.
- *C. brevis* Ulrich and Foerste, 1935, Gasconade of Missouri.
- *C. beani* UF&M, 1943, Oneota of Wisconsin, also Iowa; Gasconade of Missouri; Arbuckle of Oklahoma; Chepultapec of Maryland.
- *C. magna* UF&M, 1943, Tanyard of Texas.
- *C. missouriensis* UF&M, 1943, Gasconade of Missouri; also Unklesbay, 1954, Tanyard of Texas.
- *C. obliqua* UF&M, 1943, Chepultapec of Tennessee.
- *C. raaschi* UF&M, 1943, Oneota of Wisconsin; Tanyard of Texas.
- *C. sublonga* UF&M, 1943, Gasconade of Missouri.

Transferred from other genera:

- *C. barnesi* Unklesbay, 1954, Tanyard of Texas. From *Burenoceras*.

Transferred to other genera:

- *C. cloudi* Unklesbay, 1954; this is a slender living chamber, dorsum most faintly convex, and typical of *Eremoceras*, to which it is transferred.
- *C. bassleri* UF&M, 1943, Chepultapec of Maryland; this is a very slender shell, and, though the material is most fragmentary, that it is essentially straight, compressed in section, with strongly oblique sutures suggests assignment to *Anguloceras* Unklesbay and Young.

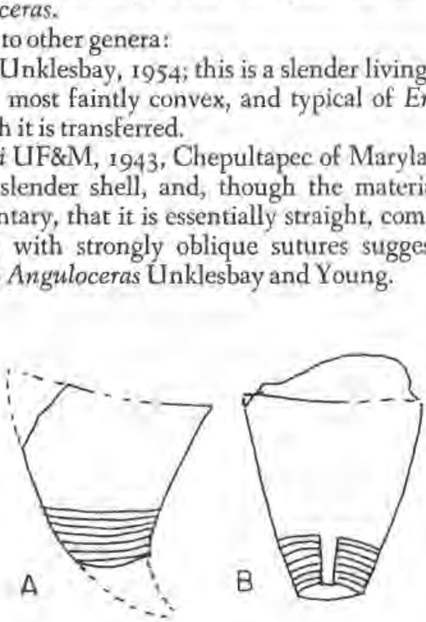

Figure 22

Conocerina brevis Ulrich and Foerste

Holotype, × 2. A. Lateral view, venter at right; B. Ventral view. After UF&M, 1943.

Conocerina reducta Flower, n. sp.

Pl. 10, fig. 7, 8

This species is known from a living chamber and one attached very shallow camera, probably one that has been shortened gerontically. The shell is evidently initially rapidly expanding. The lateral profiles diverge rapidly to the middle of the living chamber, where there is a rather abrupt reduction in the rate of expansion. The ventral profile is straight and more strongly inclined from a course normal to the last septum than is the dorsum. The dorsum is nearly straight basally, becomes markedly convex near the middle of the living chamber, and then straighter adorally.

The cross section is elliptical, 13 mm and 19 mm at the base, compressed, venter and dorsum subequally rounded and rather broadly suture. The septum shows no clear lateral lobes. The septum is unusually flat. Its surface is poorly preserved, and the siphuncle cannot be seen. The type has a maximum length of 22 mm and expands to 22 and 24 mm in the basal 10 mm, and to 29 and an estimated 27 mm at the adoral end, where the aperture is incompletely preserved. The camera at the base of the living chamber is 0.8 mm in depth.

Discussion. This is a generalized species, characterized by the flat septum, straight sutures, and adoral reduction in the rate of expansion of the shell.

Holotype. Collection of the writer; No. 196.

Occurrence. From the Smith Basin limestone, one quarter mile east of Smith Basin, New York.

Conocerina unguloides Flower, n. sp.

Pl. 7, fig. 24-26

The type retains most of a living chamber, the ventral side incomplete, and parts of a few shallow camerae. The species is remarkable for the rapid lateral expansion and was probably wider than high at the aperture. At the base of the type the cross section, slightly produced ventrally, narrowly rounded there, slightly flattened ventrolaterally, broadly rounded dorsally, is 21 mm high and 19 mm wide, with the siphuncle close to the venter, 9 mm high and 6 mm wide. Parts of a few camerae are present; apparently there are four camerae in 6 mm. Sutures show a broad, shallow, dorsal lobe; the suture appears transverse when viewed from the dorsal side, but in lateral view are seen dorsolateral saddles separating lobes, one dorsal, the other including the whole venter and more than half of the shell as seen from the side. The lateral sides of the living chamber diverge at an angle of 50 degrees, are 30 mm long, the living chamber about 26 mm long, normal to the septum. Lateral sides are straight in profile, the dorsum is slightly convex, the venter is incomplete but where it is preserved basally it diverges about 45 degrees from the dorsum. The aperture, straight dorsally, slopes down as it approaches the venter where presumably a broad sinus was developed.

Discussion. The rapid expansion and increase of shell width, apparently until it surpasses the height, is peculiar to this species. Early stages are compressed, however, as shown by the condition of the base of the specimen.

Type. Holotype, University of Texas, Bureau of Economic Geology, No. 34763, from the Standebach member, Threadgill formation, from the Llano uplift; southeastern San Saba County, Ellenburg Hills, Barnes Ranch, about 1.2 miles S. 30° E. from the south end of Long Waterhole, at the J. E. Barnes Ranch headquarters.

Conocerina cf. *brevis*

Pl. 14, fig. 13

We have a single specimen of this form, a naturally weathered section of a shell. It is straight, rapidly expanding. The phragmocone, calcite-filled and with the septa lost by replacement of calcite, expands from 3 to 6 mm in a length of 6 mm. At the anterior end can be seen the siphuncle, which is in contact with the venter, 1.5 mm high, which is unusually large, as it is about a fourth of the shell height. The living chamber extends for 7 mm, and in the basal 6 mm attains a height of 8 mm; the anterior 1 mm of the section passes to the far side of the specimen.

Discussion. The straight form and rapid expansion are typical of *Conocerina*, but the small size of the species is not. Nevertheless it seems best to retain the species in that genus;

plainly, the present specimen does not justify the erection of a new generic group.

Holotype. Collection of the writer; No. 242.

Occurrence. From 272 to 276 feet above the base of the Threadgill member of the Tanyard formation, Threadgill Creek, Gillespie County, Texas.

Genus CASEOCERAS UF&M

Text Figure 23

Genotype: *Caseoceras contractum* UF&M

Caseoceras Ulrich, Foerste, and Miller, 1943, Geol. Soc. Amer., Special Papers, no. 49, p. 74.

This genus contains very faintly endogastric shells, expanding very rapidly vertically and assuming a strongly compressed cross section, with the profiles becoming convex on the living chamber, and the mature aperture gently contracted.

Discussion. The contracted aperture is the main feature by which this genus is separated from *Clarkeoceras;* as in that genus, the sutures are little curved on the lateral surface of the shell; in *Caseoceras* they are generally less oblique than in *Clarkeoceras,* but in this respect there is no clear separation possible. *Levisoceras* may also develop mature living chambers of convex profile, but these species *L. constrictum* and *L. edwardsi,* are smaller and much more strongly curved; also, their sutures display well-developed lateral lobes.

Siphuncles are quite rapidly expanding; as yet, specimens showing clear wall structure have not been found; *C. obesum* suggests short, indeed aneuchoanitic, necks.

All known species are from the Gasconadian, Lower Canadian. The previously described known species with their ranges are as follows:

- *C. contractum* UF&M, 1943, Oneota of Michigan.
- *C. conicum* UF&M, 1943, Chepultapec of Tennessee.
- *C.(?) holtedahli* (Foerste, 1921) Gasconadian, Victoria Head, Basche Peninsula, Ellesmereland; listed also under *Clarkeoceras;* not typical of either.
- *C. intermedium* UF&M, 1943, Oneota of Michigan; also identified (Unklesbay, 1954) in the Tanyard of Texas.
- *C. nitidum* UF&M, 1943, Oneota of Michigan.
- *C.(?) sequatchiense* UF&M, 1943, Chepultapec of Tennessee.
- *C. subconicum* UF&M, 1943, Gasconade of Missouri and (Unklesbay, 1954) Tanyard of Texas.

Described below is *C. obesum* from the Tribes Hill limestone of New York.

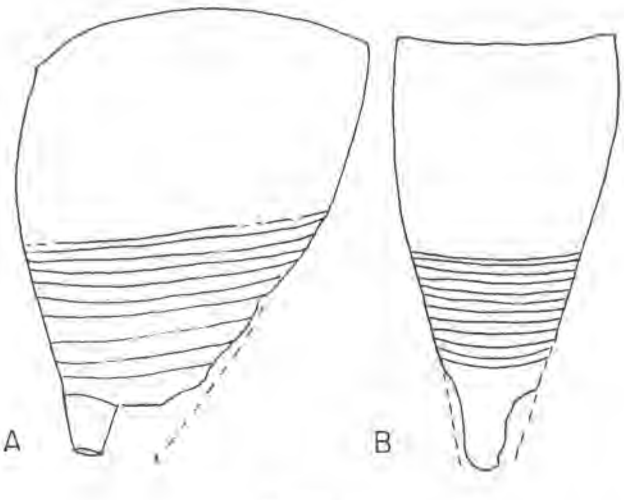

Figure 23

Caseoceras contractum

Holotype after UF&M, 1943, × 1; A. Lateral view, venter on left; B. Ventral view.

Caseoceras obesum Flower, n. sp.

Pl. 8, fig. 9-11

This is a large species from the Tribes Hill limestone of New York, known from two specimens both exposed as weathered essentially longitudinal sections. The holotype 110 mm long, preserves a part of a phragmocone and an essentially complete living chamber showing a straight ventral profile and a markedly convex dorsum mostly curved just beyond the base of the living chamber. The venter, incomplete adorally, shows a slight anterior convexity. The shell is 28 mm high and 20 mm wide at the base, increasing vertically to 46 mm at the base of the living chamber; the phragmocone is 43 mm long dorsally, 32 mm ventrally. The living chamber is 70 mm long dorsally with 40 mm preserved ventrally, increasing to a maximum height of 58 mm. If the venter is complete, it indicates a strongly oblique aperture 60 mm across. Calcite obscures the spacing of septa for the most part, but a section shows a basal camera 3 mm long dorsally, while the last two measure 1.8 and 1.0 mm. Siphuncle segments are essentially tubular; the structure of short necks and rings, a third the length of the segment, is shown in the last two segments. The siphuncle in the preserved portion expands vertically from 6 to 9 mm in the length of the phragmocone. Calcite in the siphuncle is probably adventitious, rather than representing irregular diaphragms.

The paratype, which comes from the same layer that yielded the holotype, is a somewhat larger shell, found weathered in an essentially vertical plane to the level of the siphuncle. In the phragmocone, 45 mm long dorsally and 32 mm ventrally, the shell height increases from 30 to 60 mm; the wall of the living chamber extends forward 30 mm on the venter and 75 mm on the dorsum. The dorsal profile is convex, most curved just orad of the base of the living chamber, the venter is straight, except for a slight convexity at its extreme anterior end. The living chamber shows a maximum height of 68 mm, and adorally the oblique aperture measures 70 mm. The section exposes the siphuncle, but departs from the central plane at the adoral end of the phragmocone; hence, the apparent camerae between the siphuncle and the venter there. The siphuncle apparently expands from 5 to 9 mm in height. Calcite filling the camerae obscures the spacing of septa.

Discussion. Though the paratype represents a somewhat larger individual than does the holotype, the two are quite similar in general profiles and particularly in the curvature of the adoral septa at the base of the living chamber, and it seems best to regard them as representing a single species in which mature shells show some variation in size. This species is the largest one known in the genus; it is peculiar in that the section shows unusually strong curvature of the septum, and sutures must have been relatively transverse. Also, compression of the cross section is unusually extreme.

Types. Holotype and paratype, collection of the writer; Nos. 204 and 205.

Occurrence. From the Tribes Hill limestone, from massive beds a few feet below the *Hystricurus* zone, about six miles northeast of Amsterdam and one mile south of Blue Corners, New York.

Genus BOREOCERAS Miller and Youngquist

Genotype: *Boreoceras washburni* Miller and Youngquist

Boreoceras Miller and Youngquist, 1947, Jour. Paleont., vol. 21, p. 10.

Boreoceras was erected to include three species of nautiloids found in what was regarded as a single association in Ordovician beds of Read and Sutton islands, Northwest Territory, of the Arctic archipelago. As originally defined, the genus was regarded as containing curved shells, varying from those which were compressed in section and had sutures with well-defined lateral lobes, as did the genotype, to those circular in section with transverse sutures. The siphuncles are on the concave side of the shells and were regarded originally as dorsal in position.

Restudy of the type material was required and was graciously permitted by Dr. Dunbar and the Yale Peabody Museum, for three of the species, *B. washburni*, *B. brevicameratum*, and *B. parvulum*, had the aspect of members of the Ellesmeroceratidae. On the other hand, no known member of that family agreed with *B. cloudi* in the subcircular cross section and the absence of well-defined lateral lobes of the sutures. However, specimens of the endoceroid genus *Clitendoceras* approach that species very closely in gross proportions of the shell. Further, specimens of *Clitendoceras*, which, like *B. cloudi*, are represented by living chambers and a small attached part of the anterior part of the phragmocone, will fail to show endocones the secretion of which is always delayed appreciably beyond deposition of the septa and siphuncle of the phragmocone.

The present investigation of the type material leads to the conclusion that typical *Boreoceras* is a true member of the Ellesmeroceratidae. In form, it is somewhat variable but is probably close to *Clarkeoceras*, from which it differs primarily in the failure of the sutures to be strongly inclined forward from venter to dorsum and in developing prominent, curved, rather deep lateral lobes of the sutures. The sections of the phragmocone show that the siphuncle, which is very narrowly separated from the venter, has short necks and thick rings, in short, is of typical ellesmeroceroid aspect. Further, the cavity of the siphuncle has exhibited diaphragms, structures particularly characteristic of the Ellesmeroceratidae, though present in a few other families of the Ellesmeroceratida also. It is, of course, necessary to conclude that the genus is endogastric, the concave side being ventral.

Examination of the material at the specific level proved rather vexing, because within each of the previously described species there proved to be variation in proportions comparable to those which are generally accepted as differences of specific rank in the cephalopods. In figuring and redescribing this material, these differences are pointed out, but a new species is described here only for one of them.

The specimens may be summarized as follows:

1. Typical *B. washburni*. A medium-sized shell, slightly curved, moderately rapidly expanding, attaining a mature living chamber in which both venter and dorsum are slightly convex, and the mature aperture is therefore contracted slightly.

2. A paratype shows very different proportions. It is more gently expanding, attains a considerably greater shell height at the base of the living chamber, and shows no tendency for the ventral outline to become slightly convex. In late growth stages, the cross section becomes narrowly rounded ventrally. Probably with more material, this form should be set apart from typical *B. washburni*. Other specimens attributed to the species are fragments which it is impossible to assign with certainty to these two groups of probably specific rank.

3. Typical *B. brevicameratum* is known from a rather small shell, the sides strongly flattened, the whole gently expanding to the aperture, strongly compressed, sutures close, forming deep lateral lobes and sloping forward markedly on the dorsum. Among the types there is another form, somewhat broader in cross section, with the sides more convex, the sutures forming deep, rounded lateral lobes but not sloping forward markedly on the dorsum.

4. *B. ovale*, based upon two specimens formerly included in *B. brevicameratum*, differs in that the shell is a much larger one, the cross section is compressed, the greatest width of the shell well ventrad of the center and nearly opposite the dorsal margin of the siphuncle. The venter is broadly rounded, the dorsum much more narrowly rounded. The remaining species, *B. cloudi*, is known from only portions of living chambers and adoral parts of phragmocones insufficient to establish the position of the species. The known features are, however, so close to those shown by comparable portions of *Clitendoceras*, that tentative assignment to that genus is more suitable than any other assignment that can be attempted. The implications of this assignment are (1) that earlier portions of the siphuncle should show endocones and (2) that the species is younger than the "associated" *Boreoceras*, for *Clitendoceras*, and indeed Endoceratida as a whole, is unknown in the Lower Canadian where the Ellesmeroceratidae are dominant. Some support for this possibility is found in lithic differences separating the material of *B. cloudi* from typical *Boreoceras*. Though the assignment to *Clitendoceras* is necessarily inferential, the alternative solution would be that this species is an ellesmeroceroid, but necessarily a new genus, characterized by gentle curvature and a broad cross section with attendant suppression of the lateral lobes of the sutures. Such a development is not impossible; one finds parallels to it in the orthoconic *Pachendoceras* and *Robsonoceras*, as well as in *Paradakeoceras*, but certainly the present evidence does not warrant the erection of a new genus; therefore, tentative assignment to *Clitendoceras* is the course followed here. The species is described in the systematic appendix and illustrated on Plate 17, Figures 4-6, 8, 9, 14.

Boreoceras washburni Miller and Youngquist

Pl. 16, fig. 5; pl. 17, fig. 1-3, 7(?), 10-13(?)

The holotype (pl. 17, fig. 1-3, pl. 16, fig. 5) is a moderately curved, rather rapidly expanding shell. The phragmocone, 42 mm long ventrally and 45 mm long dorsally, increases from a height of 10 mm and an estimated width of 8 mm at the base to a height of 29 mm and an estimated width of

26 mm (this may be rather greater than original which may be as little as 22 mm), while the living chamber, 36 mm long dorsally and incomplete ventrally, is too incomplete to permit one to say whether the shell is actually slightly contracted at the aperture, as the convex dorsal profile suggests, or whether the shell aperture remains expanding to the aperture. If so, the venter there is definitely concave, and a goodly portion of the venter is missing from the living chamber. However, there appears to be a slight convexity of ventral profile on the lower part of the living chamber which suggests a contracted aperture.

The septum near the base of the living chamber shows only a shallow lateral lobe, but in the median plane the septum is quite deep, 10 mm where the height is 34 mm, the shell height being about 3.5 times the depth of the septum. The siphuncle is exposed on the ventral side. It is compressed in section at its passage through the septum, 10 mm high on the curving septal surface and 8 mm wide. A cross section normal to the shell would, of course, show a much less strongly compressed section, which is partly the function of the strong forward slope of the septum. The siphuncle is separated from the venter by 2 mm in the cross section, which measures 4 mm on the septal surface.

A nearly vertical section (pl. 16, fig. 5) was taken through the phragmocone, the section being so made as to pass to one side of the dorsum in order that the nature of curvature of the dorsal region might not be lost. The section, 41 mm long dorsally, exposes all the siphuncle for a length of 27 mm, in which it increases from 1.4 mm apically to 5.8 mm adorally in height. It is separated from the venter by 0.6 mm in which septa can be seen, and adorally this distance is increased to 1.4 mm. The siphuncle wall is made up of short, gently recurved septal necks which, as usual, have their tips barely touching the connecting rings. The rings are quite thick apically, thinner adorally. No clear indication of structures in the rings is preserved adorally. The anterior part of the siphuncle is filled with matrix, but the matrix is abruptly terminated by a diaphragm, curved, sloping farther orad dorsally than ventrally. The apical 6 mm of the siphuncle contains calcite, within which can be detected traces of at least one other similar diaphragm. The dorsal wall of the siphuncle here shows traces of layering of the connecting ring.

At the extreme anterior end of the specimen where the siphuncle is incomplete ventrally, two narrow dark lines can be seen curving forward from the dorsum to the venter. They resemble diaphragms but are believed to be adventitious, first, because diaphragms are not to be expected so close to the living chamber, and second, because their curvature differs from that of the earlier undoubted diaphragms.

The figured paratype of *B. washburni* (pl. 17, fig. 10-13) is a larger shell, one evidently considerably more gently expanding than the type, and continuing to expand beyond a point commensurate with the mature living chamber of the holotype which seems to contract slightly in the vertical plane. Only the exasperation encountered in making so many species from such a small collection causes me to refrain from giving it a different specific name.

The specimen is 92 mm long. The basal 12 mm is fragmentary, but beyond it the shell expands from 22 mm high and a width estimated at 19 to 20 mm to a height of 32 mm and an estimated width of 24 mm. This increase occurs in a length 20 mm ventrally and 30 mm dorsally. Later stages are apparently less rapidly expanding, for at the adoral end the shell is 30 mm wide and has a height of between 36 and 40 mm, in a length 40 mm ventrally and 50 mm on the very incomplete dorsal side. Adorally, the cross section is narrowly rounded ventrally, a condition not developed at midlength or in the early stages.

The septa show lateral lobes and slope forward more dorsally than ventrally. Apparently, the forward slope on the dorsum is accentuated in later growth stages.

The basal part of the specimen was sectioned vertically, the resulting section showing the siphuncle in vertical section. Here can be seen typical ellesmeroceroid structure of the siphuncle wall, with short, gradually curved necks which, though bent gently apicad, have only their very tips incorporated in the siphuncle wall which is essentially composed of the thick connecting rings that form slightly concave segments. The section is slightly off center and shows more than the minimum space between the siphuncle and the venter. The anterior part of the siphuncle is filled with matrix; the apical end was hollow, the materials originally present there being dissolved. The section shows a curved boundary to the solid part of the siphuncle, and this has a definite boundary of organic material. It is a diaphragm and one quite similar to that of *Barnesoceras percurvatum*, though sloping forward ventrally much more than is usual in the Ellesmeroceratidae.

The incomplete paratype figured on Plate 17, Figure 7, seems more properly placed in a new species but is too incomplete to serve as a type. It shows a stronger curvature of the dorsal profile and strong lateral curvature of the septa.

Types. Yale Peabody Museum, holotype and one paratype, No. 17312A; paratype, here regarded as probably distinct, No. 17312B. From the Canadian of Read and Sutton islands.

Boreoceras brevicameratum Miller and Youngquist

Pl. 16, fig. 9-15

Boreoceras brevicameratum Miller and Youngquist, 1947, Jour. Paleont., vol. 21, p. 11, pl. 6, fig. 1-2.

The several specimens by which this species is represented show considerable variation in cross section, rate of expansion, and some also in the degree to which the septa are inclined forward on the dorsum. The holotype (pl. 16, fig. 9-11), adequately figured and described by Miller and Youngquist, consists of an essentially complete living chamber, with parts of ten rather faintly outlined camerae attached. At the base of the specimen, the cross section is oval, dorsum and venter strongly and essentially equally rounded, 20 mm wide and 28 mm high. The siphuncle 1 mm from the venter is 6 mm high and estimated at 5 mm wide, clearly compressed in cross section but with one side incomplete. The camerae are shallow, four occurring in a length of 5 mm dorsally. Sutures form round, broadly curved lateral lobes, ascending to a low ventral and a higher dorsal saddle. The shell is gradually expanded to the aperture, which is 40 mm high with an estimated width of 25 mm. This specimen, designated as the holotype, is unique among the several specimens assigned to the species in the strongly compressed cross section, even rounding of dorsum and venter and the rather strong adoral slope of the septa on the dorsum.

A second specimen, No. 17312A, Plate 16, Figures 12-15, is a somewhat larger living chamber with four attached camerae.

At the base, the cross section has the dorsum and venter equally rounded and the greatest width occurs midway between dorsum and venter. However, the midlateral part of the cross section is more curved than in the holotype, and the dorsum and venter are more narrowly rounded. The siphuncle is rather large, 3 mm from the venter, 7 mm high, and estimated at 6 mm wide, considerably larger in proportion to the shell than that of the holotype and markedly more removed from the venter. In a length of 36 mm, the shell increases to an estimated height of 42 mm and a width of 30 mm. Four camerae attached to the living chamber occupy a dorsal length of 6 mm. Sutures form lateral lobes which rise to essentially equally high saddles on venter and dorsum, a feature markedly at variance with that of the holotype.

Discussion. Even with the removal of two specimens showing a cross section markedly narrower on the dorsum and with the greatest shell height attained ventrad of the shell center, *B. brevicameratum* remains a rather variable species, showing some variation in cross section, rate of expansion, and the degree of slope of the sutures forward on the dorsum.

Types. Yale Peabody Museum, holotype, No. 17313; paratypes, Nos. 17312 (3 specimens), 17311B (1 specimen).

Occurrence. Ordovician, Read and Sutton islands. The holotype is from Fossil Point, Read Island.

Boreoceras ovale Flower, n. sp.

Pl. 16, fig. 1-4, 6-8

Boreoceras brevicameratum Miller and Youngquist, 1947 (pars), Jour. Paleont., vol. 21, p. 11 (not pl. 6, fig. 1-2).

This is a large *Boreoceras*, curved and rapidly expanding initially, later showing such reduction in the rate of expansion as to have an almost tubular and nearly straight living chamber. Its cross section is distinctive in that the dorsum is narrowly rounded, the venter more broadly rounded, and the greatest width of the shell is attained one third the distance from the venter to the dorsum, rather than at midheight of the shell.

The holotype (pl. 16, fig. 6-8) is a specimen extending from close to the true apex to the aperture of a living chamber which is mature or nearly so, 95 mm in length, and attaining an adoral shell height of 45 mm. The adoral portion, 35 mm long, increases in height from 40 to 45 mm. The shell width and cross section are not shown adorally, but at the base of this region, the shell width of 27 mm is attained in the ventral third of the shell. This part of the specimen represents the entire length of the living chamber ventrally, as is shown by the attached siphuncle, but elsewhere the basal part of the living chamber is lost. There follows an interval of 25 mm in which there can be seen only the siphuncle and the external mold of the far lateral surface of the shell. In this interval the siphuncle is slender, increasing in height from 6 to 8 mm. The apical portion 28 mm long contains 20 camerae. The adoral ones average 1 mm in length, and their sutures slope strongly forward from venter to dorsum describing shallow curved lateral lobes. The earlier septa show a similar curvature but are oblique, sloping apicad from the siphuncle to the dorsum. The dorsal shell wall is missing here, but evidently the dorsum was strongly convex and diverged from the venter very rapidly at first, as in *Levisoceras*. A vertical section was made of this part of the shell. It shows the siphuncle to be conically expanding here, with a small fragment at the base 1.8 mm high, 1.8 mm long, an adoral missing portion, then a preserved portion bounded apically by a curved surface, clearly a diaphragm. The whole increases in a length of 17 mm to a height of 7 mm, beyond which, as already noted, the siphuncle becomes very gently expanding. The septa on the dorsal side of the siphuncle are bent into necks only the tips of which are incorporated in the siphuncle wall, which is here essentially tubular. It is presumably composed of thick connecting rings, but the conditions of replacement make it impossible to detect the individual segmental elements or any structures within them.

A second specimen (pl. 16, fig. 1-4) consists of the basal part only of a living chamber. At its base it is 38 mm high and attains a width of 25 mm in the ventral third of the cross section, being narrow dorsally, more broadly rounded ventrally. The siphuncle is 8 mm high and 6 mm wide and 2 mm from the venter. The septum slopes forward strongly on the dorsum. One attached camera is 2 mm in length. The living chamber is incomplete adorally; its wall extends for 20 mm ventrally and 21 mm dorsally. The internal mold shows low, rather distant, longitudinal markings, clear on the ventral side, fading out dorsally and completely wanting on the dorsal half of the specimen.

Discussion. This *Boreoceras* is distinguished, as already noted, by the narrowly rounded dorsum, broadly rounded venter, attainment of the greatest width well ventrad of the center of the cross section. The holotype attains a slightly greater size than does the paratype, the two having living chambers which are 40 mm and 38 mm high at the base, respectively. The living chambers are scarcely expanding adorally, a feature at variance with typical *B. brevicameratum*.

Beside the two types, one of the two specimens, No. 17311B, appears to be a living chamber of this form.

Types. Holotype and paratype, No. 17310 and No. 17312, Yale Peabody Museum.

Occurrence. From the Canadian, Fossil Point, Read Island (holotype) and Sutton Island (paratype).

Genus WOOSTEROCERAS Ulrich, Foerste, Miller, and Unklesbay

Genotype: *W. trempealeauense* UFM&U, 1944

Woosteroceras Ulrich, Foerste, Miller, and Unklesbay, 1944, Geol. Soc. Amer., Special Papers, no. 58, p. 30.

Woosteroceras includes very slender endogastric Ellesmeroceratidae, circular in section, surface smooth, aperture with a slight hyponomic sinus, sutures straight and transverse, siphuncle ventral, with diaphragms delayed greatly or suppressed. Shells are rather strongly curved, and a lost specimen suggests that the mature shells were probably endogastric gyrocones rather than cyrtocones, though very loosely coiled. Previous species known consist only of *W. trempealeauense*, from the Oneota and not the Trempealeau of Wisconsin, and *W. cherokeense* from the Tanyard formation of Texas, evidently from the upper Standebach member, as the type is a fragment preserved in chert. Unklesbay and Young (1956) described a fragmentary specimen from the Chepultapec of Virginia as *W. chepultapecense*. The forms described below are the most complete specimens known, the first ones found in limestones, and the first preserving any real indication of the siphuncle wall structure.

The genus is known only from the Gasconadian of North

America and is one of the several Gasconadian forms which are specialized in the circular instead of compressed section and suppression of lateral lobes of the sutures.

Woosteroceras flexiseptatum Flower, n. sp.

Pl. 13, fig. 9, 10, 14

This is a very slender *Woosteroceras*, the anterior part gently curved, characterized by sutures which, at maturity, are bent sharply forward, departing from the general curvature, close to the dorsum and venter, and probably at the sides as well. The specimens known are all natural sections. The holotype, No. 208, Plate 13, Figure 10, is a specimen 56 mm long, with a radius of curvature for the dorsum of 40 to 50 mm, expanding in height from 9 mm at the base to 13 mm at the base of the living chamber, a curving dorsal length of 45 mm, and 13 mm high at the aperture, at the end of a living chamber 15 mm dorsally and 14 mm ventrally. The section at the very base suggests a very slightly compressed rather than a circular condition; in its present form it is 9 mm high and 7 mm wide, with one side incomplete from weathering. In the basal part two camerae occupy a length of 2 mm; elsewhere calcite obscures all but the last septum at the base of the living chamber, which is bent strongly forward close to the dorsum and also, though less strongly, close to the venter. The siphuncle, partially exposed, is essentially tubular and empty.

Two paratypes, Nos. 209 and 210, are believed to be two parts of a single specimen; they fit, although imperfectly, which may be due to the cleaning by gentle etching. The two parts are illustrated together, showing the weathered lateral surfaces, in Figure 9; the apical part alone, here ground down to the level of the siphuncle, is shown in Figure 14. Together the two specimens describe an arc of about 120 degrees, with a radius of curvature increasing from 30 mm basally to nearly 50 mm adorally. The basal part increases in height from 7 to 9 mm in a dorsal length of 20 mm, 22 mm on the curving surface, and basally several camerae are seen averaging 0.4 mm in length. The siphuncle, 1.0 mm wide basally enlarging to 1.6 mm, rather rapid enlargement being shown in the initial part, is without diaphragms. The adoral part shows a calcite-filled phragmocone, with the siphuncle partly exposed, a living chamber 11 mm long ventrally, 15 mm dorsally, 11 mm high at the base, 14 mm high adorally. The adoral septum shows the same strong slope forward close to the venter and dorsum as does the holotype.

Discussion. This is a gently expanding species characterized particularly by the unusually strong forward slope of the septum as it approaches both the dorsum and the venter. This form is not so broad as *Woosteroceras cherokeense*, though the fragment on which that species is based does not permit very close comparison. *W. spirale* and *W. percurvatum* are both more strongly curved species, lacking evidence of similar marginal forward bending of the septa.

Types. Holotype and two paratypes, possibly parts of a single specimen, collection of the writer; Nos. 208-210.

Occurrence. From about 272 feet above the base of the Threadgill limestone member of the Tanyard formation, Threadgill Creek, Gillespie County, Texas.

Woosteroceras percurvatum Flower, n. sp.

Pl. 13, fig. 12-13

This species, of which we have only the type, is characterized by the combination of a slender, essentially tubular shell with exceptionally strong curvature and adoral septa not produced markedly at the margins dorsally or ventrally and a siphuncle very slightly removed from the venter. The type preserves parts of a quarter volution, with a dorsal radius of curvature of 10 to 20 mm, increasing adorally. Parts of 15 camerae are preserved, averaging 1 mm in length, the basal camerae are incomplete dorsally. The shell height increases from 10 to 10.5 mm in the measurable part of the phragmocone, 10 mm ventrally, 14 mm dorsally. The living chamber is broken dorsally, only 4 mm of the shell being preserved there, but it is 13 mm ventrally, and the estimated height at the aperture is 11 mm. At the adoral end of the phragmocone the siphuncle 1.8 mm high is 0.6 mm from the venter, with camerae plainly visible between it and the ventral wall. The septum is highly oblique, so this condition is real and not from an eccentric section.

Discussion. The strong curvature and gentle almost tubular expansion characterize this species. Septa are rather deep but are not steepened marginally, and the slight removal of the siphuncle from the venter supplies an additional distinctive feature. Probably when complete this shell was gyroconic.

Type and occurrence. The holotype, No. 206, is from about 272 feet above the base of the Threadgill member of the Tanyard formation, from Threadgill Creek, Gillespie County, Texas.

Woosteroceras spirale Flower, n. sp.

Pl. 13, fig. 7-8; pl. 15, fig. 7

This is a strongly curved, gently expanding *Woosteroceras*. The holotype is a fragment retaining most of a living chamber and a portion of a phragmocone, together comprising nearly a quarter of a volution and showing a radius of curvature of 20 to 30 mm, the radius increasing adorally. At the base the section is circular, the dorsum well rounded, 9 mm across; this increases to 12 mm at the base of the living chamber, in a curving dorsal length of 17 mm, where the dorsum has become slightly more narrowly rounded, a condition which continues on the living chamber. The adoral suture slopes faintly forward from venter to dorsum. The living chamber has a dorsal length of 17 mm but is possibly incomplete, as the ventral shell continues considerably farther forward; it extends for a curving length of 17 mm, and the aperture, which is obscure at its margin, seems to slope apicad from venter to dorsum, an unusual but not impossible condition of an ellesmeroceroid shell. Calcite fills the camerae, and the siphuncle is not apparent.

A second specimen, shown on Plate 15, Figure 7, is regarded as an immature specimen of the same species. It is seen in a natural, nearly vertical section showing a living chamber with an arc of about 90 degrees enlarging apparently from 4 to 7 mm, though the rapid apical expansion is possibly false, due to weathering of the apical part below the middle. A living chamber of 9 mm shows reduced curvature and a gentle rate of expansion. This is logically the apical part of a *Woosteroceras*, which seems to agree with *W. spirale* rather than the more nearly tubular *W. percurvatum*; the reconstruction of the species from the two specimens together shows a shell completing three fourths of a volution and quite probably slightly more than a single volution.

Types and occurrence. Collection of the writer; holotype, No. 206, paratype, No. 244; from about 272 feet above the base of the Threadgill member of the Tanyard formation, Threadgill Creek, Gillespie County, Texas.

Genus KERAIACERAS Flower, n. gen.

Genotype: *Keraiaceras unklesbayi* Flower, n. sp.

Text Figure 24

Unklesbay identified as *Burenoceras undosum* a relatively complete shell, but with the venter lost, showing moderate endogastric curvature, peculiar in prominent annuli, a section which expands rapidly, becoming as broad as or broader than high, and with an aperture with appreciable lateral contraction. The little known *Burenoceras undosum* shows closer and fainter costae and is apparently a much smaller species with a flaring aperture. Some of the confusion surrounding *Burenoceras* is removed by separating this distinctive form which Unklesbay figured as a distinct genus and species.

With it is probably allied a less adequately known form from the Smith Basin limestone, described below.

Without knowledge of internal structure, assignment of the genus to the Ellesmeroceratidae is an assumption; however, no other relationship seems likely in view of the Gasconade age of the genus.

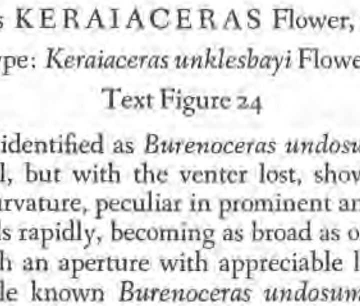

Figure 24

Keraiaceras unklesbayi Flower

Outline drawing after Unklesbay, 1956, × 1½. A. Lateral view, venter in matrix at the left. B. Dorsal view.

Keraiaceras unklesbayi Flower, n. sp.

Text Figure 24

Burenoceras undosum Unklesbay, 1954, Jour. Paleont., vol. 28, p. 640, pl. 69, fig. 1-2.

Unklesbay has provided a good description and figure of this species. The need for separating it from *B. undosum* and indeed from the genus *Burenoceras* has been noted in the preceding generic discussion.

The unique type, University of Missouri, No. 11736, is from the Standebach member of the Tanyard formation, San Saba County, central Texas.

Keraiaceras (?) percostatum Flower, n. sp.

Pl. 8, fig. 12

This form is represented only by a portion of the dorsum of a phragmocone about 20 mm long, incomplete basally as well as adorally. The shell expands laterally from 7 to 10 mm in a length of 12 mm and extends at a uniform rate 8 mm farther orad, the lateral rate of expansion being about 22 mm. The venter is wanting, but the anterior end of the specimen shows the dorsum to be broadly rounded, so that the entire shell had a cross section which was either subcircular, with the curvature extended onto the venter, or else had the venter slightly flattened, in which case the width of the whorl would be greater than its height. The dorsum is convex in profile, and the shell was evidently a gently curved cyrtocone. The camerae are rather irregular in depth, but the anterior 11 occupy a length of 12 mm. Sutures describe broad saddles on the dorsum and evidently sloped forward appreciably from venter to dorsum. The internal mold bears broad, low annuli with shallow concave spaces between, spaced 5 mm from crest to crest. There appear fainter, poorly defined, lower and narrower annuli in the concave interspaces.

Discussion. Though this species is yet known only from incomplete material, it is quite clearly a straighter and more slender edition of what Unklesbay described from the Tanyard of Texas as *Burenoceras undosum,* here renamed *Keraiaceras unklesbayi.*

Holotype. Collection of the writer; No. 202. From the Smith Basin limestone, from the section just east of Smith Basin, New York.

GENERA WITH APERTURES WITH LATERAL CRESTS

Here are grouped three genera characterized by lateral crests. It is difficult to say which is the more primitive, as each seems to have its own specialization. They may be summarized as follows:

Barnesoceras. Simple cyrtocones, with rapid vertical expansion, crests ventrolateral rather than internal in the adult, but with aperture uncontracted.

Buehleroceras. These shells are rapidly expanding in the young and curvature is relatively slight; the mature living chamber straightens, the aperture is contracted, and in its most perfect form is keyhole-shaped. Some, but not all, species show a cross section with lateral concave zones, but such a development is confined to the anterior extremity of the mature living chamber and is never developed over any considerable length of the shell, as is always the case in *Oneotoceras.*

Oneotoceras. Here are cyrtocones with a gentle instead of a rapid rate of expansion. Development of lateral crests is confined to late growth stages, but except in very early stages the midlateral region of the shell develops prominent grooves, so that the cross section there is markedly concave.

Genus BARNESOCERAS Flower, n. gen.

Genotype: *Barnesoceras clavatum* Flower, n. sp.

This genus is erected for moderately large ellesmeroceroids which expand at first much more rapidly vertically than horizontally, so that they become very strongly compressed. Mature living chambers show an uncontracted aperture, though lateral profiles are nearly straight and the rate of vertical expansion is somewhat reduced there. Growth lines show a broad crest swinging forward from the ventral hyponomic sinus, highest ventrolaterally, and swinging apicad more gently on the dorsal side, becoming sinuate in outline as the dorsum is approached. The surface shows prominent growth lines, which are actually close, fine ridges projecting above the general part of the shell surface. Sutures show only moderate curvature of lobes on the lateral surfaces and may be nearly straight. The siphuncle is ventral, compressed adorally in section, though not so much as the shell, and diaphragms have been observed, though developed only apically.

Discussion. This genus differs from *Buehleroceras,* which it resembles somewhat in the lateral crests, by the failure of the aperture to contract. *Oneotoceras* is probably related also, but shells of that genus show a much more gentle rate of vertical expansion, are more slender, and typically develop long grooves on the lateral surfaces which extend over most of the shell; in *Buehleroceras,* comparable grooves are confined to the adoral pinching of the shell near the aperture and are not apparent as long linear grooves. Neither of these genera is known to possess short, close ridges extending above the main part of the shell.

Clarkeoceras, which is somewhat similar in general shape, has no known lateral crests, and the sutures commonly slope dorsorad and are straight or nearly so laterally.

The species so far assigned to *Barnesoceras* are all from the Threadgill limestone of the Tanyard formation of Texas.

Barnesoceras clavatum Flower, n. sp.

Pl. 9, fig. 1-6

This is fine, large, curved shell in which the aperture is open. The holotype is a shell 105 mm long, incomplete basally but retaining most of the aperture. It increases from 21 to 60 mm in height, width increases from 6 to 22 mm in the basal 35 mm, beyond which the sides are apparently parallel as far as can be told; the remaining side is slightly crushed adorally. The venter is concave over the phragmocone with a radius of curvature of 40 mm, becomes faintly convex beyond the base of the living chamber, then concave to the aperture, though almost straight. The dorsum has a radius of curvature of 100 mm basally, becomes humped and more convex beyond the base of the living chamber, and remains faintly convex to the aperture. Vertical expansion of the shell is rapid throughout its length. One side of the type was incomplete, due to weathering, and this surface has been ground down to the level of the siphuncle. There are 18 camerae, averaging 2.5 to 3 mm in length, but their length is rather irregular; one attains a depth of 4 mm. Near the midlength of the phragmocone where the shell height is 31 mm, the width is estimated at 22 mm. Here the siphuncle is 8 mm high and essentially in contact with the venter. The figured section shows the siphuncle to be somewhat smaller and well separated from the venter adorally, but this appearance is deceptive and the section is slightly off center here. Sutures are nearly straight and transverse, with only very faintly developed lateral lobes. The siphuncle wall is composed of aneuchoanitic necks supplemented by the usual thick connecting rings. No diaphragms are evident in the type. The living chamber has a basal height of 44 mm, with the septum remarkably deep, attaining a curvature of 10 mm. The aperture is not quite complete ventrally, but as restored, a height of 60 mm is attained, the length of the living chamber being 40 mm ventrally and dorsally, attaining a maximum ventrolateral length of 47 mm. The growth lines are extremely prominent, rugose, and apparently took the form of short, very close frills, rather like those of *Zitteloceras.* They outline a ventral hyponomic sinus with high, rounded ventrolateral crests and slope apicad, becoming straight and oblique from these crests to the dorsum. The type shows the living chamber to be slightly crushed laterally, but there is no indication of the sinuate lateral profile of the shell found in some species of *Buehleroceras.* (See pl. 9, fig. 1-3.)

A paratype (pl. 9, fig. 3-6) is a slightly younger and smaller individual, attaining a shell height of 52 mm and a maximum width estimated at 25 mm. Basally, parts of seven camerae are exposed averaging 2.8 mm deep. A natural break in the specimen (pl. 9, fig. 4) shows a shell 32 mm high, 24 mm wide, with a siphuncle 6 mm high and 4 mm wide, very narrowly separated from the venter by less than 1 mm. Necks are short, rings thick, as usual, and no diaphragms are seen. The dorsal profile is convex, more uniform in curvature than that of the type; the venter, however, shows a much stronger convexity of profile just beyond the base of the living chamber. The lateral profiles, incomplete due to weathering, indicate that the shell expands very gently to a point at or near the aperture. There the median condition is unknown, but ventrolaterally, the shell narrows quite strongly. Transverse, rugose, vestigial frills occupy the shell surface and rise from the venter to form rounded ventrolateral crests, and then slope obliquely apicad from there to the dorsum. As in the type, sutures are nearly transverse with only faint lateral lobes, but the septum is strongly curved internally. The living chamber expands from 35 to 52 mm, is 40 mm long ventrally and about the same length dorsally, where the aperture is obscure.

Discussion. This species is distinctive in the genus for the fairly rapid expansion and curvature of the early part of the shell and the straightening of the living chamber, which continues to expand fairly rapidly to a point close to the aperture. There, the sinuous growth lines and a tendency for the shell to be even more compressed laterally than before gives this species an aspect very close to that of some species of *Buehleroceras,* indicating the relationship which obviously exists between these genera. *Barnesoceras percurvatum* is similar in the ventral conformation of the living chamber, but the species is a much more strongly curved one; *B. lamellosum* has a living chamber which attains its greatest shell height near its base, not near the aperture, and the ventral profile is less sinuous; indeed, essentially straight. *B. lenticurvatum, B. expansum,* and *B. conosiphonatum* are species not known to have the curvature or rate of expansion of the shell strongly modified on the mature living chambers.

Type. Holotype and paratype, collection of the writer; Nos. 248, 249.

Occurrence. From 272 to 276 feet above the base of the Threadgill member of the Tanyard formation, from Threadgill Creek, Gillespie County, Texas.

Barnesoceras expansum Flower, n. sp.

Pl. 9, fig. 7-8; pl. 12, fig. 3, 4, 8, 9; pl. 13, fig. 15-17

This is a fairly strongly curved shell, in which the dorsum remains convex, the venter concave to the aperture, the siphuncle, slender in the initial portion, expands in the anterior part of the shell uniformly over a considerable distance to the base of the living chamber and is, in that region, more rapidly expanding vertically than is the exterior of the shell.

The holotype, Plate 12, Figure 9, showing the latest growth stage known for the species, is a shell 80 mm long. One side, that figured, is exposed in a section, the anterior part a naturally weathered section, the apical part ground to show the maximum size of the siphuncle. Apically, the dorsum is gently curved, the radius about 80 mm, but adorally, curvature is increased. This is in part due to the nature of the section, which passes laterad adorally, so that the greatest shell height is not shown in the natural section at the anterior end of the specimen. The ventral curvature is more uniform, about 60 mm in radius. The siphuncle, 22 mm of which is clearly shown, increases in height in that length from 7 to 12 mm. The phragmocone here has a length of 47 mm dorsally and 30 mm ventrally, increasing in height from 32 to 42 mm. A break near the anterior end of the phragmocone shows the section compressed, dorsum and venter subequally rounded, neither very narrowly rounded, the shell 39 mm high, 24 mm wide, and the siphuncle 12 mm high, 10 mm wide, with dorsum and venter subequally rounded. The camerae, subequal and averaging 2 mm in depth, slope forward strongly from the siphuncle to the dorsum; in vertical section, the forward slope of the camerae around the siphuncle is not evident, and indeed, in such a section there is some difficulty in recognizing the anterior end of the phragmocone on the venter. The exterior is poorly preserved, but shows, as is usual in the genus, and the sutures are relatively transverse and develop only faint lateral lobes, and the septa are appreciably curved in a horizontal plane. The living chamber is 35 mm long dorsally, 41 mm ventrally, and 43 mm across the aperture which slopes apicad from venter to dorsum. As usual, on the living chamber the shell wall is thicker ventrally than dorsally. The extreme thickness shown in the natural section is exaggerated because the section is ventrolateral and passes through the shell wall obliquely.

A paratype (pl. 12, fig. 3, 4) consists of an apical portion sectioned vertically, while the anterior part is a natural section showing a deceptive decrease in expansion because the surface of the section passes down past the center of the shell. This specimen, 65 mm in length, is quite uniform with the holotype in curvature and rate of expansion. The phragmocone, 20 mm ventrally and 30 mm dorsally, increases in height from 31 to 36 mm, and the siphuncle, 5 mm high and 1 mm from the venter apically, increases gradually to 9 mm in height, remaining 1 mm from the venter. The distance of the siphuncle from the venter is due to slight eccentricity of the sectioned surface. Three anterior camerae occur in 5 mm, on the dorsal side of the siphuncle. Their free septa are largely destroyed. The living chamber, 28 mm ventrally and 25 mm dorsally, is incomplete.

A second paratype (pl. 12, fig. 9), 60 mm long, is a portion of a phragmocone and an incomplete living chamber. The phragmocone increases in height from 29 mm to 41 mm in a length of 45 mm dorsally and 28 mm ventrally. The siphuncle is exposed, but the section is not quite central; hence, there are camerae visible between the siphuncle and the venter. The siphuncle appears 5 mm high and 2 mm from the venter apically, and 10 mm high and 2 mm from the venter adorally. Most of the camerae are filled with calcite, but apically, there are three camerae in 5 mm on the dorsal side of the siphuncle, and the final camera is distinct. Septal necks are short, supplemented by thick rings.

A third paratype (pl. 9, fig. 7, 8) represents an earlier growth stage. This shell, 88 mm long, shows a phragmocone increasing from 12 mm in height to 32 mm, describing about a quarter of a volution, and an incomplete living chamber 45 mm long. At the base of the specimen, a length of 5 mm of the siphuncle 2 mm and 3 mm across, shows three diaphragms. Orad of this region, calcite obscures the siphuncle, and anterior to this region, the siphuncle is seen increasing from 4 to 6 mm in height. At the anterior end of the sectioned portion, the section of the shell is elliptical, dorsum and venter equally rounded, 24 mm high and 17 mm wide.

Plate 13, Figures 15-17, shows a fragmentary paratype attaining an adoral height of 40 mm. In Figure 15, a section is ground which does not attain the maximum height of the siphuncle but shows clear septa with connecting rings lighter and indistinctly outlined and separated from the matrix. As seen more fully in the enlargement in Figure 16, the rings extend as shadowy diaphragms across the cavity of the siphuncle. Further grinding resulted in the section through the siphuncle shown in Figure 17; here, clearly, no diaphragms cross the siphuncle cavity and those apparent in Figure 16 are possibly tangential sections through the rather thick rings, rather than true diaphragms.

A still smaller specimen (pl. 12, fig. 8) is regarded as an immature representative of this species, agreeing as it does with a projection from the apex of the preceding specimen in rate of expansion and curvature. This shell, 38 mm long, is strongly curved, increasing in shell height from 5 mm to 22 mm. Only the anterior 10 mm of the siphuncle can be seen clearly; it increases here from 1.0 to 2.2 mm in height. Its apical end seems to be bounded by a diaphragm; farther apicad, the siphuncle appears to be filled with calcite indistinguishable from that occupying the camerae.

It is interesting to note that without the other larger specimens, this specimen would ordinarily be assigned to the genus *Levisoceras* without any question as to its generic affinities being raised.

Discussion. This species is moderately expanding, gently curved, but, by restoration from the various specimens showing different growth stages, probably a gyrocone rather than a cyrtocone when complete. It seemed at first that the species was unlikely to be a gyroconic one and that the smaller forms placed here might represent another species. However, there is such uniformity in proportions that the series of specimens actually show overlapping growth stages, with similar proportions in commensurate parts. It is of interest, however, to note that the smaller specimen would, by itself, probably have been placed in *Levisoceras*, while larger forms might, without some knowledge of the growth lines and aperture, have been considered one of the more strongly curved species of *Clarkeoceras*.

Types. Holotype and five paratypes, collection of the writer; Nos. 253-258.

Occurrence. From 272 to 276 feet above the base of the Threadgill member, Tanyard formation, from Threadgill Creek, Gillespie County, Texas.

Barnesoceras conosiphonatum Flower, n. sp.

Pl. 12, fig. 11-12

This is a *Barnesoceras* which is moderately and uniformly curved throughout, characterized by a siphuncle which is very rapidly expanding in a moderately early growth stage and essentially tubular in the anterior part of the phragmocone.

The type is a shell 70 mm long, retaining a living chamber of 40 mm and a phragmocone of 30 mm. The basal portion of the phragmocone is exposed in vertical section, showing an increase in shell height from an estimated 32 to 40 mm in a ventral length of 22 mm and a dorsal length of 40 mm. The siphuncle here exposed increases in height from 4 to 9 mm in the apical 10 mm and is thereafter essentially tubular.

Six basal segments of the siphuncle are outlined clearly on the dorsal side of the siphuncle; anterior camerae are calcite-filled, and neither the septa nor the siphuncle wall is preserved. The apical segments show the usual short septal neck supplemented by slightly thickened connecting rings.

At the anterior end of the sectioned part of the specimen, the shell has a height of 42 mm and a width of 25 mm. The siphuncle here is 11 mm high and 8 mm wide, is slightly more narrowly rounded ventrally than dorsally, and is in contact with the ventral wall of the shell. The last septum is inclined forward slightly from the venter to dorsum, so that the height at its plane measures 42 mm and shows shallow, rounded, lateral lobes, considerably slighter in curvature than the septa as seen in vertical section. The living chamber has a ventral length of 38 mm, a dorsal length of 42 mm, and a height across the aperture, which slopes apicad slightly from venter to dorsum, of 50 mm. Throughout, the dorsum is gently convex in profile, the venter gently concave, the two walls gradually diverging to the aperture, the dorsum with a radius of curvature of 90 mm. Growth lines are not exposed in the type but in cross sections of the shell wall, that on the venter shows short, closely spaced frills near the aperture.

Discussion. This is a moderately curved species, with curvature and rate of vertical expansion of the shell uniform to the aperture, and without the usual modification of the profile of the venter on the mature living chamber. It is further distinguished by the expansion of the siphuncle, which increases very rapidly in the early part of the type and later becomes essentially tubular.

Holotype. Collection of the writer; No. 257.

Occurrence. From 272 feet above the base of the Threadgill member of the Tanyard formation, from Threadgill Creek, Gillespie County, Texas.

Barnesoceras lamellosum Flower, n. sp.

Pl. 9, fig. 9

This is a large cyrtoconic shell, moderately curved and apparently uniformly expanding up to the base of the mature living chamber at a shell height of 40 mm, beyond which the venter becomes nearly straight and so diverging from the dorsum that the rate of expansion is materially increased.

The holotype is a shell 95 mm long, one side exposed in section, the opposite lateral surface embedded in matrix. It expands vertically from a height of 20 mm to one of 41 mm in the length of the phragmocone, 28 mm ventrally, 60 mm dorsally. Here, the venter is concave, the dorsum convex. The living chamber, 38 mm long dorsally, 35 mm and slightly incomplete ventrally, attains an adoral height of 48 mm. Here, the venter is essentially straight, diverging from the dorsum, the dorsum rather strongly curved at the base of the living chamber, the curvature markedly reduced in the adoral two thirds of its length. The cross section is not full exposed but it is evidently very strongly compressed, the shell width at the aperture being estimated at 18 mm where the height is 48 mm.

Camerae are shallow, ranging in length from 1 to 1.5 mm. Sutures slope forward rather strongly from the siphuncle to the dorsum in vertical section. Apparently, they slope strongly orad from center to venter around the siphuncle, so that the last septum, 44 mm high, has a depth of 12 mm. The siphuncle as exposed in the type is relatively slender and essentially ventral, for it is not separated from the venter by any appreciable interval. Its height, as illustrated, is not quite the maximum. The siphuncle here is exposed for a length of about 25 mm, increasing in height from 5 to 8 mm. No diaphragms are evident; the wall structure of the siphuncle is poorly displayed. Most of the septa and much of the siphuncle wall are destroyed by recrystallization of calcite which occupies most of the camerae.

The exterior of the shell is not preserved. The dorsal and ventral walls are exposed in section and show an exceptionally strong development of the short, closely spaced laminae noted elsewhere in the genus. As usual, the ventral wall is prominently thickened on the living chamber. It shows short, slightly recurved laminae slightly less than 1 mm in length, variably spaced but averaging nine in a length of 5 mm. Similar laminae are apparent on the dorsum. It is evident, even without a specimen showing clear growth lines, that the shell has an aperture which slopes in general apicad from venter to dorsum.

Discussion. This species is a gently curved shell, gently expanding in the early growth stages, distinctive in the straightness of the ventral profile of the mature shell, which diverges rather rapidly from the dorsum, while the dorsum is strongly curved at the base of the living chamber; later this curvature is reduced. In the form of the living chamber, this species approaches *B. clavatum*, but the two species have living chambers quite different in shape, that of *B. lamellosum* having its greatest shell height near the base of the living chamber, while *B. clavatum* attains the maximum shell height in the anterior third of the living chamber. Until the living chamber is attained, *B. lamellosum* is a much more slender shell than *B. expansum*. *B. conosiphonatum* is comparable in this respect until the living chamber is attained, that of *B. lamellosum* being strongly modified while *B. conosiphonatum* retains the curvature and gentle expansion there which characterize the earlier part of the shell.

Holotype. Collection of the writer; No. 247.

Occurrence. From about 274 feet above the base of the Threadgill member of the Tanyard formation, from Threadgill Creek, Gillespie County, Texas.

Barnesoceras lentiexpansum Flower, n. sp.

Pl. 11, fig. 1-3; 6-9

This is a large gently curved, gently expanding cyrtocone. The early stages have not been recognized definitely and may be more rapidly expanding, but the known portion expands from a shell height of 28 to 55 mm at the aperture, in a length of 97 mm. In this length, the dorsum has a nearly uniform curvature with a radius of curvature of 90 mm. The venter, faintly concave over the early portion, becomes more faintly concave at a shell height of 40 mm and is thereafter sinuate, though straight in general, becoming first faintly convex, then faintly concave to the aperture which flares slightly on the venter. On the dorsum, the shell is contracted over the anterior 10 mm. Though all known specimens are weathered on one side, it is evident that the shell increases laterally from 20 to 25 mm in a ventral length of 60 mm.

The holotype is broken at the middle, where the height is 34 mm, the width, 20 mm. Apicad of this region, the shell has been sectioned, showing an increase in height of the interval of from 28 to 34 mm, in a dorsal length of 20 mm. Here the ventral siphuncle expands vertically from 6 to 9 mm in height, the expansion being great in the early portion, more gentle in the anterior portion. As seen in section, the septa slope strongly forward from the siphuncle to the dorsum, but they have a forward slope ventrad around the siphuncle, a feature not evident in the sectioned surface. However, it is evident that the septum is deeply curved both in the vertical and in the lateral planes, for externally the sutures are but little inclined forward on the dorsum, and the lateral lobes which they exhibit are shallow and only faintly curved. The septa are closely but not very uniformly spaced, varying in distance between 1 and 2 mm. The siphuncle wall is made up of short necks supplemented by connecting rings. At the base of the holotype, there is a trace of an incomplete diaphragm at the extreme base of the specimen.

The holotype (pl. 11, fig. 6-9) has a living chamber, 48 mm long ventrally, 50 mm long dorsally, and with a maximum ventrolateral length of 58 mm. Much of the aperture is preserved and shows a shallow ventral sinus, high, rounded ventrolateral crests, from which the aperture slopes apicad to a sinus on the dorsum. The surface is marked by prominent, rather distant, raised lines which are projected into very short close frills, 1 mm to 2 mm apart.

A paratype (pl. 11, fig. 1-2) represents a slightly less mature specimen, 95 mm in length. One side retains the sutures more clearly than does the holotype, but shows a similar pattern. The opposite side is a natural section, showing the strong curvature of the septa. The siphuncle is seen, but the section is slightly off center and as a result, the siphuncle appears smaller than its maximum height in the shell and is separated from the venter by septa which are wanting in the actual midventral region. This specimen agrees closely with the holotype in proportions. The shell increases from 35 to 37 mm in height in the 25 mm of the phragmocone. The living chamber, incomplete adorally, shows a very thick ventral wall, faintly sinuate in profile, but generally straight, 35 mm long, while the 35 mm preserved of the dorsum is thinner and uniformly convex in profile.

A third specimen (pl. 11, fig. 3) shows the same general curvature, slender form, and similarly spaced septa. This specimen, ground from a natural section, shows a section through the siphuncle which is so near the lateral side as to be nearly tangential, showing exaggerated thickness of the connecting rings, some of which appear to traverse the siphuncle. Here also the apparent appreciable distance between the ventral wall and the siphuncle is due to eccentricity of the plane of the section. Adorally, the plane of the natural section passes obliquely through the farther lateral surface of the shell. This specimen preserves 98 mm of shell length, attaining a shell height of 45 mm at the base of the living chamber. The specimen is of further significance in showing the transverse condition of the septa, which, in other specimens, where the section passes centrally through the siphuncle so that the ventral part of the septum is not seen, appear to slope strongly forward from the siphuncle to the dorsum.

Types. Holotype and paratypes, collection of the writer; No. 250-252.

Occurrence. From 272 to 276 feet above the base of the Threadgill member of the Tanyard formation, from Threadgill Creek, Gillespie County, Texas.

Barnesoceras cf. *lentiexpansum* Flower

Pl. 12, fig. 1-2

Under this name is described and figured a moderate-sized endogastric cyrtocone, a strongly curved rather small specimen, 60 mm long. The specimen describes a volution of about 150 degrees. The phragmocone increases in height from 8 to 24 mm in a curving dorsal length of 60 mm. Near its base the shell is 10 mm high, the siphuncle 2 mm high and in contact with the venter. Adorally, the shell is 24 mm high, the siphuncle here 4 mm high and 1 mm from the venter. The siphuncle is empty, its wall structure rather obscure, but apparently ellesmeroceroid, the septa are lost by recrystallization of calcite in the camerae. The living chamber continues 18 mm ventrally and 30 mm dorsally; where the height at the aperture is 30 mm, the shell width is estimated at 20 mm. A section near the aperture shows the ventral part of the cross section of the shell, which is broadly but strongly rounded, so much so, indeed, as to suggest a midlateral concavity such as occurs in *Oneotoceras*. It is evident, however, that a section passing toward the aperture at the midlateral region may give this effect, for in *Barnesocoeras* the mature aperture is commonly strongly compressed.

Discussion. Some uncertainty surrounds the specific identity of this specimen, for it fails to overlap or even approach closely the proportions shown in the apical ends of late growth stages upon which some of the larger species are based. It is evident that in proportions both *B. lentiexpansum* and *B. clavatum* are somewhat similar, but it appears that a portion of *B. clavatum* commensurate with the present specimen would be a considerably more rapidly expanding shell. Assignment to *B. lentiexpansum* seems, therefore, indicated. It is far from impossible, however, that this specimen might prove to be distinct from either of these forms, being a smaller form which attained maturity at the size indicated by the figured specimen.

Figured specimen. Collection of the writer; No. 259.

Occurrence. From about 274 feet above the base of the Threadgill member of the Tanyard formation, from Threadgill Creek, Gillespie County, Texas.

Barnesoceras percurvatum Flower, n. sp.

Pl. 13, fig. 1-3

This is a fairly large cyrtocone, strongly curved; the incomplete living chamber has the lateral profile of a *Buehleroceras* and the characteristic lateral growth lines of that species, but the strong curvature sets it apart from all other species of that genus and agrees with *Barnesoceras*. The type has a length of 80 mm, preserving some adoral camerae, the siphuncle, and the ventral part only of the living chamber. The living chamber has a ventral length of 40 mm, a height at the base of 32 mm, and a width of 24 mm. The suture at its base shows only very gentle lateral lobes, and the suture is essentially transverse to the curving axis of the shell. In the basal 15 mm, as measured on the dorsum, the shell has expanded 5 mm in height. The remaining dorsal part of the living chamber is lost by weathering, and we can only conjecture as to the shell height attained at the mature aperture, but growth lines indicate a ventral sinus and high, rounded, ventrolateral crests, as in the preceding species.

At the base of the living chamber the siphuncle is 9 mm high and 6 mm across. When traced to the apical end of the specimen, the siphuncle has decreased in 15 mm to a height of 5 mm. At its base is a clearly preserved, deeply curved diaphragm (pl. 13, fig. 3). The calcite filling the camerae obscures the septa and the length of most of the camerae. A basal camera is seen in section midway between the siphuncle and the dorsum at the extreme base of the specimen; it is 3 mm in length.

The shell shows a ventral radius of curvature of 50 mm while the dorsum has a radius of about 100 mm. In ventral view (pl. 13, fig. 1) the sinuate lateral profile typical of *Buehleroceras* is approached. Though one side is incomplete, being lost by weathering, it is evident that, as in that genus, the mature part of the shell becomes slightly narrower than the part at the base of the living chamber. The typical restricted aperture of *Buehleroceras* is not developed.

Discussion. Though this species approaches *Buehleroceras* in some respects in the indication of adoral lateral contraction, it is far remote from that genus, all known species of which are only gently curved, and for this reason is referred to the genus *Barnesoceras,* in which curvature is generally pronounced.

Holotype. Collection of the writer; No. 246.

Occurrence. From the Threadgill member of the Tanyard formation, from about 272 feet above the base of the formation, from Threadgill Creek, Gillespie County, Texas.

Barnesoceras (?) transversum Flower, n. sp.

Pl. 13, fig. 4-6

We have but a single specimen of this form, which contains only the ventral part of a phragmocone. It is 75 mm long, has a radius of curvature for the venter of 30 mm basally, increasing, the curvature decreasing, to 90 mm adorally, the decrease in curvature being quite abrupt. The specimen shows 32 camerae, 26 basal ones being clear, anterior ones filled with calcite and their septa obscured. The shell shows a height of 24 mm near the base, but elsewhere the dorsum is missing. The corresponding width can only be estimated but is not much less than the height, perhaps 20 mm. The vertical rate of expansion is therefore unknown except that in the basal part, at least, it is fairly rapid. At midlength a cross section of the shell was made, exposing a siphuncle 11 mm high, 9 mm wide, and evidently slightly distorted. The ventral part of the shell is transverse and suggests a cross section unusually broad for the genus, and possibly as wide as high. A vertical section of the basal part of the shell shows a siphuncle increasing in height from 4 to 8 mm in the length of 20 mm, beyond which the dorsal wall of the siphuncle is incomplete. It is evident, however, that the adoral expansion of the siphuncle is markedly reduced adorally, for at the anterior end a cross section shows the siphuncle to be only 11 mm high. The figured longitudinal section (pl. 13, fig. 6) is not quite central, which accounts for the appreciable development of camerae between the siphuncle and the venter. The septal necks are short, the apical connecting rings are quite well preserved, and show the layered structure of the Ellesmeroceratidae. Calcite fills the apical part of the siphuncle but is not set off sharply from the anterior part of the cavity, which contains matrix, by any discernible diaphragm.

Discussion. This fragment does not appear to be conspecific with any of the species of *Barnesoceras* with which it is associated, which are here described from more complete specimens. Indeed, even reference to the genus is dubious. The rather irregular curvature of the ventral profile of the shell is more closely approximated by *B. lamellosum* than by any other species, but the ventral wall of the shell is not thickened here as in that species, and its anterior end appears to be somewhat more curved than in a comparable part of *B. lamellosum*. The cross section of this form is apparently extremely broad, and much more broadly rounded on the venter than in any *Barnesoceras*. Nevertheless, reference to other described genera appears to be even less tenable. *Buehleroceras* is an essentially straight shell and cannot be considered. The curvature of the venter and the spacing of the septa recall some species of *Oneococeras*, but there is no evidence here of concavity in the midlateral regions and the broad rounding of the venter is anomalous, as is the rapid expansion of the siphuncle in the early part of the phragmocone. There is no evidence to suggest affinities with *Clarkeoceras;* typical species of that genus have sutures which are more strongly oblique, and the venter is less concave in profile. After viewing all other possibilities, reference of this form to *Barnesoceras* seems to do definitions less violence than any other, though it may well be that when the species is known from more complete material it will be found sufficiently anomalous to require a genus by itself.

Holotype. Collection of the writer; No. 260.

Occurrence. From the Threadgill member of the Tanyard formation, from Threadgill Creek, Gillespie County, Texas.

Genus BUEHLEROCERAS Ulrich, Foerste, and Miller

Genotype: *Buehleroceras compressum* UF&M

Buehleroceras Ulrich, Foerste, and Miller, 1943, Geol. Soc. Amer., Special Papers, no. 49, p. 60.

Buehleroceras was erected for Ellesmeroceratida which are quite like *Clarkeoceras* in early stages, being faintly endogastric, nearly straight, expanding rapidly vertically, and gently horizontally, so that the section becomes strongly compressed adorally. Sutures are generally traverse and show well-developed lateral lobes, thus differing from *Clarkeoceras,* where lobes are poorly developed and the sutures slope dorsorad. The siphuncle is ventral, essentially tubular; its structure has not been studied, but the known features suggest the general ellesmeroceroid pattern. The really characteristic features are found in the form of the living chamber. There the lateral sides become convex, lateral crests develop which converge; the sides are strongly drawn together at the mature aperture. Meanwhile, the rate of expansion is reduced on the dorsum, which may be straight or only faintly convex, and also on the venter, which may become straight or faintly sinuate, by being convex basally and faintly concave adorally. The result is a keyhole-shaped aperture with generally a round, broad, dorsal portion, narrowed centrally, and widening gently to the extended ventral portion.

The previously described species, all Gasconadian in age, are as follows:

B. compressum UF&M, Oneota of Wisconsin and Iowa. This, the genotype, shows the lateral crests high and strongly squeezed together, dorsal living chamber faintly convex, but nearly straight, much less convex than the earlier portion, ventral profile of living chamber convex below, concave above. The dorsal part of the aperture is inflated and faintly suggestive of the ventral part in *Tubiferoceras* of the Silurian.

B. apertum UF&M, Gasconade of Missouri. This species is very different in aspect of the living chamber, for the lateral crest is broadly arched instead of narrow and markedly produced. Lateral profiles of the living chamber are smoothly convex, and the species lacks the extreme adoral compression of the preceding at the aperturet. Unklesbay (1954) has identified with this species living chambers from the Tanyard of Texas. Specimens are quite fragmentary and smaller than typical *apertum*.

B. divaricatum (UF&M), Oneota of Michigan. This is removed to this genus from *Oneotoceras* because of the breviconic rather than slender form and the strong development of lateral crests of the aperture, and because the midlateral compression of the shell is limited, as in *Buehleroceras*, to the adoral part of the mature living chamber. The lateral crest is broad, as in *apertum*, but is ventrally concentrated, leaving room for the large, round, dorsal sinus extending well onto the lateral surface.

B. husseyi (UF&M), Oneota of Michigan. This is likewise removed from *Oneotoceras*, as it shows a breviconic rather than the slender form typical of *Oneotoceras*; it has clear lateral crests, narrower and slightly more pointed than those of the preceding form, and compression, so that the cross section is concave midlaterally, is only most faintly developed at the extreme adoral part of the living chamber.

B. extremum (UF&M), Oneota of Wisconsin. Formerly included in *Oneotoceras*, this is known only from a living chamber. It is like *Oneotoceras* in that the dorsum is faintly convex, the venter faintly concave, and adoral enlargement is very gentle, but the shell contracts laterally near the aperture, lateral crests are strongly developed, and the midlateral concavity of cross section is only most faintly developed and confined to the adoral extremity.

B. luthei UF&M, Oneota of Wisconsin and Iowa. This species is very similar in form to *B. compressum*, but about half the size of that species, and the crests of the lateral lobes are concentrated on the ventral side.

B. modestum UF&M, Oneota dolomite of Wisconsin. This is a species with broad, rounded, lateral crests, sides gently convex and converging orad, and rather deep camerae.

Buehleroceras sinuatum Flower, n. sp.

Pl. 12, fig. 5

The type of this species is a specimen weathered from one lateral side, but showing on the other most of the phragmocone and the living chamber, though the living chamber lacks the dorsal extremity. Apically, the shell expands vertically at an angle of about 50 degrees attaining a height of 23 mm at the base of the living chamber, which leaves a phragmocone of 26 mm, attaining close to the real apex. Apically, the venter is concave, the dorsum convex. At the base of the living chamber, the cross section is unexpectedly well rounded laterally, and the estimated height is 14 mm. The living chamber is 35 mm in maximum length, measuring from the suture, which is unusually transverse laterally, to the lateral crest which is highest well dorsad of the center. The lateral crest is asymmetrical, centered well dorsad of the middle and steeper dorsally than ventrally. The lateral profile is gently and evenly convex on the living chamber, without the extreme adoral compression which marks some other species. The ventral profile of the living chamber is perfectly straight. The dorsal profile is not shown but is apparently very gently convex. The middorsal region is lost by weathering.

Discussion. This species belongs in a group with *modestum* and *apertum* with the lateral lobes broad and gently arched and lacking the extreme midlateral compression giving the adoral end a definite midlateral concavity in cross section. This species is distinctive in the rapid vertical expansion, the straight ventral profile, the broadly rounded crest which is highest well dorsad of midheight of the shell. The transverse lateral condition of the sutures and the rather broad rounding of the cross section at the base of the living chamber are also distinctive.

A section was made of the phragmocone to study the siphuncle, but internal preservation proved too poor.

Holotype. Collection of the writer, No. 195.

Occurrence. From the Smith Basin limestone, from the section just east of Smith Basin, New York.

Buehleroceras arcuatum Flower, n. sp.

Pl. 10, fig. 3-4

This is a small species showing particularly rapid vertical expansion. The type, 45 mm long ventrolaterally, expands from 9 and 12 mm at the base to a height of 35 mm and a width of 19 mm in the basal 35 mm, and was probably 40 mm high and certainly only 21 mm wide at the aperture, which is incompletely preserved. The dorsum is very gently convex throughout. The venter is strongly bent basally but essentially straight and diverging strongly from the dorsum over the length of the living chamber. Lateral sides diverge gently and more uniformly and show progessive adoral flattening, but the preserved part, at least, fails to show definite midlateral concavity in the cross section near the aperture. Growth lines show broad crests, highest ventrolaterally. The holotype shows an unusually long living chamber, 30 mm ventrolaterally. At the base are parts of six camerae, occupying a length of 8 mm laterally and 10 mm dorsally.

Discussion. The long living chamber and general shape of this species are quite distinctive. Even in the absence of the complete aperture, the growth lines show the prominent lateral crests characteristic of the genus.

Type. Collection of the writer, No. 194. From the Smith Basin limestone, a quarter of a mile east of Comstock, New York.

Buehleroceras infundibulum Flower, n. sp.

Pl. 10, fig. 5, 6, 9, 11, 12

This is a species in which, on the living chamber, the nearly straight dorsal and ventral profiles diverge at an angle of about 30 degrees, while the sides develop concavities in cross section adorally and are pinched together, forming a keyhole-shaped aperture. The crests are high, rather narrow; thus, this species resembles in this respect *compressum* and *luthei*, but it is distinct from both in the more rapid vertical expansion of the living chamber.

The holotype is a living chamber expanding from 26 and 15 mm at the base to a height of 46 mm and an estimated width of 22 mm across the dorsal lobe, narrowing to probably 8 mm in the center, and widening more gradually ventrally to about 15 mm. The margin of the dorsal lobe of the aperture flares slightly, and ventrad of it the shell wall is pressed inward as it is extended forward in the lateral crest. The suture at the base of the living chamber shows a shallow lateral lobe and is sloped forward somewhat from venter to dorsum. The siphuncle is indistinct. (No. 191, pl. 10, fig. 9.)

A paratype, No. 192, shown on Plate 12, Figures 11 and 12, is a living chamber less complete adorally, but preserving parts of both lateral surfaces. It expands from a height of 30 and an estimated width of 18 mm at the base to a height of 40 mm and a width of 19 mm at the adoral end, in a length of 32 mm adorally and 21 mm, all that is preserved, ventrally. The sides are pressed together near the aperture, most contracted beyond the slightly flaring dorsal lobe of the aperture. Parts of adoral camerae are retained on the dorsal side but are obscurely septate.

A second paratype, No. 193, shown on Plate 12, Figure 6, preserves only one lateral surface and shows more of the phragmocone than do the other specimens, but the living chamber is incomplete adorally. The specimen shows gentle concavity of the ventral profile, the dorsum faintly convex, faintly irregular, and nearly straight adorally. The shell expands vertically from 24 to 40 mm in 45 mm. Sutures develop shallow lateral lobes, sloping slightly more forward on the dorsum than on the venter. Camerae are shallow, the last three occupying a length of 5 mm. Surface markings and siphuncle are not preserved.

Discussion. The rapid vertical expansion, adoral slope of anterior sutures on the dorsum, the strongly pinched aperture with a slight flaring of the dorsal lobe characterize this species, which is much more rapidly expanding vertically than the previously described species with similar apertures.

Types. Holotype and two paratypes, collection of the writer; Nos. 191-193. From the Smith Basin limestone, a quarter of a mile east of Comstock, New York.

Genus ONEOTOCERAS Ulrich

Text Figure 25

Genotype: *Cyrtoceras loculosum* Hall

Oneotoceras Ulrich, *in* Butts, 1926, Alabama Geol. Surv., Spec. Rpt. 14, p. 91, explanation of pl. 15.

——— Ulrich and Foerste, 1935, Denison Univ. Bull. Sci. Lab., Jour., vol. 30, p. 282.

——— Ulrich, Foerste, and Miller, 1943, Geol. Soc. Amer., Special Papers, no. 49, p. 144.

Oneotoceras contains slender cyrtocones of moderate to large size characterized most conspicuously by midlateral concavity of the cross section, shown externally by a pair of prominent midlateral grooves. Growth lines show the early aperture to be oblique, sloping strongly apicad from venter to dorsum, though transverse or faintly concave midventrally. Lateral crests are developed only in the adult stage, and even there they are concentrated ventrolaterally and are never so well developed as in other genera of the group. *Barnesoceras* differs in the more rapid rate of vertical expansion, the extreme compression of the anterior part of the shell, the absence of lateral concave zones, the better development of the lateral crests. *Buehleroceras* is a shell generally much less curved, showing convex profiles on the living chamber, which, in the most advanced species, develops lateral concavity, but only near the mature aperture, which is typically constricted and keyhole-shaped. Some confusion in apparent gradation between *Oneotoceras* and *Buehleroceras* has been eliminated by removal to *Buehleroceras* of some species formerly placed in *Oneotoceras*.

Without development of the lateral concave zones, living chambers of *Oneotoceras* would be rather similar to those of *Clarkeoceras*, and while the group of three genera with lateral crests may have come from this source, the matter seems hardly capable of proof; the typical dorsorad sutures of *Clarkeoceras* are not developed in this group, curvature of lateral lobes is better developed, and an alternate source from some smaller more generalized cyrtocones, such as *Dakeoceras*, seems also possible. The internal morphology is not known in detail, as the known material of the genus consists of silicified steinkerns. The siphuncle appears typical in the form of the segments. Considerable lengths of siphuncle are known which fail to show clear evidence of diaphragms, suggesting that probably, as in *Barnesoceras*, diaphragms are delayed in development and are concentrated in relatively apical parts of mature siphuncles.

All known species are of Gasconade age. It should be noted that three species originally described as *Oneotoceras* are re-

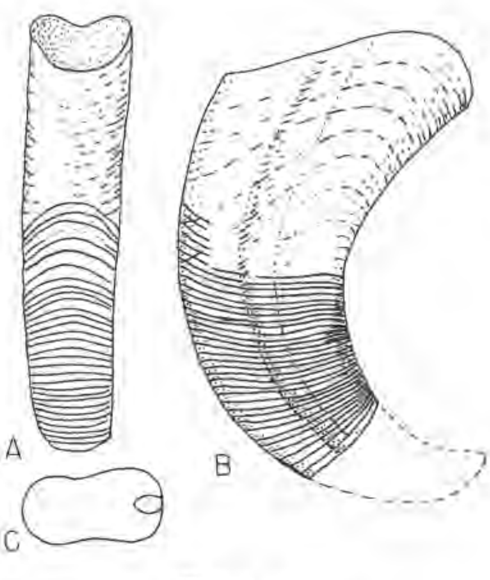

Figure 25

Oneotoceras loculosum

A. Dorsal view; aperture restored. B. Lateral view, dorsum at left; aperture and septa based upon different specimens; apex restored from a third. C. Cross section, showing lateral grooves. Based upon UF&M, 1943.

moved in this work to *Buehleroceras*, for reasons discussed under that genus.

The known species include the following:

O. loculosum (Hall) Oneota dolomite, upper Mississippi Valley, also Gasconade of Missouri and Chepultapec of Tennessee. Unklesbay (1954) has identified this species from the Tanyard of Texas.

O. curvatum Ulrich, Foerste, and Miller, Oneota equivalent, Michigan.

O. impressum Ulrich, Foerste, and Miller, same occurrence.

O. madisonense Ulrich, Foerste, and Miller. This is known from one specimen from the Oneota dolomite of Wisconsin. The lateral grooves are poor, and the form is therefore not typical. There is not enough evidence to show whether it is an *Oneotoceras*; neither is there good justification for removing it to any other genus. It is quite probably not a *Buehleroceras*, as were some other species originally placed in *Oneotoceras*.

O. magnum, Ulrich, Foerste, and Miller, Oneota equivalent in Michigan. A large typical form.

O. percurvatum Ulrich, Foerste, and Miller. This species is known from the Chepultapec of Alabama and Tennessee and the Gasconade of Missouri.

O. wisconsinense Ulrich, Foerste, and Miller. Oneota dolomite, Wisconsin.

O. sp. from the Chepultapec of Maryland (Flower, 1956, pl. 20, fig. 14, p. 80) is atypical. Lateral grooves are wanting, but there is a slight adoral midlateral contraction of the shell.

O. divaricatum, *O. husseyi*, and *O. extremum* have living chambers characteristic of *Buehleroceras* and are removed to that genus.

The very fragmentary specimen on which *Clarkeoceras minneiskense* was based shows a lateral groove and is probably to be assigned to *Oneotoceras*.

THE MICROELLESMEROCEROIDS

Here are grouped together tiny ellesmeroceroids of the Gasconadian. As noted in the discussion of proportions, they are similar to larger genera except in their tiny size, though *Burenoceras* develops specializations of the aperture. *Ectenolites* is a miniature edition of *Ellesmeroceras*, also, but less perfectly, owing to the greater length of phragmocone and living chamber in this small form. Possibly *Conocerina*, which contains tiny and large species, should be subdivided also.

Genus BURENOCERAS Ulrich and Foerste

Text Figure 26

Genotype: *Burenoceras pumilum*

Bureonceras Ulrich and Foerste, 1931, in Bridge, Missouri Geol. Surv., ser. 2, vol. 24, p. 208.

——— Ulrich and Foerste, 1935, Denison Univ. Bull., Sci. Lab., Jour., vol. 30, p. 264.

——— Ulrich, Foerste, and Miller, 1943, Geol. Soc. Amer., Special Papers, no. 49, p. 64.

Burenoceras was erected for dominantly small endogastric cyrtocones of the Ellesmeroceratidae in which the phragmocone is shorter than the living chamber. Under such a definition, the genus is plainly composite; further, without demonstrable evidence of maturity, the danger is great of including immature specimens of *Dakeoceras* and *Levisoceras*.

The described species are divisible into two groups on the basis of size; typical *Burenoceras* is always very small, but there was included in the genus a group of species two to four times the size of the typical forms; these species intergrade with *Levisoceras* and are removed to that genus.

Among the remaining small species are evident two types of apertures. One type, shown perfectly only in *Burenoceras phragmoceroides*, but less perfectly in *B. percompressum*, has the form and the constricted aperture of the Silurian *Phragmoceras*, and the Devonian *Bolloceras*. In contrast, species at the other extreme show apertures which are flared, largely in the vertical plane, but also to some extent in lateral profile. Such flaring on the venter could represent the beginning of the spout-like extension of the hyponomic sinus in either an immature shell or a shell in which the aperture is broken anteriorly, but this group overlaps another in which the later expansion of the living chamber is quite rapid, though not all species show definite flaring at the extreme aperture. Such species with flaring are *B. compressum*, *B. expandum*, *B. undosum*, *B. ungulatum*; laterally rapidly expanding forms without flaring are *B. huzzahense* and *B. angulare*; while an intermediate group, some showing definite convexity of lateral profile, includes *B. pumilum*, *B. texanum*, *B. dickhauti*, and *B. planiseptatum*. The series of species shows largely imperfect apertures but they are nearly enough complete to suggest that in this group of essentially contemporaneous forms, all from the Lower Canadian, there may be considerable if not perfect gradation between the two extreme types of apertures. This will seem odd, for obviously such apertures and living chambers as are developed homeomorphically in these tiny *Burenoceras* in the Gasconadian, appear again in *Phragmoceras* in the Silurian and in *Bolloceras* of the Devonian. Such homeomorphic development in three orders, Ellesmeroceratida, Discosorida, and Oncoceratida, suggests adaptation for a specialized mode of life, and in *Burenoceras* one would not expect such gradation into other types as seems to exist. However, it must be remembered that gradations must have occurred at the beginning of each of these phragmoceroid shells, and in the Gasconade we are faced with a particularly plastic and rapidly evolving group in the Ellesmeroceratidae; further, one which became practically extinct at the close of the Lower Canadian. The fossil evidence shows the beginning of the evolution of the phragmoceroid aperture in *Burenoceras*. On the other hand, *Phragmoceras*, which has a wide range in the Middle Silurian, not only survived for a longer time but is a type which almost certainly is known from species which entered both Europe and North America after perfection of the shell form, and the same is probably true of the dominantly European *Bolloceras* of the Middle Devonian.

Unklesbay (1954) figured as *Burenoceras undosum* an odd species with a top-shaped lateral profile, distinguished from *Bureonceras* in general proportions and in the development of costae. This form is set apart as the new genus *Keraiaceras*, and a second species is doubtfully referred to the same genus.

Heller (1954, p. 41, pl. 17, fig. 1) has identified *Burenoceras pumilum* from the Roubidoux of Missouri. From the figure, identification is not possible but assignment to *Cumberloceras* seems likely.

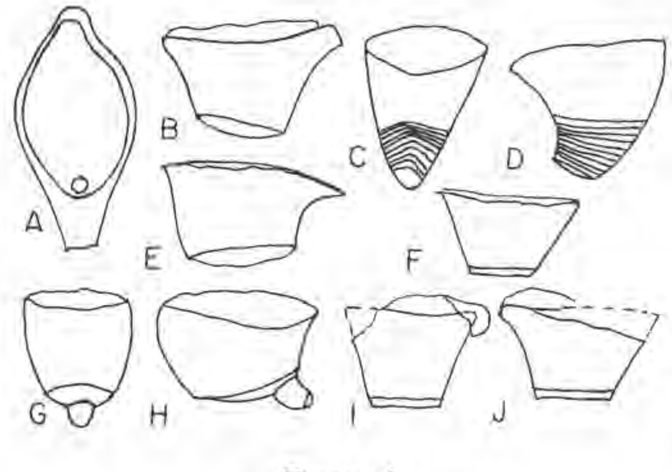

Figure 26

Variation in *Burenoceras*

A-B. *B. percompressum*, A, Basal view, venter below, B. Lateral view, venter at right. C-D. Ventral and lateral views of *B. compressum*. E-F. *B. expandum*, lateral and dorsal views showing a species with flaring aperture. G-H. *B. pumilum*, a form with the profiles, both vertical and horizontal, convex on the living chamber. G. Dorsal view; H. Lateral view, venter on right. I-J. *B. huzzahense*. I. dorsal view; J. lateral view; a form with a conical, slightly flaring, living chamber. A, B × 5; C-H × 1.5.

SPECIES

A. Aperture phragmoceroid

B. phragmoceroides, n. sp. Tanyard, Texas
B. percompressum UF&M, Gasconade, Missouri

B. Aperture intermediate
sides slightly convex

B. pumilum Ulrich and Foerste, Van Buren, Missouri
B. planiseptatum UF&M, Oneota, Wisconsin
B. dickhauti UF&M, Van Buren, Missouri
B. texanum UF&M, Tanyard, Texas

sides diverging, straight

B. angulare UF&M, Van Buren, Missouri
B. huzzahense UF&M, Gasconade, Missouri
B. oneotense UF&M, Oneota, Wisconsin; ?Tanyard, Texas

C. Aperture flaring

B. compressum UF&M, Van Buren, Missouri
B. expandum UF&M, Van Buren, Missouri
B. undosum UF&M, Gasconade, Missouri
B. ungulatum UF&M, Chepultapec, Tennesse; ?Gasconade, Missouri

In addition, Unklesbay (1954) has identified *B. dickhauti*, *B. dilatatum*, *B. expandum*, and *B. huzzahense* from the Tanyard of the Llano uplift of central Texas. They are certainly *Burenoceras*, though the specific identity of *expandum* seems questionable, and *oneotense* might be closer.

SPECIES REMOVED

Species transferred to other genera are as follows:

B. pumilum of Unklesbay, 1954	*Cumberloceras llanoense*
B. compressum Unklesbay, 1954	*Ellesmeroceras (?) compressum*
B. undosum Unklesbay, 1954	*Keraiaceras unklesbayi*
B. pumilum Heller, 1954	*Cumberloceras* sp.
B. curticei UF&M	*Levisoceras curticei*
B. minor UF&M	*Levisoceras minor*
B. peramplum UF&M	*Levisoceras peramplum*
B. cornucopiaeforme Powell	*Levisoceras cornucopiaeforme*
B. barnesi Unklesbay	*Conocerina barnesi* *Paradakeoceras* sp.

NEW SPECIES

Burenoceras cornucopia

Pl. 14, fig. 29

This is a tiny, strongly curved, rapidly expanding ellesmeroceroid. The holotype, a specimen exposed in vertical section, has a phragmocone increasing in height from 3.5 to 7.1 mm in a dorsal length of 7 mm and a ventral length of 4 mm. The living chamber extends 5.5 mm dorsally and an estimated 4.5 mm ventrally, being incomplete at the extreme anterior part of the venter. The adoral shell height is 9 mm. In profile, the venter is uniformly and rather strongly concave. The dorsum diverges from the venter quite rapidly, is convex, showing sinuate irregularities near the aperture, plainly indicative of minor constrictions and expansions of the shell at this region. The phragmocone preserved contains eight camerae, moderately curved in vertical section, and exposes a siphuncle. In the section, the siphuncle is 0.6 mm in diameter and 0.1 mm from the venter. Adorally, it is 0.7 mm high and 0.7 mm from the venter. The cross section is clearly compressed but is unknown in detail.

Discussion. This is an extremely small, rapidly expanding shell. From the sinuate outline near the dorsal part of the aperture, the specimen is very close to maturity, if it is not absolutely mature, and plainly belongs to a group of species in which the aperture flares at maturity, rather than contracting.

Holotype. Collection of the writer; No. 241.

Occurrence. From 272 feet above the base of the Tanyard formation, Threadgill Creek, Gillespie County, Texas.

Burenoceras muricoides Flower, n. sp.

Pl. 14, fig. 25-28

This is a small, strongly curved shell of compressed section, moderately rapid expansion, the septa rather strongly curved in the vertical plane. The known parts of the shell range from 3 to 7 mm in height, and describe an arc of a little more than a quarter of a volution.

The holotype (pl. 14, fig. 25) is a shell 17 mm long, exposed in a vertical section, though at the anterior end the dorsum is seen passing below the plane of the section, and thus approaches the venter, a condition which would not be apparent were the entire section in the median plane. The radius of curvature is small, about 15 mm. The phragmocone expands vertically from 5.5 to 6.5 mm in a length of 7 mm ventrally and 10 mm dorsally. The living chamber continues for 4 mm ventrally and 7 mm dorsally, the apparent aperture normal to the axis of the shell. The apertural height of 6.5 mm may be corrected for 7 mm in a vertical plane. The phragmocone contains 12 camerae, less than a millimeter deep, seven occurring in the adoral 5 mm on the dorsal side. The siphuncle expands in the plane of the section from 0.6 to 0.9 mm. No septa are apparent between it and the venter, only a slight apparent thickening of the shell wall which continues to the adoral extremity of the phragmocone on the venter. The siphuncle segments are tubular, composed of aneuchoanitic necks and connecting rings without obvious thickening or layering. The septa are deep, those at the base of the living chamber having a depth between one third and one fourth the height of the shell at that point.

A paratype (pl. 14, fig. 26) (No. 229) is exposed in a section which is essentially vertical and central through the phragmocone, but oblique, passing toward the far lateral side as it approaches the aperture. This specimen shows a cross section of the shell at the base, which is compressed, elliptical, dorsum and venter equally rounded, 4 mm high and 3 mm wide. The phragmocone increases from 4 to 6 mm in a length 12 mm dorsally and 7 mm ventrally. Calcite fills the camerae, obscuring all septa except the last one, and filling much of the siphuncle. At the anterior end of the phragmocone the siphuncle is 1.0 mm high and 0.2 mm from the venter. The living chamber continues for 6 mm dorsally and 4.5 mm ventrally; the aperture, here seen off-center in section, measures 6 mm in height. As in the preceding from, the septa are quite strongly curved.

A second paratype (pl. 14, fig. 27) (No. 237) is a portion essentially commensurate with the preceding specimen, but not showing the cross section. It expands from 4.2 to 6 mm in the phragmocone, 11 mm dorsally and 5.5 mm ventrally. The last camera, 0.8 mm deep, is clearly defined; others are filled with calcite. The siphuncle, 1 mm high and separated from the venter by only a faint thickening of the shell there, is tubular and uniform in the length exposed. The living chamber 3.8 mm ventrally and 4.2 mm dorsally, attains a height of 7 mm at the aperture. As in the previous forms, the septum is deeply curved in vertical section.

A third specimen (pl. 14, fig. 28) (No. 226) is slightly more rapidly expanding, increasing from 3 to 5 mm in the length of the phragmocone, 10.5 mm dorsally, 7 mm ventrally. The siphuncle is tubular, increasing from 0.6 to 0.7 mm in height and with only a faint thickening of the ventral wall apparent. The living chamber 3.0 mm dorsally and 2.5 mm ventrally, attaining a height of 7 mm. This form may be distinct, as it is slightly more rapidly expanding, and has an aperture somewhat longer ventrally than the other forms.

Discussion. This species is evidently a very simple one, and though there is not definite evidence of maturity in irregularities of the shell near the aperture, the several specimens are all of about the same size. The species is readily distinguished among associated forms by the strong curvature, the radius being uniformly close to 1.5 mm for the dorsum, the strongly curved septa, and the moderately rapid vertical expansion of the shell and the compressed cross section.

In rate of expansion, this species is rather similar to *Burenoceras texanum*, differing primarily in the extremely deep curvature of the septa.

Types. Collection of the writer; holotype, No. 225; paratypes, Nos. 229, 237, 226.

Occurrence. From 272 to 276 feet above the base of the Threadgill member, Tanyard formation, from Threadgill Creek, Gillespie County, Texas.

Burenoceras phragmoceroides Flower, n. sp.
Pl. 15, fig. 12-16

This is a tiny *Burenoceras*, known only from a silicified internal mold of a living chamber which, in form and aperture, is a duplicate in miniature of the Silurian genus *Phragmoceras* and of the Devonian genus *Bolloceras*. At the base of the living chamber, the cross section is narrowly rounded ventrally, the diverging ventrolateral regions nearly flat, merging into broadly rounded sides above the middle of the cross section, with slight flattening of dorsolateral zones which, as developed, approach a narrowly rounded dorsal region at an obtuse angle of about 110 to 120 degrees, whereas the ventrolateral faces form an acute angle of 60 to 70 degrees. The septum is flat, showing only an indistinct siphonal perforation, 4 mm wide and 5 mm high. The living chamber is 5 mm long, with the lateral profiles subparallel over the basal half, but becoming convex and approaching each other in the adoral half, curving to form a domelike anterior part of the living chamber interrupted by the greatly restricted aperture. The ventral profile is essentially straight, forming an angle of 55 to 60 degrees with the plane of the septum. Both dorsum and venter extend for 2.6 mm before reaching the sinuses of the aperture. The aperture consists of dorsal and ventral sinuses connected by a narrow slit 5 mm long. The dorsal sinus is broadly rounded, slightly wider than high, the anterior part, near the aperture, well rounded and convex, the entrance of the slit into it being quite sharp and well marked. On the venter, the sinus is less broadly rounded, the upper part merging into the slit of the aperture, and the whole sinus pear-shaped rather than well rounded. The internal mold shows an outward slope at the margin of the sinuses, and this is more striking in the central slit of the aperture, indicating a shell of some considerable thickness at the aperture. The slit is imperfect, but enough of its outline is preserved to show the original form. At the adoral end the shell is 7.5 mm in height and 4.3 mm in width.

Discussion. The type of this species shows a nearly perfect aperture, and confirms the suspicion that within *Burenoceras* there are some species in which the aperture is greatly restricted and in which the mature living chamber has essentially the aspect of a *Phragmoceras*. The features of the phragmocone of this species are unknown, but all similar forms of Gasconade age have proved to belong to the Ellesmeroceratidae, and there is no reason to believe that our present form is exceptional in this respect.

The most similar of the previously described species is *Burenoceras percompressum*, but its living chamber shows a number of differences in proportion. At its base, the greatest width is attained almost at midheight of the section, the dorsum is more narrowly rounded, the dorsolateral faces less flattened, forming a more acute angle, while the venter is slightly less narrowly rounded, though the angle of the ventrolateral faces is close to that shown in *phragmoceroides*. Comparison of lateral and dorsal or ventral views of *B. percompressum* is made difficult by inadequate explanations of the plates illustrating that species; a good lateral view is shown, but the reader is left in doubt as to which side is supposed to be ventral and which should be dorsal, and it is also uncertain whether another view is taken from the dorsal or from the ventral side. It appears, however, that the side showing a straight profile is the ventral one, and the shorter side, more oblique to the septum and strongly concave, is the dorsum. This orientation is, however, not what would be expected by comparison with *phragmoceroides*, where the dorsum is longer than the venter and forms a smaller angle with a line normal to the suture. In another view, apparently taken from the dorsal side, it is evident that the lateral profiles diverge slightly from the septum to three fourths of the way to the aperture, and the anterior region, evidently incomplete, over which the side approach, presumably to a median slit-like aperture as in *phragmoceroides*, is relatively short.

A suggestion of a somewhat similar aperture is found in *Burenoceras ungulatum* (Ulrich Foreste, and Miller, 1943, pl. 37, fig. 31), but here one side of the living chamber, the shorter one, which, by analogy with *percompressum*, is dorsal, is even more rapidly flaring.

Holotype. Texas Bureau of Economic Geology, University of Texas; No. 34832.

Occurrence. From cherts of the Tanyard formation, from the Barnes Ranch headquarters, in the northeast corner of the Llano quadrangle.

Genus MURICERAS Flower, n. gen.

Genotype: *Muriceras murus* Flower, n. sp.

This genus is erected for tiny, slender endogastric cyrtocones compressed in cross section, dorsum more broadly rounded than the venter, or with the dorsum and venter subequally rounded, sutures with moderate lateral lobes, the siphuncle tubular, aneuchoanitic necks, rings moderately thick, failing to show more than a suggestion of layering and that only in later growth stages of the larger forms; diaphragms suppressed or confined to apical regions. Living chamber with the aperture slightly contracted laterally, showing faint rhythmic expansion. Shells are essentially smooth and a faint ventral sinus is developed.

Discussion. The nucleus of this genus is the group of small species from the Tanyard, described below. *Dakeoceras* is quite similar, but its species are two to four times the size of those of *Muriceras*. *Ruthenoceras* Korde, described from beds supposedly Upper Cambrian in age from Siberia, was based upon a chance-oriented section of a shell, which, were it better known, would be a small endogastric cyrtocone rather similar to *Muriceras*, but apparently more nearly tubular in form. Possibly the two genera should be one, but we will never know the real features of *Ruthenoceras* until it is restudied from better topotype material. *Ruthenoceras* is apparently a very slender shell and distinctive in that the siphuncle is relatively large, being nearly half the height of the phragmocone. *Clelandoceras* is a genus of small endogastric cyrtocones from the Cassinian; the originally described specimens are known from only silicified phragmocones. In general shape, such shells are similar to *Muriceras*, except that in cross section the dorsum is more narrowly rounded than the venter. However, a new specimen, described below as *Clelandoceras (?) rarum*, if correctly assigned, shows a contracted living chamber and a siphuncle of faintly expanded instead of tubular segments.

Unklesbay and Young (1956, Jour. Paleont. vol. 30, p. 487, pl. 51, fig. 22, 23) identified as *Clelandoceras elongatum* a small shell from the Chepultapec of Virginia. This form agrees with *C. elongatum* in rate of vertical curvature and expansion, but the lateral expansion is more gradual, septa are extremely close, and lateral lobes are much more poorly developed than in that species. Whether this form shows the typical narrowly rounded condition of the dorsum is not indicated. The specimens are rather coarsely silicified and fail to show much of the siphuncle. The age alone would suggest that an assignment to *Muriceras* is at least more reasonable than to *Clelandoceras*, and that certainly this cannot be the late Canadian species *C. elongatum*.

In addition to the Gasconadian species, one from the Demingian, *Muriceras ? obscurum*, is tentatively included in the genus. This species, younger than any of the others and occurring in beds in which few Ellesmeroceratidae survive, will quite possibly be separated eventually as a distinct genus. At present, it is known to differ from *Muriceras* only in that the siphuncle is somewhat smaller and is slightly but definitely removed from the ventral wall of the shell.

True *Woosteroceras* is a somewhat larger shell, and one in which the cross section is circular, rather than compressed, from the earliest known growth stage. *Burenoceras* is similar to *Muriceras* but is a much more strongly curved and a much more rapidly expanding shell. We have no true apices of *Burenoceras*, but they are clearly even more short and blunt than those of *Muriceras hebetum*.

Stemtonoceras is a very slender cyrtocone, approached in form by some *Muriceras*, but is generally more tubular and considerably larger.

The Gasconade species of *Muriceras* here described look much alike, but exhibit wide variation in proportions. The following summary will serve as a general key, showing their salient differences:

M. murus. A small, moderately expanding shell, the aperture with only faint lateral contraction; apex extremely small.

M. anomalum. Small, slightly larger than *murus*, but with much longer camerae and a relatively tiny siphuncle; unique in showing slight contraction of the segments at the septal foramina.

M. hebetum. A slightly larger species, one which has, in contrast to *M. murus*, a large, blunt, apical end. Moderately curved, adorally more gently expanding than *murus*.

M. micromurus. A tiny shell commensurate with *murus*, but much more gently expanding and with lateral contraction of the aperture, mature shells reaching a maximum cross section slightly smaller than that of *murus*.

M. curviseptatum. A relatively large species in which the adoral septa show deep and rather irregular curvature similar to that of the larger *Woosteroceras flexiseptatum*.

M. gracile. A moderate-sized form with relatively slender form, gentle curvature, and closely spaced septa which are relatively gently curved in the sagittal plane.

M. medium. A moderately large form, intermediate in size between the preceding forms and the associated *Woosteroceras*, but retaining a compressed cross section. Septa are moderately spaced, never closely spaced as in *gracile*, and more strongly curved than in that species, but lacking the irregular and deep curvature of *M. curviseptatum*.

The specimens which Unklesbay and Young (1956) identified as *Shelbyoceras* and *Clelandoceras* from the Chepultapec of Virginia are better assigned to this genus; specific evaluation is difficult; the types show evidence of slight distortion, possibly from folding of the containing strata.

Muriceras murus Flower, n. sp.

Pl. 14, fig. 1-7, 16

This is a tiny cyrtocone, moderately compressed in cross section, gently curved, moderately expanding, the siphuncle tubular, not perceptibly separated from the ventral wall, septa transverse, their curvature shallow in vertical section, and sutures transverse externally or nearly so.

The holotype (pl. 14, fig. 4-5) (No. 219) is a tiny cyrtocone exposed in vertical section. The entire specimen is 6 mm long, enlarging gradually from 0.6 mm in height at the base to 2.0 mm in the length of the phragmocone, 4.5 mm dorsally, 3.5 mm ventrally, and continuing to an aperture 2.2 mm high, the living chamber being 1.8 mm long ventrally and 2.0 mm dorsally. Septa are transverse, only very slightly curved in vertical section, depth of septum slightly less than one fourth the shell height. The siphuncle, visible in the basal half of the phragmocone only, is 0.2 mm in diameter, tubular. No details of wall structure of the siphuncle are apparent. A single camera at the base of the shell is 0.4 mm in length.

A second specimen (pl. 14, fig. 1-3) (No. 221) is closely similar in proportions. It is 7 mm in length, increasing from 1.6 mm to an aperture 3 mm high. The living chamber is 1.8 mm ventrally, 2.2 mm dorsally, is 2.1 mm high at the base. The siphuncle, apparent only in the anterior half of the phragmocone, is 2 mm across and in contact with the venter, here faintly thickened.

Two other tiny shells of comparable proportions are exposed in specimen No. 231 (pl. 14, fig. 16). One is a section slightly curved, largely lateral, but not exposing the siphuncle. The phragmocone, 2 mm long increases from 0.4 mm to 0.8 mm; the living chamber, 1.4 mm long, attains an apertural height of 1.3 mm. A second specimen shows a slender phragmocone increasing from 0.2 to 0.6 mm in 2.0 mm; the living chamber, 1.4 mm long, increases to 1.2 mm. Plainly, the section shown here is a transverse one, so oriented that it intersects the phragmocone at such a level that its maximum width is not shown, but curvature brings the aperture of the living chamber into such a position that it is seen at or close to the maximum shell width.

A somewhat larger specimen, No. 235, is shown in vertical section (pl. 14, fig. 6-7). This shell expands from a height at the base of 1 mm, where the true apex is clearly not attained, as shown by the relatively flat septum there, to 3 mm in the length of the phragmocone, 6.6 mm dorsally, 5.8 mm ventrally. Septa are as before, transverse and but little curved. The siphuncle here increases in diameter from 0.2 mm to 0.6 mm. It is essentially in contact with the venter, where as usual the shell is slightly thicker than on the living chamber. In the extreme apex of the siphuncle two faint diaphragms are evident. The living chamber, 4 mm long dorsally and 2.5 mm ventrally, attains an aperture 4 mm high and 3.6 mm wide. Curvature and expansion of the shell are uniform throughout its length.

Types. Collection of the writer; Nos. 219, 221, 231, 235.

Occurrence. All specimens are from 272 to 276 feet above the base of the Threadgill member of the Tanyard formation, Threadgill Creek, Gillespie County, Texas.

Muriceras micromurus Flower, n. sp.

Pl. 14, fig. 15

This is a very small *Muriceras*, more gently expanding vertically than *M. murus*, and showing a lateral contraction of the living chamber indicative of the attainment of maturity at a relatively small shell size. Our single specimen is a nearly sagittal section of a shell, as at present figured; it is shown by a section which is slightly removed from the median plane. The slight grinding required to attain this condition suggests the shell to be even more strongly compressed in cross section than is *M. murus*. In its present condition, the phragmocone of the type, which is incomplete basally, increases from 1.2 to 2.2 mm in height in a length measuring 4.0 mm on the venter, 4.8 mm on the dorsum. The living chamber, 1.8 mm ventrally and 2 mm dorsally, is contracted, the venter becoming convex, the dorsum approaching it in an almost straight line. Such contraction is the result of a section passing through the living chamber close to a lateral surface and is clearly an indication of lateral contraction of the shell. The phragmocone is largely filled with calcite which destroys all septa except the one at the base of the living chamber. A trace of the siphuncle can be seen, but is very obscure.

Discussion. This tiny shell is regarded as distinct from *M. murus*, the only form which is similar in proportions. Its apparently more slender form may be adventitious, but the evidence of lateral contraction of the shell at the aperture is clear, and *M. murus* plainly shows only the faintest contraction of this kind, if any exists, which is extremely unlikely. Prior to grinding, the section showed no apparent vertical contraction.

Holotype. Collection of the writer; No. 218.

Occurrence. From 272 to 276 feet above the base of the Threadgill member, Tanyard formation, from Threadgill Creek, Gillespie County, Texas.

Muriceras anomalum Flower, n. sp.

Pl. 14, fig. 24

This is a small shell resembling *Muriceras murus* in general proportions. The holotype and only specimen recognized so far is an endogastric cyrtocone. The phragmocone increases in height from 1.3 to 3.5 mm in its length, 12.5 mm dorsally and 12.0 mm ventrally. The living chamber 3.5 mm long dorsally and 2.8 mm ventrally increases to a height of 5 mm. Faintly sinuous outlines on both the dorsum and venter of the living chamber suggest faint constrictions and expansions which suggest the shell to be mature. Part of the cross section at the aperture indicates that the shell was elliptical in cross section, though not strongly compressed; probably about 3 mm wide where the height is 5 mm.

The septum at the base of the living chamber is moderately curved, transverse in vertical section, the depth-height ratio is 3:10. Curvature of the septum in the vertical plane is even, the greatest depth attained at midheight of the section. Here the siphuncle is 0.8 mm high and 0.2 mm from the venter. The siphuncle can be traced apicad only a very short distance before it is lost in calcite indistinguishable from that which fills the camerae and has destroyed most of the septa. Here the siphuncle seems perfectly tubular, and there is no clear indication of its wall structure. At the apical end of the type, one camera is preserved filled with matrix. It is 0.8 mm in length, much longer than the camerae in *M. murus*. The siphuncle segment here is preserved, and anterior to it are three additional segments filled with matrix and thus differentiated from the calcite of the surrounding camerae. The apical siphuncle segments are remarkable in that the very short septal necks are clearly differentiated, and the siphuncle is faintly constricted by them. The expansion between the necks is slight, however, and the segments are scarcely convex in outline over the greatest extent of their lengths. Connecting rings are thin, poorly differentiated from surrounding materials, and show no layered structure.

Discussion. The specimen on which this species was based was at first regarded as conspecific with *M. murus*, which it resembles in general size, curvature, and rate of expansion. It is, however, evident that it is a distinct form by the much longer camerae, and the small siphuncle, slightly but clearly constricted at the septal foramina in the apical portion, is without a close parallel in the Ellesmeroceratida.

A natural section close to a lateral surface, photographed before further sectioning was done, shows that the lateral lobes of the sutures were relatively slight, the sutures essentially transverse. This section shows an apparent contraction of the shell at the aperture, the result of the position of the section, and clearly not a real feature of the species. A curious preservation phenomenon is the destruction of the siphuncle in the middle part of the phragmocone. Plainly, it was filled with calcite which, upon recrystallization, became indistinguishable from that in the camerae; the septa have suffered the same fate. It is not impossible that a diaphragm may have been present, but there is no clear indication of such a structure.

The slight constriction of the apical siphuncle segments presents the only structures in the Ellesmeroceratidae thus far found which even remotely resemble the siphuncular bulbs of the Plectronoceratidae, but even here the resemblance is not close, for the segment is not rounded in outline or greatly expanded, nor is there the thickened ring with a suggestion of layering which occurs in *Palaeoceras*. The anterior end of the siphuncle shows no such contraction, and though preservation of its structure leaves much to be desired, it is evident that the neck is here very short and not markedly lengthened, as in late growth stages of some Plectronoceratidae.

Type. Holotype, collection of the writer; No. 220.

Occurrence. From 272 to 276 feet above the base of the Threadgill member of the Tanyard formation, Threadgill Creek, Gillespie County, Texas.

Muriceras gracile Flower, n. sp.

Pl. 13, fig. 11; pl. 25, fig. 9

This is one of the larger species of *Muriceras*, comparable in size to *curviseptatum* and larger than the moderate-sized *anomalum* and *hebetum*. It is distinguished by the very slender rate of expansion of the shell, the very shallow camerae, and the slight and uniform curvature of the septa as seen in the sagittal plane of the species. The holotype is a shell exposed in sagittal section, increasing from 4.5 to 8.5 mm in height in a length of 27 mm, gently curved, the radius of curvature of the dorsum about 30 mm in the adoral part of the shell. The cross section is compressed, 6 mm wide where the height is 8.5 mm.

The phragmocone, 19 mm long dorsally and 14 mm long ventrally, increases from 4.5 to 7.5 mm in height. The basal four camerae occupy a length of 3.5 mm. Adoral camerae are obscured by calcite. The siphuncle is tubular, its wall structure clear only in the basal camerae, where short aneuchoanitic necks and slightly thickened rings can be recognized. Near the base of the specimen the siphuncle is 0.6 mm in height and 0.1 mm from the venter. Here its cavity is traversed by several diaphragms. At the adoral end of the phragmocone, the siphuncle appears 0.6 mm from the venter and 1.0 mm in height. All septa are gently curved, the depth of curvature being between one fourth and one fifth of the shell height. The living chamber, 7.5 mm high at its base, is 5 mm long ventrally and 7 mm dorsally, increasing to a height of 8.5 mm.

The profile of the living chamber is largely smooth but shows faint undulation close to the aperture on the dorsum. Both dorsal and ventral walls of the shell are markedly thinner on the anterior fifth of the living chamber than on the earlier part.

Discussion. The distinguishing features of this species have been noted in the first part of the above description. The shallow camerae and slightly curved septa are the most salient features distinguishing this from species which attain an equally large size. Aside from some fragmentary specimens, we have only the holotype of this form.

Holotype. Collection of the writer; No. 216.

Occurrence. From 272 to 276 feet above the base of the Threadgill member, Tanyard formation, from Threadgill Creek, Gillespie County, Texas.

Muriceras curviseptatum Flower, n. sp.

Pl. 14, fig. 8, 18

This is a relatively large *Muriceras*, compressed in section, rather strongly curved, but not enough to grade into *Burenoceras*, with septa strongly curved so that sections approach those of *Woosteroceras flexiseptatum* in aspect. The holotype (pl. 14, fig. 18) (No. 213) expands vertically from 5 to 8 mm in the phragmocone, 16 mm long dorsally, 14 mm ventrally. The living chamber, 8 mm long dorsally and 7 mm long ventrally, attains an adoral height of 8 mm but is weathered beyond the center, and the original shell height in the median plane was clearly at least 9 mm. Two incomplete camerae near the base average 0.6 mm long. Adorally, four camerae occupy a length of 5 mm. The anterior septa are strongly curved in vertical section, the depth of the camera being one third the shell height. Adorally, septa are increasingly curved as they approach the dorsum, meeting the dorsal wall at a sharp angle. A similar condition would be apparent on the ventral side were it not that the septa are obscured here, for the section passes through the siphuncle. The siphuncle is tubular, segmentation being obscured in its outline, ventral, increasing in the section from 0.8 mm to 1.2 mm.

A paratype, a smaller shell (pl. 14, fig. 8) (No. 214), is seen in a longitudinal section which cuts the siphuncle only in the adoral part of the phragmocone. Here the shell expands in height from 3.5 to 6.5 mm in the phragmocone, 10 mm ventrally and 14 mm dorsally. The living chamber appears to contract, being weathered adorally beyond its median plane, and is 4 mm ventrally and 6 mm dorsally, attaining an apparent height at the aperture of 6 mm, which was clearly at least 7 mm in the median plane. The oblique section through the living chamber shows clearly that the shell had a cross section much narrower than high. Septa are mainly obscured by calcite, but near the base two incomplete camerae occupy 1 mm, and adorally a camera is 0.8 to 0.9 mm in depth. Septa are deeply curved, as in the holotype. The shell is quite strongly curved.

Neither of the two specimens show anterior modifications of the wall of the living chamber which can be taken as evidence of maturity, but the holotype shows two calcite-filled anterior camerae which are shorter than the preceding camera which is clearly defined and filled with matrix.

Discussion. This form is a larger one than *murus, anomalum*, or *hebetum*, all of which show signs of attaining maturity at a much earlier stage and a much smaller shell height. The relatively commensurate forms *M. gracile* and *M. exile* are somewhat more slender, slightly less strongly curved, and lack the strongly curved anterior septa of the present form.

Types. Holotype and paratype, collection of the writer; Nos. 213, 214.

Occurrence. From 272 to 276 feet above the base of the Threadgill member of the Tanyard formation, from Threadgill Creek, Gillespie County, Texas.

Muriceras hebetum Flower, n. sp.

Pl. 14, fig. 9, 21, 22; cf. 10-12, 14

This is an appreciably larger species than *M. murus* or *M. anomalum*, the blunt apex of the shell expanding rapidly in the first millimeter of its length to dimensions nearly twice those at which *murus* shows a very slender shell.

The holotype (pl. 14, fig. 9) is a shell exposed in vertical section increasing to 1.5 mm in the first 1 mm and later more slender, so that in the length of the phragmocone a shell height of 4.5 mm is attained, the length of the phragmocone being 7.5 mm dorsally and 7 mm ventrally. The section shows a siphuncle which is filled with matrix at the anterior end of the specimen, 0.9 mm high and 0.2 mm from the venter. It can be traced apicad for a third of the length of the phragmocon and is thereafter represented by calcite largely indistinguishable from that of the camerae. One camera in the apical third is filled with matrix dorsally, but the siphuncle is indicated by a band of calcite. The apical camera is distinct, but the section fails to show the siphuncle here. The siphuncle is tubular, the septal necks very short. The apical camera, 0.3 mm deep, is succeeded by camerae filled with calcite, the septa separating them being no longer evident. The one camera with matrix in it in the apical third is 0.6 mm long. Beyond it are more camerae undifferentiated from one another and filled with calcite, but the last is distinct and is 0.4 mm long. The living chamber is incomplete, 1.6 mm ventrally, while dorsally 1.4 mm of it is in place, and a slightly dislocated piece extends it to 2.5 mm and a shell height at the aperture of 4.8 mm. Modification of outline of the living chamber is not evident, owing probably to its poor condition. A second specimen, a paratype (pl. 14, fig. 21), shows a shell of very similar proportions but lacking the apex and retaining a living chamber with dorsum and venter faintly sinuate. The phragmocone here expands from 1.7 to 5.0 mm, is 4.0 mm ventrally and 6.0 mm dorsally, and the living chamber, 3 mm long ventrally and 4.5 mm dorsally, increases to a height of 6.0 mm. Calcite fills the phragmocone, obscuring the septa, and only a short anterior part of the siphuncle is evident, 6 mm high and 0.4 mm from the venter.

Next to the holotype is a specimen regarded as belonging to the same species but shown in a section which is clearly oblique. The siphuncle is not shown. On Plate 14, Figure 11 is shown a section (No. 223) believed to be a section of the same form, but one which passes from a nearly central position apically to a lateral one at the aperture, where there is an apparent contraction of the living chamber, suggesting strongly that near the aperture the lateral sides of the shell converged slightly. There are also in our material a number of sections essentially vertical but more oblique to the longitudinal axis, and which, as a result, expand more rapidly and contract rapidly adorally, giving much the impression of a shell of the general form of a tiny *Oncoceras*, except, of course, for the tubular ventral siphuncle. These are shown on Plate 9, Figures 10 and 12 and are indicated as *Muriceras cf. hebetum*.

Types. Collection of the writer; holotype, No. 224, paratype, No. 215; additional specimens referred tentatively to the species include Nos. 223, 232, 234.

Occurrence. From 272 to 276 feet above the base of the Threadgill member of the Tanyard formation, Threadgill Creek, Gillespie County, Texas.

Muriceras moderatum Flower, n. sp.

Pl. 14, fig. 17, 23; pl. 15, fig. 5

This is a moderately large *Muriceras*, characterized by moderate expansion, well curved but generally evenly curved septa, as seen in the sagittal plane, but exhibiting some variations in proportions. The three specimens are designated as syntypes, thereby leaving full choice for any future investigator who may restrict the species further.

Syntype No. 211, Plate 14, Figure 23. This is a cyrtoconic shell exposed in a vertical longitudinal section. The phragmocone increases in height from 7 to 10 mm in the length of 22 mm dorsally and 20 mm ventrally. The siphuncle is 1.2 mm high at the base and 1.6 mm near the living chamber. Camerae occur two in 1.5 mm basally, but are exactly 1 mm long near the middle of the specimen. Anterior camerae are obscured by calcite and their length cannot be determined. Necks are aneuchoanitic, supplemented by rings which give the segments faintly concave outlines, and show an appreciable thickness and a suggestion of layering. The depth of the anterior septum is about one third the height of the shell. In section, it is somewhat flattened at midheight of the shell, curvature increasing as the septum approaches both the dorsum and venter, meeting them at sharp angles.

The living chamber, 9 mm long dorsally and 6 mm ventrally, attains an aperture 7.5 mm high. Both dorsal and ventral outlines of the living chamber are quite irregular. An incomplete cross section at the base of the specimen suggests that the cross section was approximately circular, with height and width equal.

Syntype No. 212, Plate 15, Figure 5. A slender cyrtocone exposed in a naturally weathered longitudinal section 34 mm long. The phragmocone expands from 7 to 10.5 mm in its length, 22 mm ventrally, 25 mm dorsally, but at the base the section is below the plane of symmetry, and apparent shell expansion forward from this point is deceptively rapid. In the anterior part of the phragmocone, 14 mm ventrally and 19 mm dorsally, the shell increases from 9 to 10.5 mm. The living chamber, 6.5 mm ventrally and 10 mm dorsally, attains a height at the aperture of 11 mm.

Basally, seven camerae occur in 6 mm; slightly farther orad, six camerae occupy 6 mm, but septa are quite irregular in spacing. Anterior septa are obscured by calcite in the camerae. The section passes below the plane of the siphuncle apically, but it is retained in a little more than the anterior third of the phragmocone. It is 0.8 mm in height there, and the ventral shell wall is 0.4 mm thick, part of which includes structures of the phragmocone rather than the true shell wall. Calcite obscures details. The siphuncle is nearly one fourth the height of the shell here. The anterior septum is somewhat uneven, a result of the irregular plane of the natural section here, but the septum is one fourth the shell height in depth, not flattened in the median portion as in the preceding form but with curvature of the septum becoming greater and steeper as the dorsum and venter are approached.

This form is more slender than the preceding specimen, has the septa more deeply curved in the median part of the vertical section, and is a considerably less strongly curved shell.

Syntype No. 217, Plate 14, Figure 17. This is a slender cyrtocone with rather deep camerae and a rather large siphuncle somewhat removed from the venter. The phragmocone expands in the anterior nine camerae from 4.8 to 6.2 mm in height, in a length 9.5 mm dorsally and 4.8 mm ventrally. The camerae are 1 mm in depth, the siphuncle 1 mm across apically and 0.6 mm from the venter; adorally, the siphuncle is 1.4 mm high and 0.8 mm from the venter. Septa are gently curved, their depth one fourth the shell height at the anterior end of the phragmocone and essentially the same apically. The living chamber, 9 mm dorsally and 6 mm ventrally, attains an aperture 7.5 mm high.

An oblique natural section through the base of the specimen exposes four more camerae and passes below the level of the siphuncle. It is evident that the ground section is essentially central; the large siphuncle and its position removed from the venter are real. The cross section of the shell is broad and if not circular, it is nearly so. On this basis, the form is comparable with species of *Woosteroceras*, but it cannot be reconciled with any of those known from later stages in our present material. The large siphuncle and rather deep camerae are not comparable to any of the described forms, and the rate of expansion of the shell is too great and persists to too late a growth stage for this to be an apical rapidly expanding part of any of these forms.

Types. Three syntypes, collection of the writer; Nos. 211, 212, 217.

Occurrence. From 272 to 276 feet above the base of the Threadgill member, Tanyard formation, from Threadgill Creek, Gillespie County, Texas.

Muriceras spp.
Pl. 27, fig. 10-24

Clelandoceras elongatum Unklesbay and Young, 1956, Jour. Paleont., vol. 30, p. 487, pl. 51, fig. 22, 23.

Unklesbay and Young identified as *Clelandoceras elongatum* several small endogastric cyrtoconic phragmocones from the Chepultapec of Virginia. The specimens were kindly lent for study. Though silicified so that details of the siphuncle wall cannot be ascertained, the known features are consistent with assignment instead to the Lower Canadian genus *Muriceras*. Assignment to *Clelandoceras* was reasonable at the time of the description of these forms; indeed, the only alternative would have been to regard them as diminutive specimens of *Dakeoceras*. Our present material, however, of *C. ? rarum* indicates that *Clelandoceras*, a genus of the Cassinian, has slightly expanded siphuncle segments. The Virginia specimens show some variation but, in general, are extremely compressed, show poor development of lateral lobes, and are somewhat more gently expanded vertically than in typical *C. elongatum*. In all these features they approach our present material of *Muriceras*, except that material of this genus fails to show the extreme compression of cross section, which in the Virginia material may well be the result of distortion. It seems pointless, in view of probable distortion of proportions and the necessary dependence of recognition of species upon shell proportions, to attempt close specific evaluation. The several specimens show in themselves some variation which may indicate more than one species, but decision on the matter is not really possible as the degree of variation produced by distortion is impossible to estimate.

The specimens here illustrated show some considerable variation. Plate 27, Figures 10-12, shows distortion in that sutures describe broad lobes on one lateral surface but are transverse on the other. Plate 27, Figures 13-15, shows the same general suture pattern and is strongly compressed. Figures 16 and 17 show sutures swinging apicad on the dorsum. Figures 18 and 19 are early stages, showing considerable variation in curvature and rate of expansion. Figures 20 and 21 show a fairly rapidly expanding bit of phragmocone; the anterior end shows irregularities which suggest distortion. Figures 22 to 24 show probably the least distortion, but the siphuncle is slightly askew, as seen from the adoral side.

The Virginia specimens are Nos. 12724 and 12725, the latter containing a series of six unfigured fragments, in the University of Missouri collections; all are from the Chepultapec of Virginia.

Muriceras spp.
Pl. 5, fig. 7-11

Shelbyoceras sp. Unklesbay and Young, 1956, Jour. Paleont., vol. 30, p. 484, pl. 51, fig. 1.

Shelbyoceras cf. *S. bessemerense* Unklesbay and Young, ibid., p. 483, pl. 51, fig. 2.

Unklesbay and Young figured the two specimens cited above and described them briefly, assigning them to *Shelbyoceras*. The material was kindly lent for study. The larger specimen, *Shelbyoceras* sp., is a silicified portion of a phragmocone, compressed, endogastric, clearly showing a ventral siphuncle at the adoral end. Its assignment to *Shelbyoceras* was influenced by the cross section at the anterior end, which is more narrowly rounded dorsally than ventrally. This condition is not, however, found at the apical end of the specimen. The irregularity in form combined with the eccentric position of the siphuncle at the adoral end suggest that the present shape and cross section are in part the result of slight distortion. In view of the absence of a siphuncle on the concave side of *Shelbyoceras*, indeed, present evidence indicates it to be an exogastric cephalopod; assignment of this species to the genus is not possible; instead, the species fits the genus

Muriceras, but distortion forbids close comparison at the specific level.

The same remarks may be applied to S. cf. S. *bessemerense*. This is based upon a smaller fragment, again suggesting some distortion by irregularities of profile and section. The siphuncle, though obscurely preserved, is clearly on the concave side of the shell.

Both specimens, Nos. 12711 and 12712, are in the University of Missouri collections and came from the Chepultapec of Virginia.

Muriceras (?) obscurum Flower, n. sp.

Pl. 20, fig. 8-10

This is a tiny, slender, endogastric, compressed cyrtocone, known as yet only from one specimen. The type is 19 mm long, most gently curved, expanding from 3.5 and 4 mm at the base to 7.0 and 8.5 mm at the adoral end. The section is only moderately compressed, very slightly more narrowly rounded ventrally than dorsally. Six camerae, subequal, occupy the basal 4.5 mm; they show lateral lobes, rather sharply bent at the middle of the lateral surfaces, rising to saddles higher dorsally than ventrally. The apical end shows a tiny siphuncle 0.3 mm across, circular in cross section, separated from the venter by less than half its diameter. The siphuncle wall is dark and suggests a thick connecting ring such as is common in the Ellesmeroceratidae. It suggests a perfectly tubular siphuncle, also, but the observation does not include a clear septal foramen. Bits of the shell adhering to the specimen indicate an essentially smooth exterior. The living chamber is incomplete adorally, 15 mm long, increasing in shell height from 5.0 at the base to 8.5 mm.

Discussion. Probably the greater part of the length of the living chamber is retained on this specimen, though it is broken adorally and there is no trace of the aperture. There is clearly no indication of such adoral contraction as is shown in *Clelandoceras (?) rarum*; rather, the shell is gently expanded throughout. The observed camerae show no indication of maturity. The type is somewhat friable from weathering, and any attempt to explore the siphuncle by a section seemed likely to result in crumbling of the phragmocone. Interestingly, this form from the first piloceroid zone was at first considered as belonging to the otherwise Cassinian genus *Clelandoceras* and presented evidence of a tubular siphuncle and an uncontracted aperture at variance with that presented by *C. (?) rarum*. However, with further comparison, it was found that this form differs from typical *Clelandoceras* in that the venter is more narrowly rounded than the dorsum, in this respect agreeing with *Muriceras*, but differing, however, in the relatively small siphuncle and the fact that the siphuncle is definitely, though only slightly, separated from the ventral wall of the shell.

The first piloceroid zone which yielded this specimen contains in its upper part some hard calcilutite layers with abundant small shells. The type came from such an association. Ordinarily, such shells are not only hard to see because of slight color differentiation, but also they commonly fail to separate from the matrix, and the separation of the type of this species is the result only of propitious weathering. This specimen is notable as the only moderately expanding, endogastric, compressed cyrtocone between the close of the Lower Candian and the appearance of *Clelandoceras* in the Cassinian. In aspect, it is typical of the Ellesmeroceratidae except in the small diameter of the siphuncle and its slight removal from contact with the ventral wall of the shell. As noted under the discussion of *Clelandoceras ? rarum*, this specimen may well be our one indication of a lineage developed from *Muriceras*, surviving through the Demingian and Jeffersonian and culminating in *Clelandoceras*, which, from *C. (?) rarum*, sems to be slightly contracted at the aperture and to be further specialized in slight expansion of the siphuncle segments.

Holotype. No. 855, from the first piloceroid zone of the El Paso group, from the section in the Cooks Range, New Mexico. A second specimen, poorly preserved, is from the same horizon from exposures on the east side of the Florida Mountains.

Genus RUTHENOCERAS Korde

Genotype: *Ruthenoceras elongatum* Korde

Ruthenoceras Korde, 1949, Adad. Nauk U. S. S. R., Doklady, v. 49, no. 5, p. 672.
Angaroceras Korde, 1949, ibid., p. 673.
Ruthenoceras Flower, 1954, N. Mex. Inst. Min. and Tech., State Bur. Mines and Mineral Res., Bull. 40, p. 22-25.

Flower (1954) has shown that the two chance-oriented sections on which Korde based *Ruthenoceras elongatum* and *Angaroceras globosum* are not demonstrably distinct and probably represent a single species. Neither are they members of the Ascoceratida (formerly Mixochoanites) but show the ventral tubular siphuncles of the Ellesmeroceratidae.

The shells are tiny endogastric cyrtocones and are apparently different from any of the genera here described, except the much larger *Stemtonoceras*, in being so gently expanding as to be essentially tubular. Oddly, while I had regarded *Ruthenoceras* as a genus which could not be recognized, our material from the Tanyard formation of the Llano uplift has yielded two specimens, both represented by chance-oriented sections, which agree with *R. elongatum* in gentle curvature and extremely gentle rate of expansion, differing in that the siphuncle is smaller in relation to the height of the shell. Though we do not know the cross sections or suture patterns, these forms are worth illustrating and describing.

The discovery of these similar forms in the Gasconadian makes one wonder whether the original material of *Ruthenoceras* is really from the Upper Cambrian, as Korde stated. The Cambrian age is reported as having been determined by S. V. and V. A. Obruschev, but without a statement as to the associated fauna, which is not given, there is no evidence supporting this conclusion. Oddly, the discovery of rather similar forms in the Gasconadian makes the Cambrian assignment of the Siberian material more suspect, but the discovery of *Ectenolites* in the Trempealeauan of the Llano uplift would suggest that other Ellesmeroceratidae, and possibly *Ruthenoceras* itself, might be found in the true Upper Cambrian.

In spite of the most inadequate information supplied by the type material of *R. elongatum*, there is no similar tiny member of the Ellesmeroceratidae known combining gentle curvature with extremely gentle expansion. Figure 27 reproduces the figure and interpretation of *R. elongatum* of Flower, 1954.

"*Ruthenoceras*" sp.

Pl. 14, fig. 19, 20; pl. 15, fig. 4

One small specimen from the Threadgill Creek locality

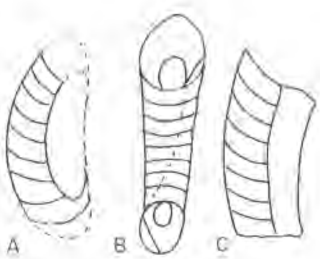

Figure 27
Ruthenoceras elongatum Korde

A. The chance-oriented section on which the species was based, slightly restored. B. Ventral view, restored, showing the essential relationship between the plane of the section with A, with the shell as a whole. C. Restored sagittal section of a portion of the phragmocone.

was ground to two slightly different levels, at one of which a chance-oriented section is found very similar to Korde's original figure of *Ruthenoceras elongatum*. The section here is essentially vertical, central apically, eccentric adorally, as a result of which the shell and siphuncle both show an adoral contraction which is, of course, the result of the relation of the section to the plane of symmetry. In its present condition the shell is 1.8 mm high at the base, where four of the five clearly apparent camerae occupy a length of 1 mm. Anterior to the five camerae, the shell contracts further, but the shell wall is not clear, and the interior is occupied by dark granular material.

At a very slightly higher level, a section of the same specimen showed a very different aspect. Here is a cyrtoconic slender shell, with a part of a living chamber, an anterior part of a phragmocone filled with calcite, corresponding to the anterior obscure portion of the preceding section, apicad of which are five and part of a sixth camerae largely occupied by matrix, with the septa preserved. Calcite occupies much of the venter of these camerae but shows no indication of the siphuncle.

Figured specimen. Collection of the writer; No. 236.

Occurrence. From the Threadgill member of the Tanyard formation, Threadgill Creek, Gillespie County, Texas.

Possible apices
Pl. 14, fig. 14, 18

The various sections have shown several sections of small straight or curved shells, with the apex subconical, much more deeply curved than the septum seem shortly anterior to it. Such sections so far encountered have shown calcite between the septum and the apex, and in the calcitic area no trace of a siphuncle has been observed. Presumably, the siphuncle has been lost in cutting the section in every one of the few examples so far observed, though it is evident that the siphuncles in these tiny shells may be destroyed where calcite occupies both camerae and siphuncle, apparently as the result of recrystallization. Where such recrystallization has occurred, it is possible, however, to detect the anterior septal neck, at least when the plane of the section intersects the siphuncle.

Figured specimens. Nos. 213 and 238. From the Threadgill limestone, Threadgill Creek, Gillespie County, Texas.

POST-GASCONADE ELLESMEROCERATIDAE

So significant is the concentration of Ellesmeroceratidae in the Lower Canadian, and so marked is the decline of the family at the close of that interval, that the younger genera are here grouped together. They are unrelated and plainly a heterogeneous lot. Most of them are poorly known morphologically, and our present findings in relation to *Clelandoceras* suggest that others of these genera may also show some significant departures from the general structural pattern of the family. The genera may be summarized as follows:

Copiceras. This is seemingly a rather large *Ellesmeroceras* with an unusually small ventral siphuncle. No structural details of the siphuncle are known. There is one Cassinian species.

Cumberloceras. This is a rapidly expanding endogastric form apparently allied to *Levisoceras, Dakeoceras,* and *Burenoceras;* small species have been confused with this last genus. Diaphragms are well developed, the shell becomes costate, most marked in the larger species, and the genus appears to be a good member of the Ellesmeroceratidae surviving into the Demingian, with one species in the still younger Jeffersonian.

Beekmanoceras. This genus is known only from poor silicifed steinkerns in dolomites of the Demingian in the Champlain Valley. It is a small, rather rapidly expanding, endogastric gyrocone apparently of circular section. As *Woosteroceras* of the Lower Canadian is apparently a looser, more slender, gyrocone of circular section, the separation of *Beekmanoceras* into a family by itself is not necessary or possible Structural details remain unknown.

Clelandoceras is a tiny endogastric cyrtocone, moderately slender, previously known only from silicified bits of phragmocones in the Cassinian. New material suggests that the siphuncle segments are slightly expanded and the mature aperture slightly contracted. Such material is described as *Clelandoceras (?) rarum,* and such a development clearly occurs in the Cassinian. Some question could be raised as to whether this form is a *Clelandoceras* or a new genus. The former treatment is at least the more conservative of the two in reference to proposal of names.

Oelandoceras is a moderate-sized endogastric cyrtocone known only from the Glauconitkalk of the Scandinavian–Baltic region, apparently Cassinian. In form and in the siphuncle wall, as described by Foerste, this seems typical of the Ellesmeroceratidae and close to our simpler endogastric genera.

Genus COPICERAS Ulrich, Foerste, Miller, and Unklesbay

Genotype: *Copiceras erectum* UFM&U

Text Figure 17

Copiceras Ulrich, Foerste, Miller, and Unklesbay, 1944, Geol. Soc. Amer., Special Papers, no. 58, p. 65.

This genus is erected for a single species, characterized as a large, straight cephalopod, compressed in cross section, with slight lateral lobes, very closely spaced camerae. The siphuncle is small in proportion to the size of the shell, its segments are cylindrical, their structure not definitely known.

Ulrich, Foerste, Miller, and Unklesbay compared this genus to *Bassleroceras*. This is, of course, not impossible, but the shell could more easily be considered an *Ellesmeroceras* which has grown to a large size and in which the growth of the siphuncle did not keep pace with that of the rest of the shell. The genus is tentatively regarded as one of the post-Gasconade genera assigned to the Ellesmeroceratidae. A relationship with the contemporaneous Baltoceratidae is possible, but there does not seem sufficient basis for proposing affinities with any forms now assigned to that family. It falls by definition within the Ellesmeroceratidae and is therefore placed there.

C. erectum, the only species, is from the Smithville formation of Arkansas.

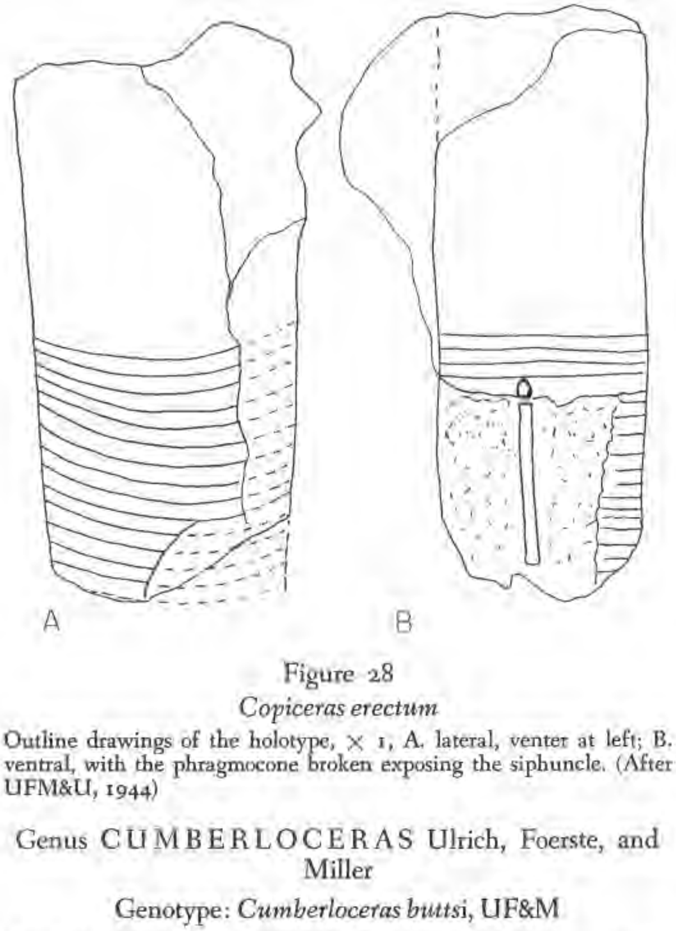

Figure 28
Copiceras erectum

Outline drawings of the holotype, × 1, A. lateral, venter at left; B. ventral, with the phragmocone broken exposing the siphuncle. (After UFM&U, 1944)

Genus CUMBERLOCERAS Ulrich, Foerste, and Miller

Genotype: *Cumberloceras buttsi*, UF&M

Cumberloceras Ulrich, Foerste, and Miller, 1943, Geol. Soc. Amer., Special Papers, no. 49, p. 106.

Cumberloceras is a short, rapidly expanding, rather strongly curved endogastric cyrtocone. The phragmocone is most incompletely known, but the siphuncle shows conical expansion. The living chamber is short, may show a slight adoral decrease in the rate of expansion resulting in convex profiles, but is uncontracted. The genotype shows costae that are faint or only most poorly indicated in other species, which may perhaps be a matter of preservation. Characteristically, the siphuncle is unusually large at the base of the living chamber, ranging up to half or even a little more than half the height and width of the shell there. The rounded apex of the siphuncle as seen in steinkerns is indicative of diaphragms, which must extend well orad in the phragmocone.

Discussion. Though this genus is known only from steingerns, it shows the general form of such Ellesmeroceratidae as *Levisoceras* and *Burenoceras* and cannot be regarded as distinct from the family. *Burenoceras* is a smaller shell, having a much smaller siphuncle in proportion to the base of the living chamber. *Levisoceras*, with which this genus is more in accord in size, also has a proportionately smaller siphuncle; species are commonly narrower in cross section.

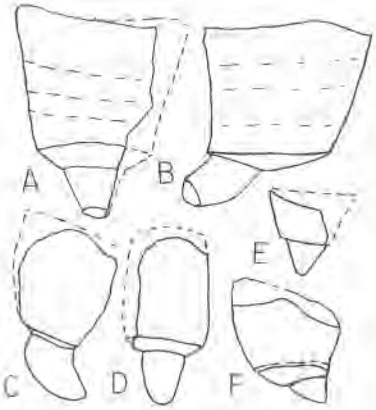

Figure 29
Cumberloceras

A. Ventral view of *C. buttsi*, dashed lines indicate concavities between low costae, Longview limestone, Tennessee. B. Lateral view of the same, venter on left. C. C. sp., lateral view venter on right, Jefferson City dolomite, Buffalo, Missouri. D. Same form, dorsal view. E. *C. elwayense*, ventral view of holotype. Longview limestone, Elway, Virginia. F. Same lateral view.

UF&M (1943) described the genotype *C. buttsi*, a relatively large species with costae showing clearly on the ventral side of the living chamber; apparent absence of costae laterally and dorsally is possibly the result of rather poor surface preservation. At the base of the living chamber the siphuncle is half the shell width, but between a half and a third of the shell height; its blunt apex plainly represents a diaphragm. *C. elwayense* is a smaller species without obvious costae; at the base of the living chamber the siphuncle is three fourths the shell width and scarcely less than half the shell height. Both species are from the Longview limestone, the former from Tennessee, the latter from Virginia. In addition, these authors figured as C. sp. a rather poorly preserved steinkern of a living chamber gently expanding vertically, the lateral sides subparallel, from the base of which protrudes a siphuncle rapidly expanding apically, slender adorally, but slightly more than half of both the width and height of the base of the living chamber. This form is from the Jefferson City dolomite of Missouri.

Heller (1954, p. 41, pl. 17, fig. 1) identified a Roubidoux species as *Burenoceras pumilum* which, from the description, is possibly a small *Cumberloceras* allied to the form described below.

Below is briefly described a new species from the Gorman of central Texas which is a small—indeed, one might call it an abortive—species of the genus which was formerly identified in terms of the genus *Burenoceras*. Age, siphuncle size, and general aspect indicate that it is closer to *Cumberloceras* than to the older *Burenoceras*.

Cumberloceras llanoense Flower, n. sp.

Burenoceras sp. Cloud and Barnes, 1946, Univ. of Texas, Publ. 4621, pl. 41, fig. 38, 39, 43.
Burenoceras pumilum Unklesbay, 1954, Jour. Paleont., vol. 28, p. 638, pl. 68, fig. 7-8.

This is a species which has been illustrated and described by Unklesbay under the name of the Van Buren species *Burenoceras pumilum*. The living chamber, 8 and 3 mm at the base, increases to 11 and 8 mm near the anterior end, not quite complete, and the living chamber shows a length of 8 mm. One camera is retained at its base, very short, the suture almost straight laterally; from the apical end protrudes the internal mold of a rather large siphuncle, the apex of which seems broken but suggests a general conical shape. The surface is poor but shows the faintest trace of costae.

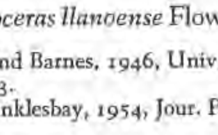

Figure 30
Cumberloceras llanoense
Holotype; A. dorsal view; B. lateral view; Gorman formation, central Texas; × 1.

Discussion. Though this species has the general aspect of some species of *Burenoceras*, it is also interpretable as a small (indeed, one may be tempted to call it an abortive) species of *Cumberloceras*. Affinities with *Cumberloceras* rather than *Burenoceras* are indicated by the relatively large conically expanding siphuncle and the vestiges of costae. *Cumberloceras elwayense* is, indeed, a species which is only slightly larger and shows a siphuncle slightly larger in proportion to the shell at the base of the living chamber; this species also lacks the prominent costae which are found in the genotype, *C. buttsi*. In size, *C. llanoense* is small for *Cumberloceras*, but it is also large for *Burenoceras* and from dimensions alone seems slightly closer to the former than to the latter genus.

Genus BEEKMANOCERAS Ulrich and Foerste 1936

Beekmanoceras Ulrich and Foerste, 1935, Denison Univ. Bull., Sci. Lab., Jour., vol. 21, p. 10.
——— Ulrich, Foerste, and Miller, 1943, Geol. Soc. Amer., Special Papers, no. 49, p. 156.

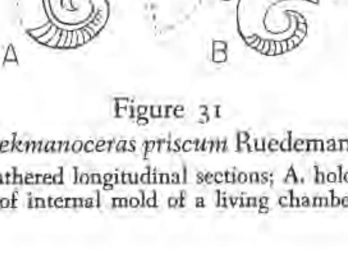

Figure 31
Beekmanoceras priscum Ruedemann
A-B. Natural weathered longitudinal sections; A. holotype; B. a paratype. C. Portion of internal mold of a living chamber. D. Cross section of C. × 1.

Only the genotype, *B. priscum*, is known. The material consists of rather rough dolomitic or siliceous fillings of internal molds on weathered surfaces, and one specimen shows enough of an external mold to indicate a shell of circular rather than compressed cross section. The specimens indicate a small gyroconic shell, attaining at least one and a half volutions. There is a small, ventral, tubular siphuncle. Septa on the dorsal side of the siphuncle swing forward, and the sutures, though none is clearly shown, should slope forward from venter to dorsum. Nothing is known of the detailed structure, and the structure of the siphuncle wall can only be inferred. However, the assumption of holochoanitic structure is unwarranted, and this genus appears to by a gyroconic development of the Ellesmeroceratidae which developed in middle Canadian time. *Woosteroceras* is comparable in the broad cross section, but the shell is much more slender and not nearly so closely coiled.

The single species, *B. priscum* (Ruedemann), originally assigned to *Cyrtendoceras*, is known only from the Spellman ledge near Beekmantown, New York. This ledge I was unable to identify with certainty, and neither records nor Dr. Ruedemman's memory was of more than general help, but at the location given there are ledges of Middle Canadian age with *Lecanospira* and a few poorly preserved cephalopods, among them the endoceroids which Ruedemann described as *Endoceras* (?) *champlainense* (Ruedemann, 1906, pl. 1, fig. 1-2) which possibly includes both fragments of *Proteoceras* and of *Clitendoceras* (Ruedemann, ibid., pl. 1, fig. 3).

UF&M (1943) erected the Beekmanoceratidae for this genus alone, but its strong curvature is approached by the Lower Canadian *Woosteroceras*, which supplies such gradation into the Ellesmeroceratidae that is is impossible to draw a line between the two possible families. It therefore seems undesirable to recognize the Beekmanoceratidae but to refer *Beekmanoceras* tentatively (its detailed siphuncle structure being necessarily unknown) to the Ellesmeroceratidae.

Genus CLELANDOCERAS Ulrich, Foerste, and Miller

Genotype: *Clelandoceras elongatum* UF&M

Clelandoceras Ulrich, Foerste, and Miller, 1943, Geol. Soc. Amer., Special Papers, no. 58, p. 134.

The genus *Clelandoceras* was based upon a suite of tiny, compressed endogastric cyrtocones, section more narrowly rounded dorsally than ventrally, the sutures with lateral lobes, the ventral siphuncle tubular. The known specimens were silicified phragmocones; no living chamber had been found. Two species were recognized, *C. elongatum* and *C. breve*, both from the Smithville beds of Arkansas. The authors suggest that if the shell of *Plectronoceras* does not have the cross section more narrowly rounded dorsally than ventrally, *Clelandoceras* is a synonym. *Clelandoceras* is also comparable to small *Dakeoceras*, *Stemtonoceras*, which is more slender, and *Levisoceras*, which is more rapidly expanding and more curved, but all these genera have the venter more narrowly rounded than the dorsum.

Flower (1956) figured and described as *Clelandoceras* sp. some very fragmentary phragmocones from the late Canadian of Maryland, representing a form which is evidently specifically distinct and having extremely shallow camerae.

Clelandoceras elongatum as identified in the Chepultapec of Virginia by Unklesbay and Young (1956) is certainly not that species, and the age suggests assignment instead to the genus *Muriceras*.

New material has shown diversity of structure in small cyrtocones of the general aspect of *Clelandoceras*. First, a group of similar tiny cyrtocones was found in the Tanyard formation of Texas of Gasconade age. These small shells have ventral tubular siphuncles and living chambers which are uncontracted, though with gentle undulations just before the mature aperture. These shells differ from *Clelandoceras* in that the cross section is either equally rounded dorsally and ventrally or else the venter is the more narrowly rounded of the two extremes. These shells constitute the nucleus of the new genus *Muriceras*.

While cutting for other material, a species was found in the Cassinian part of the El Paso limestone, in beds equivalent to the Smithville which yielded the material on which *Clelandoceras* was based, revealing a cyrtocone which may well be a *Clelandoceras* but shows two features new to the genus. The living chamber is preserved, and it shows faint vertical and strong lateral contraction of the aperture; the shell had, when complete, much the shape of that of an *Oncoceras*, except of course that this is endogastric and *Oncoceras* is exogastric. A second surprise was the fact that the small ventral siphuncle is composed of segments very slightly convex in outline, with curvature most marked at the ends of the segments. The contracted aperture is as possible for *Clelandoceras* as an open one. As the expansion of the siphuncle segments is concentrated at the two ends and might well be obscured by the septa in viewing a partially exposed siphuncle from its exterior in silicified material, this feature, though at variance with the original description, seems a perfectly possible emendation for the genus as a whole. It should be noted, however, that certain assignment to *Clelandoceras* and the consequent revision of the definition of the genus are conclusions which are necessarily inferrential.

Oddly, a third form turned up which seemed to have bearing on the problem, a tiny cyrtocone from the first piloceroid zone of the El Paso. This specimen shows an open aperture and a tubular siphuncle. At first the possibility was considered of including this in *Clelandoceras* and erecting a separate genus for the other and more anomalous *C. rarum*. However, this form differs from *Clelandoceras* in that the cross section is more narrowly rounded ventrally than dorsally, and so it is tentatively referred instead to *Muriceras*, otherwise a Lower Canadian genus. It seems not improbable that *Muriceras* of the Lower Canadian may be the point of origin of one of the rare post-Gasconade surviving lineages within the Ellesmeroceratidae and that *M. (?) obscurum* represents a sample of this continuity, but that by Cassinian time such differentiation as indicated by *C. (?) rarum* in the faint expansion of the siphuncle segments and the contracted aperture had developed. To be sure, these features are at such variance with those of the typical Ellesmeroceratidae that a separate family could be erected for *C. rarum*, but obviously the present nomenclatorial problem and the doubtful identity of this species with *Clelandoceras* makes such a course premature at the present time. Also, it may be questioned whether regard for definition is of sufficient importance that a family should be erected for this single rare genus.

Clelandoceras (?) rarum Flower, n. sp.

Pl. 20, fig. 1-3, Text Figure 32

Under this name is described an endogastric cyrtocone known from two opposing faces of a cut. The shell is an endogastric cyrtocone with close septa and a ventral siphuncle, clearly of the general aspect of a *Clelandoceras*, but the information supplied by the two surfaces leaves some doubt as to whether this is best considered an additional species of the genus or whether a new genus should be erected for it. One section cuts the venter, at least at its center, as is shown by the marginal position of the siphuncle, but the planes of the sectioned surfaces are longitudinally oblique to the axis of the shell.

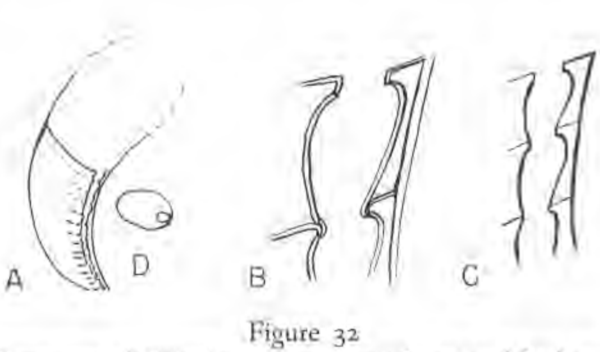

Figure 32

A. Restoration of *Clelandoceras rarum*, sagittal section. Adoral part restored. B. Restoration and enlargement of anterior siphuncle segments. C. Smaller enlargement of B, showing thick rings in contrast to septa and distance of siphuncle from the venter. D. Hypothetical cross section.

One surface (pl. 20, fig. 2) shows a phragmocone 6 mm long enlarging rapidly to a height of 7 mm, beyond which only the ventral wall of the living chamber is preserved for a length of 8 mm. It is this surface which preserves four anterior segments of the siphuncle in a length of 3 mm, showing short vestigial necks, rings thicker and darker than the necks, outlining segments very faintly convex on the dorsal side and more strongly expanded on the ventral side. The opposing surface (pl. 20, fig. 1) shows a phragmocone of 10 mm, increasing in height from 5 to 8 mm, beyond which the ventral profile extends for 10 mm, reversing curvature from concave to convex; the dorsal profile extends for 13 mm and is more strongly convex throughout, showing a very slight anterior increase in curvature suggestive of an aperture which might be very slightly contracted. Calcite fills all the phragmocone except the last camera, and this surface shows no trace of the siphuncle. The plane of the section should intersect the siphuncle apically, and the present appearance may be due to calcite in the apical part of the siphuncle which has, under recrystallization, merged with the calcite of the phragmocone.

Discussion. This species is of importance in that it is the first indication of a small endogastric cyrtocone in the late Canadian (Cassinian) with faintly expanded siphuncle segments and a contracted aperture. Previously known breviconic shells of this general age are confined to the Cyclostomiceratidae, and the genus *Cyclostomiceras*, which contains essentially straight shells of depressed section and ventral siphuncles composed of faintly concave segments of short necks and layered rings.

It seems eminently reasonable that *C. rarum* may represent *Clelandoceras*, the living chamber of which was previously unknown, for the siphuncle, previously observed from exfoliated silicified phragmocones, might well under such circumstances fail to show the slight expansion of the segments, since such expansion is most marked at the ends which might be concealed externally by the septa. Some question may always remain until a living chamber is found pertaining to the genotype, *C. elongatum*, and the possibility of such a find seems rather remote. The tentative assignment of this species to *Clelandoceras* seems a more conservative course than the erection at this time of a new genus.

From only two sections, interpretation of the form of the living chamber is necessarily approximate. It is evident that the strong adoral contraction indicated by Plate 20, Figure 1, is not in the vertical plane, but this section is perhaps nearly central at the base, becoming increasingly eccentric as it is traced adorally, so that the apparent vertical expansion is more a result of lateral than real vertical contraction. In Plate 20, Figure 2, the section is central at the base of the living chamber; the rapid expansion of the phragmocone is exaggerated, and one would expect the adoral part to be slightly off-center. The venter on the living chamber is nearly straight, very faintly convex. The dorsum is largely wanting. It is uncertain whether the curved bit of shell seen in section in the upper left is a part of the living chamber which is wanting basally, possibly continuous outside the plane of the section, or whether it is completely adventitious. In any case, it is apparent that the living chamber has an appreciable lateral contraction near the aperture, and probably a relatively slight vertical contraction.

Holotype. Collection of the writer; No. 813.

Occurrence. From the thin-bedded limestones of the Cassinian portion of the El Paso, 80 to 100 feet below the top of the unit B2b of Cloud and Barnes of the El Paso group. The specimen came to light only by the merest chance, being found on a cut made for the extraction of associated coiled cephalopods, in this case because the paratype of *Centrotarphyceras longicameratum* was on a piece of limestone a little too thick to fit well in the collections. The material lies above the calcarenite with *Hesperonomiella* and below the asaphid layers in the upper half of unit B2b and is from McKelligon Canyon, at the southern extreme of the Franklin Mountains at El Paso.

Genus OELANDOCERAS Foerste
Text Figures 33, 34

Genotype: *Oelandoceras haelluddenense* Foerste

Oelandoceras Foerste, 1932, Ohio Jour. Sci., vol. 32, no. 8, p. 170.

This genus was erected for endogastric, slightly compressed shells, sutures slightly inclined forward on the convex dorsum, with faint lateral lobes, siphuncle of straight or concave segments with short septal necks. No deposits are known in the siphuncle.

Foerste erected this genus for the reception of three species from the Glauconitkalk, *O. haelluddenense* from Oeland, *O. byrumense*, also from Oeland, and *O. kristdalaense* from Smoland, Kristadala, Humlenaes; the horizon of the last form is somewhat doubtful.

The genotype (Text fig. 33A, B) is a slender shell which, unless it has an apical end that is blunt, rapidly expanding until the shell reaches an unusually large size, is possibly gyroconic; the known portion, however, shows only a little less than a quarter of a volution. *O. byrumense* (Text fig. 34A, B) is a considerably larger species, cyrtoconic, and with lateral lobes only vestigial. *O. kristdalaense* (Text fig. 34C, D) is relatively large; it shows a living chamber and a small portion of the anterior part of the phragmocone. It is distinctive in that the dorsum is faintly convex, but the venter is straight. Curvature is slight, and the species could, when complete, have only shown crytoconic curvature.

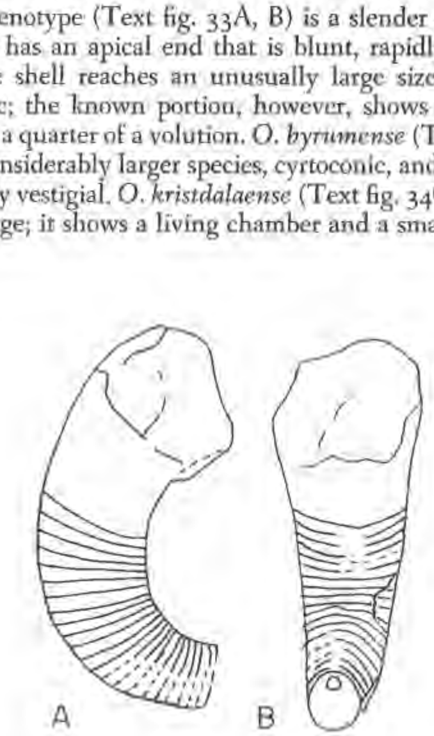

Figure 33

Oelandoceras haelluddenense, the genotype of *Oelandoceras*. A. Lateral view, venter on right. B. Ventral view, both after Foerste, 1932. × 1.

What is known of this genus is consistent with placing it in the Ellesmeroceratidae. The Glauconitkalk, the source of certainly two and possibly all three of the species, apparently is late Canadian in age, and if so, *Oelandoceras* is one of the isolated Ellesmeroceratidae surviving beyond the close of the Lower Canadian. The writer has not seen material of the genus, the siphonal structure has not been illustrated, and it may be that this form is specialized beyond the normal limits of the family. The range of proportions shown by the three species would place this genus close to a number of Lower Canadian Ellesmeroceratidae in general aspect. *O. kirkdalaense* is close to such species as *Clarkeoceras luthei* but shows a much less marked adoral slope of sutures on the dorsum. *O. byrumense* is also close to species assigned to *Clarkeoceras*, but its sutures fail to slope adorally on the dorsum. The genotype, however, while suggestive of species of *Clarkeoceras*, *Conocerina*, and *Dakeoceras*, differs from all three, and there are no really closely similar species. It is more curved than known *Dakeoceras*, less rapidly expanding than either *Clarkeoceras* or *Conocerina*, and also shows stronger curvature.

FAMILY BALTOCERATIDAE Kobayashi

The Baltoceratidae, as here defined, consists of a stock of dominantly straight, slender, smooth shells derived from the Ellesmeroceratidae, subcircular or depressed in cross section, with a siphuncle which lacks diaphragms. In the family there is some simplification of the connecting ring and the

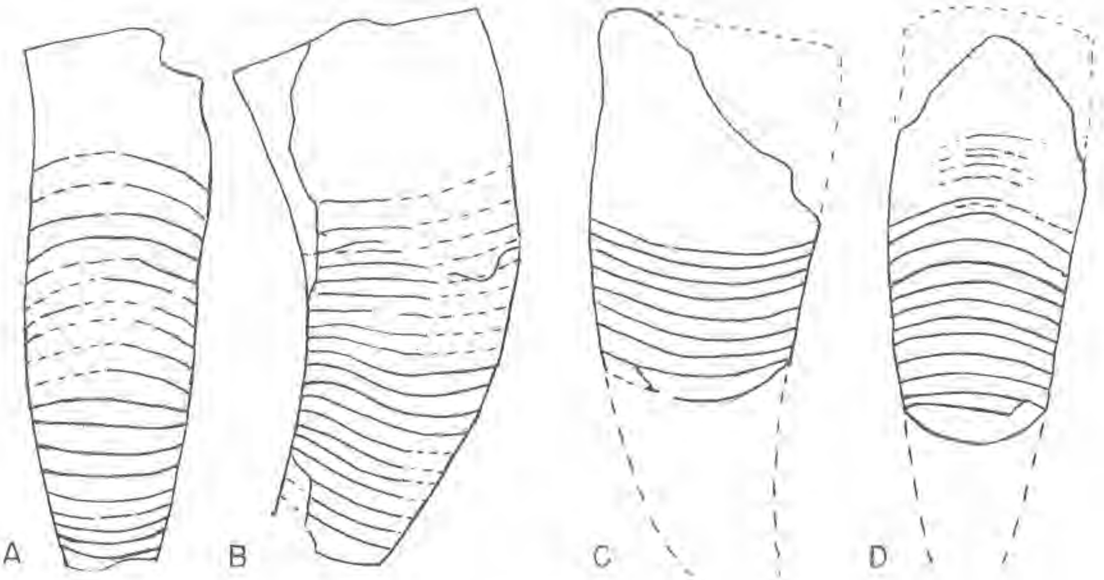

Figure 34
Oelandoceras

A.B. *O. byrumense*, holotype; A. dorsum; B. lateral view, venter on left. C.-D. *O. kristdalaense*. C. lateral view, venter at right, outlines partially restored. D. Dorsal view. All × 1, after Foerste, 1932.

primitively ventral siphuncle comes to assume a more central position.

Its relationships are indicated in Text Figure 2; it is derived from the Ellesmeroceratidae and gave rise to the small, straight breviconic family Cyclostomiceratidae and is also the source of the Michelinoceratida.

Some genera are similar to some Ellesmeroceratidae to a vexing extent. It has been necessary, because they show diaphragms and thus agree with the Ellesmeroceratidae, to include in that family the smooth orthoconic genera of circular and depressed cross sections, *Pachendoceras* and *Robsonoceras*. Species of *Pachendoceras* are certainly Lower Canadian, and a similar assignment of age seems probable for *Robsonoceras*. Species of the Middle Canadian genus *Rioceras* of the Baltoceratidae resemble these genera quite closely, and the inception of the Baltoceratidae is drawn morphologically on the disappearance of diaphragms. In view of the difficulty in demonstrating diaphragms, this definition is drawn with some reluctance, but no other is possible, and it serves also to mark the boundary between the Lower Canadian Ellesmeroceratidae and the Middle Canadian inception of *Rioceras*.

After the boundary was thus seemingly satisfactorily established, the Lower Canadian genus *Microbaltoceras* came to light. This is, by definition, a member of the Baltoceratidae and is here treated as such. It is a small orthoconic shell of circular section, rather rapid conical expansion, with a ventral tubular siphuncle. It suggests from its factual evidence another possible origin of the Baltoceratidae in the Ellesmeroceratidae, quite apart from that suggested for *Rioceras* from *Pachendoceras* and *Robsonoceras*, themselves closely related genera, for it suggests that through *Microbaltoceras* the Baltoceratidae might have their inception in this Lower Canadian genus. However, as tiny Ellesmeroceratidae in the same association which yielded *Microbaltoceras* may fail to show diaphragms, it is not impossible that this genus is properly a member of the Ellesmeroceratidae, and may be an isolated genus departing from the general pattern of compressed shells with lateral lobes which dominates in that family; more material might readily show diaphragms. From the facts now available, we have had no course other than to consider *Microbaltoceras* as a member of the Baltoceratidae, but future work may show diaphragms requiring its transfer to the Ellesmeroceratidae.

The known Baltoceratidae are not numerous, either in terms of the number of species known or, for many species, the number of specimens available, though in a few forms represented by my own collecting, good suites of specimens have been studied. Probably the scarcity of these forms is more apparent than real. Species are relatively small, generalized, and nondescript and are overshadowed by the larger and more striking Endoceratida and Tarphyceratida in the later Canadian. They are the sort of shells that are apt to be overlooked in collecting, and that my own collecting has added materially to the known forms lends some slight support to the belief that this has been generally true in the past and that with more careful work more species will be made known and the forms will be found to be more widely distributed, particularly in the Middle and Upper Canadian, than now seems apparent.

In Middle and Upper Canadian time the general pattern of the Baltoceratidae, straight, smooth, slender shells, subcircular in section, with relatively simple sutures and a ventral siphuncle, is a generalized one. Potentially at least, shells of similar aspect may develop in the Endoceratida and again in the Tarphyceratida. We are faced in dealing with the Baltoceratidae with the following questions: Can some or all of the family be developed either from the Proterocameroceratidae, the simpler and more primitive Endoceratida, or from straightening of the dominantly exogastric Bassleroceratidae of the Tarphyceratida? Is it possible, granting the validity of much of the Baltoceratidae as here defined, that we may have placed with it homeomorphs derived from the endoceroid and tarphyceroid lineages? Is it possible that some other stocks, as the dominantly annulated Protocycloceratidae, may have produced smooth, slender shells of the aspect of the Baltoceratidae? There are, further, really two aspects to these questions; first, whether such homeomorphy existed, and second, the more subjective question as to whether, if it does exist, there remain features by which the two lineages can be distinguished.

Our present evidence shows that while there is little reason to accept such complete convergence that confusion may well result from the inability of the taxonomist to distinguish shells which really have lost differences indicative of different origins, there is a particular hazard here in the description of species and genera from too little material. However, with either relatively complete material or suites of fragmentary specimens large enough to show various parts and parts from various growth stages, the possibility of error can be greatly reduced. Evidence of forms of the aspect of the Baltoceratidae derived from the Bassleroceratidae or from the Protocycloceratidae has not been found. However, there is a real possibility of confusing fragmentary remains with those of Ellesmeroceratidae which developed broad cross sections, or with members of the Proterocameroceratidae of the Endoceratida. Diaphragms are necessary to distinguish the Ellesmeroceratidae, and unfortunately exceptionally good material is necessary for the definition and recognition of such structures. *Microbaltoceras* is an instance in which our present separation of the families may be imperfect and erroneous. However, with the Endoceratida, we are on somewhat safer ground. In that order, the apical parts of the siphuncles are filled with endocones and the endosiphuncles thus produced are quite solid and more resistant to the vicissitudes of preservation than are anterior parts showing the conch and septa around the empty anterior parts of the siphuncles. Quite commonly, one finds endosiphuncles in considerable numbers without the anterior parts of shells or without the surrounding phragmocone. Indeed, a good many Endoceratida are known from endosiphuncles alone. Some such genera, difficult to place taxonomically in relation to others members of the order, have been summarized by the writer (Flower, 1955) and some additional endoceroid genera in the Canadian have been recognized on the basis of the endosiphuncle pattern alone (Flower, 1956; Teichert and Glenister, 1952, 1954). However, one can fall into error if one attempts to define genera and species from single fragmentary specimens alone.* Attention has already been given to *Thylacoceras* and the Thylacoceratidae, which illustrate the kind of dilemma that can result from description from insufficient material. Teichert and Glenister (1952) described the new genus and species *Thylacoceras kimberleyense*, an orthoconic shell with a ventral siphuncle with long septal necks. Under the impression that slender Canadian Endoceratida had dominantly long necks, this form was assigned to the Endoceratida and, indeed, to the Endoceratidae. There is no good evidence of true Endoceratidae in the Canadian (Flower, 1941, 1947, 1955). The single specimen did not show endocones. Teichert and Glenister (1954) redescribed this form and added some other genera and species which they put together in the new family Thylacoceratidae, assigned to the Ellesmeroceratida, and defined as orthocones, superficially like the Baltoceratidae but having ventral siphuncles of small diameter and with long, generally at least, subholochoanitic necks, while the Baltoceratidae have generally larger siphuncles in which the necks are short, and, indeed, quite commonly vestigial.

This presented a puzzle to the present investigation, for while the structures indicated were well shown, it was evident that there was imperfect separation between the forms with small siphuncles and long necks on one hand and the large siphuncles with short necks on the other. Such gradation was not apparently confined to the older forms, as might be the case if we were dealing with two significant divergent lineages of a common origin. Rather, it seemed that the two morphological groups intergraded so that, as defined above, the conditions noted represented two extremes in a single variable lineage. It was finally decided to present the genera of the Thylacoceratidae only in summary, noting the above-outlined situation as it then appeared. However, more material currently being studied by Dr. Glenister (Teichert and Glenister, oral communication, December, 1960; Glenister, *fide litt.*, 1962) has revealed endosiphuncles in *Thylacoceras* and in at least some of the additional genera assigned to the Thylacoceratidae in 1954. As such, it appears that the Thylacoceratidae are Endoceratida and are thus far unique among the small, slender Canadian Endoceratida in developing long septal necks.

The description of the Thylacoceratidae added some other problems. On purely theoretical grounds, it seems possible that there could be some isolated developments of long necks in the Baltoceratidae, comparable to those found in the Ellesmeroceratidae, within some but apparently not all species of *Clarkeoceras*, and in *Metaellesmeroceras*. Teichert and Glenister (1954) expressed the belief that the Thylacoceratidae might be highly modified descendants of the Endoceratida, forms which were rather small, and that in siphuncles below a certain definitive diameter, endocones might be lost. While not applicable to the Thylacoceratidae, it was worth considering whether such a trend could develop from the simpler Proterocameroceratidae, for if endocones were suppressed in members of that group, something very much like the Baltoceratidae would result. The evidence now available does not support the existence of such a trend in evolution. First, the El Paso group has yielded endoceroid endosiphuncles containing good endocones which are as small as 1.5 mm across, after a short, rather rapidly expanding, initial portion, while Baltoceratidae, represented by abundant material showing consistently empty siphuncles, show siphuncles up to 10 mm across. Second, support for such a transitition would be found if one could demonstrate shells similar in siphuncle wall structure and gross features, with large species which have endocones and are endoceroids, and small species with empty siphuncles which are apparent Baltoceratidae. Barring the inevitable similarity of such generalized forms as *Proendoceras* of the Endoceratida and *Rioceras* of the Baltoceratidae (and even these forms are not strictly in agreement, having differences in the connecting rings) such instances of similarity were not found. Oddly, the most apparent instance of this sort involved the Canadian Baltoceroid *Cyptendoceras* which,

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*The greater number of Thylacoceratidae of Teichert and Glenister are, from the descriptions, based upon one or at the most two or three fragmentary specimens. Such description is surely premature.

by its depressed section, large ventral siphuncle, and ventral lobes, is close in gross features to a true endoceroid, a genus as yet undescribed. However, derivation of *Cyptendoceras* from this genus could not be postulated. The endoceroid is a genus known only from the Whiterock stage of Nevada and Utah, too young to be the ancestor of *Cyptendoceras*, and further, it has holochoanitic septal necks. It would then appear that no good support can be found for the possible endoceroid origin of some forms currently placed in the Baltoceratidae. That species described as Baltoceratidae, or Thylacoceratidae as Ellesmeroceratida, from too fragmentary material might prove to be Endoceratida when known from more complete material is a completely different problem.

The present study yielded yet another problem and surprise. For some time it was known that some of these forms had persistent calcite in the siphuncles, the nature of which was not understood (Flower, 1955C). In the study of these forms, it was found that in the higher Baltoceratidae there were some genera and species which developed a rod within the siphuncles, which lay close to the ventral wall, was generally round in cross section, came to a point anteriorly, thickened apically, and eventually filled the apex of the siphuncle completely. At a glance, such a rod is obviously the complete antithesis of the endoceroid endocone. However, in the light of the odd modifications of endosiphuncles already known, I would hesitate to lay down laws as to what odd developments could not evolve in the endosiphuncles of the Endoceratida. The weird structures of the Allotrioceratidae (Flower, 1955) supply an adequate example. Investigation of the possible derivation of the rods from the endocones failed to find adequate support for such a hypothesis. True, some Endoceratida develop ventrally prolonged processes, extending far anterior of the generalized part of the endosiphuncle. Such forms, largely as yet undescribed, are either in shells and siphuncles specialized in shape or in other internal features so as to make them unsuitable as potential ancestors of these rod-bearing Baltoceratidae, or are too young; to a good many, both objections apply. Such forms include the Wolungian *Manchuroceras* and *Coreanoceras* of eastern Asia, which are apparently Cassinian in age, and some undescribed genera of Whiterock age. In the Jeffersonian, *Mcqueenoceras* develops, a genus in which the endocones are prolonged far forward on the ventral side of the siphuncle into a tongue-like process which might possibly be a forerunner of the rods. However, the resemblance is only approximate, for such processes are commonly concave or flat on their upper surfaces and close to the dorsal side of the siphuncle; the anterior end of the endosiphuncle shows a small conical cavity leading to the usual endosiphotube. The absence of such cavities and any trace of a similar tube in the rods of the Baltoceratidae suggests that there is no real relationship. Further, these rods show only gross irregular calcite crystals in calcitic preservation, and even under the best of conditions show only very fine, closely spaced growth lines which are quite alien to the more distant and usually more prominent endosiphosheaths that characterize the Endoceratida in general.

One cannot give attention to possible origin of the Baltoceratidae in the Endoceratida without considering also the possibility of an origin in other contemporaneous stocks. Possibly similar straight, smooth shells could develop by reduction of curvature in the Basseleroceratidae. Oddly, some species of *Bassleroceras* show a marked reduction of curvature, but they are so alien to the Baltoceratidae in the strongly compressed cross section and the prominent lateral lobes of the sutures that no confusion could result. Higher and more specialized genera, however, develop circular or depressed cross sections and simple transverse sutures, as in the genera *Leptocyrtoceras* and *Onychoceras*, genera which are particularly prevalent in the Cassinian. Unfortunately, no such tendencies toward straightening in these genera that might produce shells which one could confuse with the Baltoceratidae are known. Oddly, *Cyrtobaltoceras* seemed at one time to supply such a possible connection, but further study showed that this genus is alien to the Bassleroceratidae in the large diameter of the siphuncle and the ventral lobes of the sutures, while in both respects it was quite close to evident Baltoceratidae as the genera *Cyptendoceras* and *Metabaltoceras*; it was, then, to be regarded as the single, known, exogastric deviant from the dominantly straight form of the Baltoceratidae.

The Protocycloceratidae is regarded as a family of annulated slender shells, differentiated from the Ellesmeroceratidae late in Lower Canadian time, and characterized by siphuncles either empty or retaining diaphragms. As in the Ellesmeroceratidae, the diaphragms appeared wanting in the smaller siphuncles. Had some apparent Baltoceratidae been found with such diaphragms, the possibility would have to be considered that they were Protocycloceratidae which had lost the annuli of the shell surface, but no such forms were found. There is, however, oddly, some evidence suggesting that among forms not only currently placed in the Protocycloceratidae but also forms which cannot be differentiated otherwise from its type genus, there are, in addition to forms with diaphragms crossing the siphuncle, which are considered characteristic of the true Protocycloceratidae, some other forms which seem to have ventral rods. Such rods would suggest that these species are shells derived from the rod-bearing Baltoceratidae which developed annuli. Material for a full investigation of the matter was not available, but the evidence suggests, as is shown more fully in the discussion of that family, that the Protocycloceratidae may contain, as at present delimited, stocks of more than a single, real, evoluntionary lineage.

Having discussed possible origins of all or part of the Baltoceratidae in the Endoceratida, Tarphyceratida, and Protocycloceratidae, a course taken mainly to forestall further nonsense on these subjects, it is well to reaffirm the close affinities of the simpler Baltoceratidae to the Ellesmeroceratidae, as already noted, and the relatively slight differences on which some long-recognized genera are based, which suggest that the family is a unified group. Interestingly, the rods—the feature which is strikingly distinctive in the higher genera—fail to supply a basis for separating these genera into another family. Our present evidence suggests that the rods are developed actually within the genus *Cyptendoceras*; they are unknown in the Jeffersonian species and are not known in some Cassinian species represented by material abundant enough that the rods should, if present, be demonstrable. These considerations indicate that the recognition of the family as a single, natural, evolutionary development is correct. The family is one of the very few such groups in the Nautiloidea which pass the Canadian–Ordovician boundary without significant change. Possibly the genera *Rhabdiferoceras* and *Cyptendoceras* pass from late Canadian into Whiterock beds, but some dubious records are involved and the matter needs further investigation. From our present evidence *Baltoceras,* probably *Balticoceras,* and certainly *Murrayoceras* and *Cartersoceras* are Ordovician genera. The youngest known members of the family occur in beds correlated with the Rockland, considered by Kay the basal member of the Trenton, but considered by Cooper and the writer as more properly the closing phase of Black River sedimentation.

The first proposal of the name Baltoceratidae is that of Kobayashi (1935, p. 751; *see also* pl. 746) who regarded it as an endoceroid in which septal necks shortened. Our findings have failed to support this interpretation of relationship; were it true, *Baltoceras* and the Baltoceratidae should retain endocones.

Troedsson (1937, p. 16) proposed the same family group apparently without knowledge of Kobayashi's proposal. He regarded the family as containing slender, dominantly straight shells with marginal siphuncles of tubular segments and short necks. With the emendation that the dominantly compressed Ellesmeroceratidae, which possess diaphragms, are set off in a separate family, one regarded as more archaic than the Baltoceratidae, Troedsson's *Protobaltoceras* is apparently a member of that family and probably not distinct frim *Ectenolites* (= *Ectenoceras*); Troedsson's concept of the family is remarkably close to our present definition. This is the more to be noted, because since Troedsson's proposal, a great mass of new information on these forms has become available.

GENERA WITH EMPTY SIPHUNCLES

Genus RIOCERAS Flower, n. gen.

Genotype: *Rioceras nondescriptum* Flower, n. sp.

This genus is erected for small, slender orthocones, the cross section circular or nearly so, varying to both slightly depressed and slightly compressed forms, the apex perhaps slightly endogastric. The siphuncle is rather large in diameter, of short necks and moderately thick rings of ellesmeroceroid aspect, and is close to the venter. Sutures are straight and transverse. The shell is smooth externally, living chambers are simple and tubular, though some species may develop faintly fusiform shells. So far as is known, the siphuncle is without internal organic deposits.

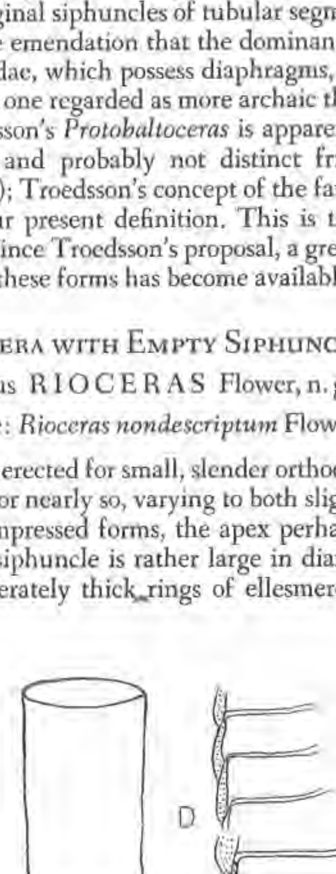

Figure 35

General features of *Rioceras*

A. Ventral view, showing general simple sutures and slender form. B.-C. Two cross sections, showing variation in relative size and position of the siphuncle. D. Portion of siphuncle wall. E. Further enlargement, showing obscurity of layering in rings.

Discussion. This genus is erected for the generalized Baltoceratidae which occur throughout the Middle and Upper Canadian. As yet, known species and known specimens are few; specimens seem to occur in limestones from which they do not separate readily, are small when complete, and are more commonly found in an extremely fragmentary state. Their apparent scarcity is quite possibly due as much to their obscurity as to real rarity.

Of related genera, *Baltoceras* is a much more slender shell with conspicuously deeper camerae, known only from appreciably younger beds, but the structural differences are not great. *Murrayoceras* is similar in being closely septate, but with the close septation there is a conspicuously broadened cross section, and typical species in the Ordovician have rods in the siphuncle.

Some shells tentatively assigned to this genus have depressed cross sections, and such forms resemble the Lower Canadian *Pachendoceras* on one hand and *Murrayoceras* on the other. True *Pachendoceras* possesses diaphragms; true *Murrayoceras,* slightly more different in proportions, has a thin, more homogeneous ring and a rod in the siphuncle, though the rod is difficult to use taxonomically because it is so rarely preserved that it is shown only in exceptional material. Shells of this general aspect may also be confused with some of the smallest of the Endoceratdia. While separation of fragmentary material is not always possible, it is clearly evident that there are Canadian Baltoceratidae quite distinct from the tiny endoceroids. *Eobactrities* appears similar, but the extremely tiny siphuncle of that genus gives its members such a different appearance that treating the two groups as one genus seemed undesirable. Further, the siphuncle wall of typical *Eobactrites* has never been figured. *Wolungoceras* is allied but differs in that the siphuncle is subcentral, according to Kobayashi's description, though some species have been assigned to it with submarginal siphuncles, which should perhaps be placed elsewhere. *Baltoceras* and *Bactroceras* are markedly more slender shells with deeper camerae.

Rioceras nondescriptum Flower, n. sp.

Pl. 18, fig. 1-3, 10, 16-21

This is a straight, slender shell, expanding from the earliest observed growth stage, where the shell height is 5 mm, at a rate of 3 mm in a length of 25 mm. The siphuncle is tubular, with short necks supplemented by thick rings, slightly broader than high, in a shell which is similarly slightly depressed in cross section. Sutures are straight and transverse. Camerae average 2 mm in length adorally, roughly from a shell height of 10 mm upward to the observed limit, but are closer in early growth stages.

A syntype, No. 856, represents the earliest growth stage observed. It is a shell, weathered from one side adorally, the basal part ground to expose the siphuncle. The whole specimen is 40 mm long, and the shell height increases in the basal 25 mm from 5 to 8 mm. The siphuncle in the same length apparently increases from 1 to 1.5 mm, but the apical part of the surface may not be strictly central. Camerae are spaced 7 or 8 in a length of 10 mm. Adorally, the weathered surface is eccentric, the siphuncle is not seen, and something less than the maximum shell height is indicated (pl. 18, fig. 10).

A second syntype, No. 857, shows a later growth stage but is rather poorly preserved externally and appears slightly distorted. It expands from 13 and 14 mm to 16 and 17 mm in the basal 30 mm, which was sectioned longitudinally, and to 18 and 19 mm in the adoral 30 mm. The cross section at the base of the unsectioned part (pl. 18, fig. 16) shows a rather unusually large siphuncle. The basal longitudinal sections are significant in showing the siphuncle tubular and empty (pl. 18, fig. 19-20). Camerae range adorally from 1 to 1.8 mm in length.

A third syntype, No. 858, increases from 10 to 16 mm in a 45-mm length. Sutures are obscurely preserved but appear to be outlining camerae 1.5 to 2.0 mm long.

Syntype No. 859 is a slightly distorted phragmocone 40 mm long, 15 × 16 mm at the base, where the siphuncle is 5.5 × 7.0 mm. Camerae, visible laterally (pl. 18, fig. 1), are 2 mm deep.

Syntype No. 860 is a rather weathered specimen which appears to be a complete living chamber, 30 mm long, increasing from 15 and 16 mm to 17 and 18 mm.

A sixth specimen (No. 859, pl. 18, fig. 18, 21), sacrificed to obtain a thinsection, showed 35 mm of the phragmocone and siphuncle. The siphuncle is 3.5 mm high apically, 4 mm adorally. The shell is incomplete dorsally in the apical 15 mm, increases from only 16 to 17 mm in the adoral 20 mm. Camerae are subequal, 2 mm long throughout. Septa are strongly curved, tangent to the horizontal dorsad of the siphuncle, curving scarcely forward to the siphuncle from the point of greatest depth, but inclined strongly forward dorsally, so that a horizontal line crosses two and a half camerae. In the dorsal wall of the siphuncle, the septal necks are curved, point most faintly toward the siphuncle center, and are supplemented by necks which thicken apically, the broad apical end lying over the base of the next adapical ring. On the ventral side an apparently thick shell wall of coarsely granular material is lined by segments of finer granular material which appear to be connecting rings, with no trace of the septal necks recognizable. The dorsal side of the shell shows the shell wall thickening from about 0.3 to 1.0 mm adorally, faintly undulate in outline, and rather irregular. The interior of the siphuncle contains fine light rods, apparently very fine sponge spicules.

Discussion. Though there are numerous specimens of this form available, most of them are small scraps, rarely over 20 mm in length, and many of them fail to show the entire cross section of the shell. It has seemed best, in case of future division of the species, to base it now on syntypes, leaving selection of a lectotype to future workers should such a step be necessary.

Types. Syntypes are Nos. 856 to 861, all from the first piloceroid zone of the El Paso limestone. No. 856 is from the Mud Springs Mountain Section; others are from the section in the Cooks Range.

Rioceras fusiforme Flower, n. sp.

Pl. 18, fig. 4, 5

This is a *Rioceras* in which moderately rapid expansion gives way adorally to an almost tubular shell. The type is 57 mm long. In the basal 25 mm, where dolomitization has obscured the septa, the shell expands from 10 and 11 mm to 16 and 17 mm, a rate of expansion of 1 mm in 5 mm. Adorally, in an equal length, the shell width expands from 18 to 20 mm. Shell height, estimated since the dorsum is not preserved, is 1 mm less than the width here. Sutures are clear adorally, straight and transverse, with six camerae in a length of 5 mm, a condition seen over a length of 30 mm. The siphuncle, well shown only apically, is circular in section, 2 mm wide where the shell is 11 × 10 mm, expanding gently orad, and apparently maintaining the same proportions, one fifth of the shell height.

Discussion. The fusiform shape of the shell is diagnostic of this species, but small, poorly preserved fragments, unless they represent the early rapidly expanding portion, cannot be separated easily from *Rioceras nondescriptum* with which this form is associated.

The holotype, NMBM No. 858, is from the first piloceroid zone of the El Paso, from the Cooks Range, New Mexico.

Rioceras(?) depressum Flower, n. sp.

Pl. 19, fig. 7-13

This is a small, straight shell of strongly depressed section, tubular ephebically, slightly contracted at the adoral end of the phragmocone. The holotype (No. 882) is a portion of phragmocone 24 mm long, increasing in the basal 17 mm from 8 and 11 mm to 8 and 12 mm, then contracting to 9 and 10 mm. At the base the siphuncle is 3 mm across, very slightly depressed in section. Sutures are straight and transverse, four camerae in a length of 5 mm apically, five in 5 mm adorally. Siphuncle wall obscured by weathering, but with short necks and connecting rings.

A paratype is a poorly preserved fragment representing a slightly earlier growth stage and lacking the adoral contraction, increasing from 7 and 10 mm to 8 and 12 mm in a length of 15 mm.

Discussion. Though this form has the general features of the generalized baltoceroid *Rioceras*, its position is necessarily inferential from the evidence afforded by the two known fragmentary specimens. It is distinctive in proportions and apparently characteristic of the first endoceroid zone of the El Paso. In gross aspect, it resembles the Lower Canadian genus *Pachendoceras.*

Types and occurrence. Holotype No. 882, paratype, No. 883; both from the first endoceroid zone of the El Paso limestone, from Rhodes Canyon, San Andres Range, New Mexico.

Rioceras expansum Flower, n. sp.

Pl. 19, fig. 14

A single specimen from the first endoceroid zone shows a portion of a phragmocone of a fairly rapidly expanding orthocone, circular in section, increasing from 14 to 16 mm in diameter in the length of 20 mm, the siphuncle 3 mm across, circular in section at the base. There are two camerae in the length of the specimen, those in the base 2 mm long and regular, those in the later half rather irregular, showing slight crowding of septa. The details of the siphuncle wall are not known.

Holotype. NMBM No. 884.

Occurrence. From the first endoceroid zone of the El Paso limestone, Rhodes Canyon, San Andres Mountains, New Mexico.

Rioceras(?) lobatum Flower, n. sp.

Pl. 18, fig. 11-14

This is an orthocone represented in our material by a single specimen, a bit of phragmocone 30 mm long which is complete around its circumference only in the basal 10 mm in which it expands from 11 and 12 mm to 12 and 13 mm, being very slightly compressed. The sutures develop lateral lobes, separated by subequal dorsal and ventral saddles; lobes are shallow, their depth less than the length of a camera. Ten camerae occupy a length of 19 mm. The septum at the base shows curvature in the vertical plane conspicuously greater than that in the horizontal plane. On the ventral side of the septum, the siphuncle is 4 mm wide, 4.5 mm high, measured on the sloping plane of the septum, and in broad contact with the venter.

Discussion. Without more material, the taxonomic position of this form must remain uncertain. In general aspect it resembles *Rioceras nondescriptum*, with which it is associated, but differs in the strong vertical curvature of the septa, the slightly compressed section, and the lateral lobes of the sutures. In these respects it approaches the Ellesmeroceratidae, but compression and lobation are so slight that the resemblance to orthocones of that family is not pronounced. It seemed unwise to sacrifice the distinctive shape of the one specimen in an effort to ascertain the nature of the siphuncle wall.

Holotype. NMBM No. 863, from the first piloceroid zone of the El Paso, from the Cooks Range, New Mexico.

Rioceras dartoni Flower, n. sp.

Pl. 21, fig. 1-14

This is a small shell rather distinctive in the fairly rapid expansion of the early portion, followed by a much more slender adoral portion in which the cross section shows the venter more strongly rounded than the dorsum, and the greatest width lies dorsad of the center. The siphuncle is rather small, close to the venter, depressed in cross section, and the larger fragments show very faint exogastric curvature.

Only silicified phragmocones are known, ranging in diameter from 6 to 15 mm, and representing a length of 45 mm. The holotype (pl. 21, fig. 1-4) expands from 9 and 10 mm at the base, where the siphuncle is 1.0 and 0.8 across, being depressed, and where the section is essentially circular, to a height of 15 and a width of 14 mm, with the greatest width attained dorsad of the center, and the venter is conspicuously more rounded than the dorsum. The siphuncle here is 2.0 mm wide and 1.8 mm high. Sutures are straight and transverse with four to five camerae in a length of 5 mm. A paratype (pl. 21, fig. 5-8) expands from 7 and 6 mm to 12 and 13 mm in 26 mm; the surface shows septa more clearly than does the type, but slight wear has increased the compression of the cross section at the base.

A second paratype (pl. 21, fig. 9-12) expands from 8 to 13 mm in 19 mm, being essentially circular, though with the greatest width dorsad of the center adorally, where the siphuncle is small and markedly depressed in section.

A third paratype (pl. 21, fig. 13, 14) is a fragment of a phragmocone, broken obliquely at both ends, increasing from 6 to 11 mm in the adoral 16 mm, but in all 21 mm in length; it has camerae averaging 1 mm in length. The holotype has the anterior end of the siphuncle empty, the apical end filled with silica. The apical end of the cavity extends farther apicad dorsally than ventrally, but details of structure are too obscure for one to be certain whether there is a bluntly pointed rod here as in *Cyptendoceras ruedemanni* or whether the apical filling is adventitious and inorganic.

Types and occurrence. The holotype and three paratypes are Nos. 866 (holotype) and 867 to 869 (paratypes). All are from the upper part of the dolomites, bed 8 of Cloud and Barnes, in the lower part of the Cassinian (unit B2b) from the southern Franklin Mountains at El Paso, Texas.

Rioceras wellsi Flower, n. sp.

Pl. 21, fig. 15-23

This is a small *Rioceras*, very slender, nearly tubular, developing a slightly depressed cross section, with a small ventral siphuncle. Although it is common in the black dolomites near the top of bed 8 of Unit B2b (Cloud and Barnes, 1946), all specimens so far found are rather short fragments of phragmocones.

The type consists of 14 mm of phragmocone expanding from 7.5 and 9 mm to 9 and 10 mm; basally, the siphuncle is 1 mm high and 1.4 mm wide. There are six and a half camerae in a length of 5 mm. Three additional paratypes are designated, which show some variation in the length of the camerae; apparently such variation is erratic in short lengths of the phragmocone. A paratype 14 mm long expands from 6 and 7 mm to 11 and 13 mm. It has six or seven camerae in a length of 5 mm. The venter is weathered and the siphuncle, exposed to the surface, is possibly slightly enlarged by addition of silica to its surface, its segments are indistinct, and in width it is apparently 1.5 to 2.0 mm. Phragmocones are strongly silicified, show some evidence of slight crushing, and have been modified further by weathering.

Discussion. The straight, slender shell of slightly depressed section is distinctive, in combination with the close septa, somewhat variable in spacing and the small siphuncle. The advanced silicification precludes any close knowledge of the structure of this form.

Types. Holotype and five paratypes, NMBM Nos. 876 to 881. From the same locality and horizon as *R. dartoni*.

Rioceras tubulare Flower, n. sp.

Pl. 21, fig. 33-35

This is a shell so slender as to be tubular, subcircular in section, sutures straight and transverse, a rather large siphuncle slightly depressed in section and close to the venter. The holotype shows a shell width of 15 mm, increased to 16 mm in the basal 20 mm, the only portion complete enough for measurement, but a considerable portion of the phragmocone surface is preserved for another 10 mm, and scant traces of silicified septa are found 12 mm farther orad. Broken fragments of the venter, not illustrated, extend 15 mm apicad of the figured portion. The cross section shows height and width subequal at the only point where both can be ascertained. The venter is slightly flattened, and there is also slight dorsolateral flattening. At the base of the type, the siphuncle is 5 mm wide and 4 mm high and in contact with the venter.

Discussion. Surprisingly, there is only one Canadian cephalopod described from North America which is at all close to this form, generalized as it is in aspect. This is the form which Ulrich, Foerste, Miller, and Unklesbay described as *Cyptendoceras whitfieldi*, from the Fort Cassin beds of the Champlain Valley. The species shows, however, expansion of the siphuncle and is referred to *Rhabdiferoceras.*

Holotype, No. 881, from the upper part of the dolomites, bed 8 of Cloud and Barnes, in the lower part of the Cassinian portion (B2b) of the El Paso group, of the southern Franklin Mountains at El Paso, Texas.

Rioceras sp.

Wolungoceras? sp. Flower, 1956, Jour. Paleont., vol. 30, no. 1, p. 81, pl. 19, fig. 29, 31.

This form, known only from a very short fragment of a phragmocone, is a *Rioceras* by the large ventral siphuncle, straight slender form, and transverse sutures. It is distinctive in the slightly compressed cross section. The figured specimen is from the *Archeoscyphia* zone, of Jefferson City age, from the Canadian of Maryland.

Rioceras cf. *consuetum* (Sardesson)

Endoceras consuetum Sardesson, 1896, Minnesota Acad. Nat. Sci., Bull., vol. 4, p. 103, pl. 6, fig. 11.

Clitendoceras ? consuetum UFM&U, 1944, Geol. Soc. Amer., Special Papers, no. 58, p. 107, pl. 27, fig. 10-12 (contains intervening references).

Endoceras consuetum ? Stauffer, 1937, Jour. Paleont., vol. 11, p. 65, pl. 13, fig. 4-6.

There is some doubt concerning the identity of Sardesson's species, and the location of the type is not known. However, Stauffer (1937) figured under this name a portion of a straight circular orthocone with transverse sutures and a large, tubular, ventral siphuncle, typical in all respects of *Rioceras.* It is from the Shakopee dolomite of Stillwater, Minnesota. Precise correlation of the Shakopee dolomite in the Canadian is somewhat doubtful, but it would appear from the meager fauna known that it is more probably Jeffersonian than Cassinian, but clearly Upper Canadian. Stauffer (1937) had compared his fossils largely to Fort Cassin species, one of the very few good Canadian associations adequately described at an early date, but the specific comparisons then made now seem highly doubtful in the light of subsequent knowledge of earlier Upper Canadian faunas. The absence of endocones in the form makes, of course, its assignment to the Endoceratida merely a wishful assumption.

Rioceras pusillum (Ruedemann)

Baltoceras ? pusillum Ruedemann, 1906, New York State Museum, Bull. 90, p. 431, pl. 9, fig. 4-5.

Endoceras ? pusillum UFM&U, 1944, p. 100, pl. 45, fig. 3-6.

This species is based upon a single specimen, a tiny septate portion of a shell obviously representing the apical end. Two surfaces show a longitudinal section and an adoral half of a cross section. Ruedemann's description is accurate and need not be reproduced. The apex shows slight curvature, apparently exogastric, but shows a septal space which is broader ventrad than dorsad or the siphuncle at the apex; later, the siphuncle occupies an apparently ventral position. Ruedemann's two cross sections show the siphuncle closer to the venter adorally; the last is diagrammatic, for the longitudinal section shows no septa adorally ventrad of the siphuncle.

Interpretation of this tiny specimen poses some problems, and, curiously, subsequent collecting has failed to yield specimens which can be considered logically as later growth stages of this same form. Interpretation of *Wolungoceras valcourense* as the same species seems unconvincing in view of the subcentral position of the siphuncle, without the evidence of transition supplied by intermediate growth stages. One could, indeed, question the orientation of this form and suggest that the early convex portion is ventral and that adorally, the siphuncle moves to a dorsal position, but in considerable, careful, critical examination, we have found no Canadian straight cephalopods to which a marginal dorsal siphuncle can be attributed; the same applies as well to Chazyan forms. The presence of septa ventrad of the siphuncle at the apex could, however, be explained by a section which is slightly eccentric apically and central adorally; such an interpretation would involve the belief that the siphuncle would be considerably higher in relation to the shell in a perfectly central section at the apex. I had, to my regret, never discussed with Dr. Ruedemann the recognition or the preparation of this form, but it is logical that the section was prepared in the light of the adoral cross section seen on an exposed surface, and it is practically impossible, from such a section, to gauge the orientation of the specimen in the rock perfectly; so, this interpretation is convincing, though not, of course, capable of proof.

Discussion. In the light of the above discussion, the appearance of septa on the ventral side of the siphuncle is quite possibly adventitious; if so, reference of this species to *Rioceras* is quite in accord with the features of the genus. Reference of the species to *Endoceras* or, indeed, to the Endoceratida is quite unjustified in the absence of endocones. Associated Endoceratida show commensurate stages much more rapidly expanding.

The unique holotype in the New York State Museum, is from the Fort Cassin beds at the shore of Lake Champlain at Valcour, New York.

Rioceras (?) sp.

Pl. 20, fig. 11

This is an orthoconic shell of slightly depressed cross section, slender, with a ventral siphuncle very slightly depressed in cross section. Necks are short, rings form faintly concave segments, and no deposits appear in the siphuncle. The one specimen is most incomplete. As illustrated, it is a section weathered from the dorsum, showing apically a curving surface rising from the venter just to the left of the siphuncle, to about half way up the right side of the shell. Adorally, the "plane" of weathering is more nearly transverse, so the siphuncle seems to assume a more central position.

The phragmocone is a fragment 70 mm long increasing in width in its present state from 12 to 22 mm; original expansion was probably much less. Siphuncle segments at the apex indicate segments and camerae 3 mm long; adorally, the penultimate camera is 3 mm long, the last 2 mm suggesting a mature phragmocone. Septa are not seen; yellow dolomite occupies most of the phragmocone except the siphuncle. The siphuncle is slightly depressed in cross section, 3.2 mm wide basally, increasing to 5 mm near the anterior end. Several breaks in the specimen show that no rod or other deposit is developed. Probably originally the shell was quite slender and, if complete, this bit of it would expand in width possibly from 18 to 23 or 24 mm. Depression of the siphuncle is moderate but difficult to estimate owing to weathering of its dorsal surface.

Discussion. It seems that more and better material should be studied before this form is named; it is of significance in showing the presence of one of the small, slender orthocones with fairly large ventral siphuncles, generalized in slightly depressed cross section, moderately close septa, high in the Pogonip in association with *Cyptendoceras* and *Lobosiphon*.

Figured specimen. U.S. National Museum. From locality 2175, from the north end of the Ely Springs Range, Highland Peak quadrangle, Nevada; listed as "from above the *Receptaculites*," and regarded as "Chazyan"; the association, however, suggests the material to be of Cassinian rather than Whiterock or Chazyan age.

Genus ENDORIOCERAS Flower, n. gen.

Genotype: *Endorioceras rarum* Flower, n. sp.

This genus is erected for a small, slender shell, circular in section, with simple transverse sutures, a rather large ventral siphuncle, differing from *Rioceras* in that the early portion is markedly endogastric.

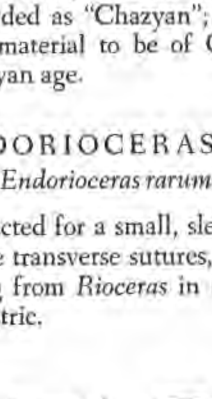

Figure 36

Restoration of *Endorioceras rarum*

A. Vertical section through phragmocone. B. Cross section at anterior end of A. Both about × 3.

Endorioceras rarum Flower, n. sp.

Pl. 18, fig. 15

This is a very slender shell known from a portion of phragmocone 45 mm long. The section, shown adorally, is circular, and in the adoral 30 mm the shell height increases from 7.5 to 8 mm in the basal 25 mm, the anterior 5 mm being incomplete. In the basal 15 mm, the shell height apparently expands from 6 to 7.5 mm, but expansion is exaggerated greatly by obliquity of the plane of the section. Septa are about equally spaced throughout, six camerae occurring in 5 mm. Where the shell height is 7.5 mm, the siphuncle is 2.1 mm high.

The only known specimen was encountered by a chance section. It appears to be a *Rioceras* except for the strong apical curvature which is reduced, but not completely lost, adorally. It seems not impossible that late stages may be difficult to distinguish from *Rioceras;* that it might be an early growth stage of typical *Rioceras* was, indeed, considered, but evidence fails to suggest that *Rioceras* is other than orthoconic throughout. Known portions of *R. nondescriptum* overlap in size range in this remarkable form and show the shell to be straight.

Type and occurrence. Holotype, No. 888; first piloceroid zone, Cooks Range, New Mexico.

Genus MICROBALTOCERAS Flower, n. gen.

Genotype: *Microbaltoceras minore* Flower

This is a tiny orthoconic shell of the Lower Canadian, moderately rapidly expanding, circular in section, with a siphuncle which is circular in cross section and in narrow contact with the venter. Sutures have not been observed but are nearly, if not perfectly, straight and transverse.

Discussion. Although there are available only two specimens of this elusive form, it is one which must not be ignored; first, because a tiny straight shell of circular section has not been suspected previously in the Lower Canadian, and second, because this appears as a tiny edition of such straight genera as *Ellesmeroceras* and *Eremoceras*, paralleling the tiny editions of *Dakeoceras* and the genus *Muriceras*, which is again paralleled to some extent in species assigned to *Burenoceras*.

Family assignment of this form presents difficulties. From the circular cross section and the absence of diaphragms, assignment to the Baltoceratidae is indicated. If this is true, *Microbaltoceras* is the only Lower Canadian genus thus far known assignable to that family; it is, further, the logical ancestor of younger genera and quite possibly marks the transition from the Ellesmeroceratidae to the Baltoceratidae. However, with such scant material, one must view the evidence with some reservation, for the one baltoceroid rather than ellesmeroceroid feature which is really crucial is the absence of diaphragms; and diaphragms, because of their delay in development, cannot be demonstrated in small Ellesmeroceratidae in many instances. Curiously, Middle Canadian forms assigned to the Baltoceratidae are very similar in general aspect to genera of the Ellesmeroceratidae which are retained there because, although their broad cross sections are exceptional, they retain diaphragms; these are the genera *Robsonoceras* and *Pachendoceras*.

Microbaltoceras minore Flower, n. sp.

Pl. 15, fig. 2, 3

This shell is known only from a single specimen which was found in two opposing longitudinal transverse sections. They reveal it as a small shell, straight, moderately rapidly expanding, peculiar among Lower Canadian forms generally in having a circular instead of a compressed cross section. The siphuncle is circular in cross section, in contact with the venter, rather large in proportion to the shell. The suture pattern is not displayed, but apparently the sutures are nearly if not perfectly straight and transverse. One of the surfaces was ground down to expose the siphuncle, which is made up of nearly straight, only most faintly concave segments. Apical camerae are filled with calcite, which obscures septa, leaves the outline of the siphuncle and the shell exterior both a little irregular. The siphuncle comes to an abrupt apical termination, which may well be the true shell apex but is unfortunately rather obscure.

The type is 10 mm long, consisting essentially of phragmocone. A section at midheight and essentially parallel to the shell axis increases from 2.0 to 4.5 mm in 10 mm. The opposing section, ground down to the level of the siphuncle, does not attain the greatest shell width. Here the siphuncle is apparently more slender than the shell, which increases from 1.4 to 2.0 mm, and at the anterior end the siphuncle is circular and 1 mm in diameter. In the plane of this section, the curvature of the septum seems unusually deep.

Holotype. Collection of the writer; No. 240.

Occurrence. From the Threadgill member of the Tanyard formation, Threadgill Creek, Gillespie County, Texas.

Microbaltoceras sp.

Pl. 15, fig. 1

This is a very tiny shell, known only from a section which is essentially longitudinal and not preceptibly oblique to the shell axis, as was shown by observations made in grinding. It is only 3.2 mm long, increasing from 0.4 to 1.2 mm in width. The apical 2 mm shows seven camerae, the last slightly shorter than the preceding ones; the remainder represents a living chamber. The section does not show the siphuncle, and the original cross section of the shell is not, of course, demonstrable. The shortening of the last camera suggests that in spite of its tiny size, this shell represents a mature individual.

Reference to *Microbaltoceras* is, of course, inferrential in the absence of knowledge of the siphuncle. It seems, however, important at this time to figure and to call attention to such a tiny orthoconic shell in the lower Canadian. Only one such individual has been observed in sections exposing a multitude of tiny ellesmeroceroid shells, in a thanatocoenoses which is composed primarily of tiny cephalopods and gastropods in the Threadgill member.

Figured specimen. Collection of the writer; No. 243.

Occurrence. From the Threadgill member of the Tanyard formation Threadgill Creek, Gillespie County, Texas.

Genus EOBACTRITES Schindewolf

Genotype: *Bactrites sandbergi* Barrande

Eobactrites Schindewolf, 1932, Palaont. Zeitschr, Bd. 14, p. 174.
——— Schindewolf, 1933, Preuss. Geol. Landedanstalt, Abh., N. F. Heft 148, p. 72.
——— Flower and Kummel, 1950, Jour. Paleont., vol. 24, no. 5, p. 607.
——— Sweet, 1958, Norsk Geol. Tidsskr., bd. 38, h. 1, p. 28.

This genus was erected for a single species, *Bactrites sandbergi* Barrande. Shells are small, very slender orthocones, circular in section, with a very small, tubular, marginal siphuncle, commonly exposed upon internal molds, and sutures which are straight and transverse but are discontinuous, developing neck lobes at the siphuncle. The siphuncle (Schindewolf, 1933, p. 693) is reported as composed of short necks supplemented by thick rings. Sweet (1958) has presented fine illustrations of this species showing septal lines on the venter which are apparently the anterior limit of small, ventrally concentrated episeptal deposits comparable to those noted in *Murrayoceras* and *Cyptendoceras*. The initial stage is unknown.

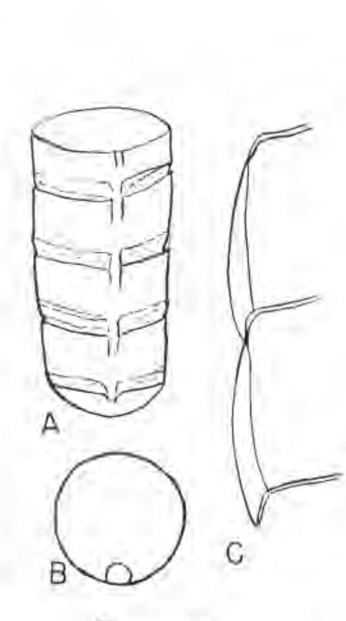

Figure 37

Eobactrites sandbergi (Barrande)

A. Ventral view of a typical specimen, after Sweet, 1958, pl. 2, fig. 5. B. Septal view. C. Reconstruction of the siphuncle wall. A-B about × 2.

Discussion. The round cross section, simple sutures, and the siphuncle composed of short necks and thick rings indicate the position of this genus as a member of the Baltoceratidae; the ventral small episeptal deposits support this conclusion. Schindewolf in describing the genus regarded it as a forerunner of the Bactritidae, but *E. sandbergi* occurs in upper D of the Bohemian basin, beds regarded as of Skiddaw (Arenig) age, and Sweet (1958) has described and figured material which he regards as conspecific from the equivalent upper Didymograptus shale of Norway. There is a stratigraphic gap from the late Canadian to the lower Devonian in which no connecting forms are known, highly suggestive of homeomorphy rather than a real relationship between *Eobactrites* and the true Bactritidae. The Silurian *Protobactrites* is a slender shell of the Michelinoceratidae which has a central siphuncle and in no way supplies any link. The baltoceroid affinities are supported by the thick rings reported by Schindewolf but unfortunately not figured.

In the present study, the question arose as to whether perhaps it would be better to extend the scope of *Eobactrites* to include forms with siphuncles of larger proportional diameter, such forms as are here assigned to *Rioceras*. The decision against such a course was influenced by two considerations. First, while the differences are relative, the *Rioceras* with the smallest known siphuncle, *R.(?) clinchburgensis*, is still relatively close to *R. nondescriptum* and remote from *Eobactrites sandbergi* in proportions. Second, while decision as to proportions may involve subjective elements, it seems advantageous to keep by themselves those species which have such small siphuncles that they look like the bactritids. That there are no such species in the plural but only a single known species in the late Canadian which fulfills these requirements is beside the point.

Initial stages of *Eobactrites* are not known, but we know initial stages certainly for only one species in the Baltoceratidae, *Rioceras pusillum* (Ruedemann, 1906). In that form, the apex is blunt and rapidly expanding, and though the expansion and curvature of the dorsum are far less than in the Ellesmeroceratidae, as known from *Eremoceras* and *Pachendoceras,* the similarity is still close, and quite remote from the swollen protoconchs known in Devonian Bactritidae. Such protoconchs are found also in Michelinoceratidae. Ruedemann (1912) described some such forms from the Snake Hill shale of late middle Trenton age. In my previous reference to this matter (Flower, 1961, p. 570), the occurrence was referred to as late Trenton, which was an incorrect editorial correction made without the knowledge of the author.

Teichert and Glenister (1954) regard the Thylacoceratidae as distinguished from the Baltoceratidae by the small siphuncles with long necks in the former family, in contrast to the large siphuncles and short necks in the latter family. *Eobactrites* shows that the combination of the two characters is not uniform.

Eobactrites inopinatum (Stauffer)

Cameroceras inopinatum Stauffer, 1937, Jour. Paleont., vol. 11, p. 59, pl. 11, fig. 1-3.
Clitendoceras? inopinatum, Ulrich, Foerste, Miller, and Unklesbay, 1944, Geol. Soc. Amer., Special Papers, no. 58, p. 108, pl. 27, fig. 1-2.

This is a tiny orthoconic shell subcircular in section, with straight transverse sutures and a small ventral siphuncle, its diameter equal to about one seventh that of the shell. The types are silicified fragments of phragmocones, showing a diameter of only 5 mm as a maximum. The slender shell and the proportionately very small ventral siphuncle suggest *Eobactrites,* and though this species is slightly more expanding than the genotype, the only species previously assigned to the genus, and the camerae are somewhat shorter, it is clearly more allied in proportions to this species than to *Baltoceras,* which is larger and has typically much deeper camerae, or *Rioceras,* which is more rapidly expanding and has a proportionately much larger siphuncle. It is difficult to see any justification for assignment to the Endoceratida or to the endoceroid genus *Clitendoceras.*

Types. The types are University of Minnesota, Nos. 4870, 4872; from the Shakopee dolomite of Stillwater, Minnesota.

Eobactrites (?) eburneolum (Stauffer)

Orygoceras eburneolum Stauffer, 1937, Jour. Paleont., vol. 11, p. 59, pl. 11, fig. 2, 4, 5, 7.
Endoceras? eburneolum Ulrich, Foreste, Miller, and Unklesbay, 1944, Geol. Soc. Amer., Special Papers, no. 58, p. 94, pl. 27, fig. 3-7.

This species is based upon several short, silicified fragments of phragmocone, none more than 3 mm in diameter, showing a straight shell of circular section, slightly more rapidly expanding than *E. inopinatum,* with septa straight and transverse, slightly closer in spacing, the siphuncle small, but slightly larger than in that species and narrowly separated from the venter. It would appear that the faint annuli on the basis of which Stauffer referred this species to *Orygoceras* are features of the camerae rather than of an externally annulated shell.

Although departing from the pattern of *Eobactrites sandbergi* still more than does *E. inopinatum* in greater expansion, shorter camerae, and in having a slightly larger siphuncle slightly separated from the venter of the shell, the proportions of this species remain closer to those of *Eobactrites* than to other simple orthoconic genera of the Baltoceratidae, being more widely removed from *Rioceras,* with its much larger siphuncle and more rapidly expanding shell, as well as from the larger *Baltoceras* which is slender but also has a large siphuncle, or *Bactroceras,* which has much deeper camerae. The material prohibits by its silicification any detailed knowledge of the siphuncle structure. The small size of the siphuncle and of the shell is foreign to the known Endoceratida; there is no evidence of organic deposits in the siphuncle.

Types. University of Minnesota, Nos. 4871, 4873, and 4876, from the Shakopee dolomite of Cannon Falls, Minnesota.

Genus LOXOCHOANELLA Teichert and Glenister

Text Figure 6G, p. 37

Genotype: *Loxochoanella warburtoni* Teichert and Glenister

Loxochoanella Teichert and Glenister, 1954, Bull. Amer. Paleont., vol. 35, no. 150, p. 37.

The genus is erected for simple orthocones with ventral siphuncles in which the necks are so inclined as to point obliquely apicad and inward. Rings are thick and show differentiation of materials, layering such as is not uncommon in thicker rings, but with the inner (siphonal) layer showing the apex differentiated. The cross section is circular, the sutures transverse dorsally, with a broad shallow lobe on the ventral side. The figured internal mold shows sutures continuing across the venter and the siphuncle.

Only the genotype, from high in stage 3 of the Emanuel limestone, is known. The holotype is a very small slender shell.

Discussion. Except that the holotype is an extremely small shell, it seems to have the general features of the inadequately known genus *Cyptendocerina,* which contains only one species, *C. explorator* (Billings), from the Upper Canadian of Pistolet Bay, Newfoundland. Apparently, only the holotype of this species is known, and the structure of the siphuncle wall has never been investigated.

Teichert and Glenister assigned *Loxochoanella* to the Ellesmeroceratidae. On the basis of the circular rather than compressed cross section, the absence of lateral lobes, the development instead of a ventral lobe, and the apparent absence of diaphragms, it should be assigned instead to the Baltoceratidae, a conclusion which finds some further support in the relatively high position of the one known species in the Canadian. It is unfortunate that the possibility exists that this genus, based upon a species which has been studied extensively, may well prove to be a junior synonym of *Cyptendocerina,* a genus described on the basis of a species on which a similar careful study has not been made. Oddly, the distinction between *Cyptendocerina* and *Cyptendoceras,* resting as it does upon the slight removal of the siphuncle from the venter in the former, seems most tenuous, but in *Cyptendoceras* the siphuncle wall is quite unlike that of *Loxochoanella,* and ventral rods are developed in the siphuncle of some, though not demonstrably all, of the species. Absence of the rods in both *Cyptendocerina* and *Loxochoanella* may be more apparent than real.

Genus METABALTOCERAS Flower, n. gen.

Genotype: *Metabaltoceras fusiforme* Flower, n. sp.

Shell essentially straight, gently expanding to the middle of the living chamber, which is faintly fusiform. Shell smooth externally, aperture faintly inclined apicad on the venter. Cross section subcircular at base, becoming faintly depressed adorally. Siphuncle large, tubular, in contact with the ventral wall; siphuncle wall aneuchoanitic, the juncture of the sutures transverse and not strongly inclined as in many ventral siphuncles. Sutures straight and transverse dorsally and laterally, but with a prominent deep lobe on the ventral surface.

Discussion. This genus is a small, slender, faintly fusiform shell with the large, empty siphuncle of a *Baltoceras*, from which it differs in shape and also in the prominent ventral lobes of the sutures. *Cyptendoceras* has similar sutures but is a large—much larger—shell, with a rod in the siphuncle. *Metabaltoceras* approaches somewhat the fusiform condition of the Cyclostomiceratidae.

Metabaltoceras fusiforme Flower, n. sp.

Pl. 19, fig. 1-6

Holotype 48 mm long, increasing from 7 mm at the base, where height and width are equal, to 11 and 11.5 mm in the 22 mm on the phragmocone. The living chamber is 25 mm in length laterally, increasing to 12 and 13 mm at the middle and contracting to 11 and 11.5 mm at the aperture. The shell is smooth externally showing only very faint transverse markings. The aperture is slightly inclined apicad on the ventral side but is transverse over most of the ventral surface. The siphuncle is large and tubular, 3 mm in diameter at the base of the living chamber, the septal necks greatly abbreviated, the tubular segments composed essentially of the connecting rings. The septum, shown only at the base of the living chamber, is peculiar in that it is shallow dorsally, deep ventrally, and the juncture of the septum and the siphuncle is transverse instead of oblique as is usual with these early Paleozoic genera with marginal siphuncles. The interior of the siphuncle is empty. The camerae are moderate in depth, five occupying the adoral 10 mm of the phragmocone. The sutures, straight and transverse dorsally and over most of the lateral surface, are modified by a deep, rounded lobe occupying most of the width of the shell as viewed from the venter. The shell is very faintly curved endogastrically.

Discussion. The suture pattern is essentially that of the much larger genus *Cyptendoceras*, which is found in the same association as in *Metabaltoceras*, but is distinguished by the development of a rod in the siphuncle; also the siphuncle is broader, in more prominent flattened contact with the ventral wall, and the sutures are inclined more steeply in the ventral lobe. *Cyptendoceras* is an essentially tubular shell.

Type. Holotype, collection of the writer.

Occurrence. The holotype and only known specimen is from an erratic boulder of Fort Cassin limestone found near the Middle Canadian ledges between West Chazy and Beekmantown. The associated species included *Proterocameroceras brainerdi* and *Centrotarphyceras seelyi*.

Metabaltoceras minutum Flower, n. sp.

Pl. 26, fig. 6

This is a very small, straight, slender shell, the living chamber contracting and faintly fusiform, distinguished by its very small size and slightly compressed cross section. The holotype is a shell with a phragmocone 17 mm long, increasing in height from 2.5 to 6 mm, followed by a living chamber, incomplete adorally, 11 mm long in which the height increases to 7.5 mm at the middle and decreases to 7.2 mm adorally. In the basal 10 mm there are fourteen camerae, with six more in the adoral 7 mm, in which the penultimate one is slightly shortened, the ultimate one markedly shorter, indicating the shell to be mature. The sutures are very faintly oblique, sloping slightly forward from dorsum to venter. The siphuncle is very small and in contact with the ventral wall of the shell. Fragments of the shell indicate its surface to be smooth.

Discussion. This shell is anomalous in that the cross section is slightly but definitely higher than wide. It seems, however, that the affinities of the shell with *Metabaltoceras* are sufficiently obvious that a new genus for this form, erected because of the slightly narrowed cross section, would be inadvisable. Only a lateral view of the type is shown; the opposite side is incompletely preserved and embedded in matrix.

Holotype. Collection of the writer.

Occurrence. From beds just above the oolite of the El Paso limestone, Demingian, Mud Springs Mountain, New Mexico.

Genus CYRTOBALTOCERAS Flower, n. gen.

Genotype: *Cyrtobaltoceras gracile* Flower, n. sp.

This genus is erected for a small, slender shell which resembles *Metabaltoceras* in the large ventral siphuncle and sutures forming broad lobes on the venter, but the mature shell shows no contraction of the living chamber, and the ephebic portion, all that is known, shows very gentle but uniform exogastric curvature. The genus is as yet known only from the genotype of Cassinian age.

Cyrtobaltoceras gracile Flower, n. sp.

Pl. 18, fig. 6-9

This is a small, slender shell, very slightly curved exogastrically. The type and only known specimen is 25 mm long, slightly depressed in cross section, 6 mm wide, 5.8 mm high at the base, showing a siphuncle 2.5 mm high and 3.2 mm wide, its ventral side showing reduced curvature and being in broad contact with the venter. Expansion is gentle; adorally, a width of 8 mm is attained; the height cannot be measured owing to loss of part of the dorsum by weathering, but evidently height remains slightly less than the width. The sutures slope down on the venter, forming prominent lobes which occupy all the width of the shell, as seen from the venter. Laterally, it is evident that the obliquity is not uniform, but that the sutures become rather abruptly transverse on the dorsal side. The type retains eight camerae occupying a length of 13 mm. Earlier camerae are uniform in length, averaging 2 mm, but the last three are progressively shorter, measuring 1.7, 1.2, and 1.0 mm, respectively, indicating that the specimen represents a mature individual. The anterior 13 mm (measured laterally) pertains to a living chamber, incomplete adorally. The shell was smooth externally.

Discussion. The phragmocone resembles that of *Metabaltoceras fusiforme* in the suture pattern and in the large siphuncle in broad contact with the ventral wall of the phragmocone. Indeed, so strong is the resemblance that redefinition of *Metabaltoceras* to include this species was considered, but it was deemed wiser to separate these forms generically because of the considerable differences in form. It was thought inadvisable with the present small specimen to sacrifice the features of the surface of the internal mold by attempting to grind to expose the siphuncle wall. Though these older cephalopods have yielded surprises in internal structure, the sutures and large siphuncle common to *Cyrtobaltoceras* and *Metabaltoceras* are highly distinctive and suggest that the siphuncle walls of the two genera are probably similar.

Holotype. Collection of the writer; No. 341, from the Fort Cassin formation, Valcour, New York.

Genus WOLUNGOCERAS Kobayashi

Genotype: *Wolungoceras foerstei*

Wolungoceras Kobayashi 1931, Japanese Jour. Geol., Geogr., vol. 8, no. 3, p. 166.

This genus was erected for slender, straight shells, subcircular in section, with straight transverse sutures, a moderately large siphuncle which is subcentral, or at least considerably removed from the venter. The siphuncle wall, originally considered holochoanitic, is composed of short necks supplemented by the thick rings which many investigators mistook for long holochoanitic necks. The siphuncle is without known internal deposits.

Discussion. *Wolungoceras* is of particular interest in that it retains the large siphuncle and the wall structure of the Baltoceratidae, but approaches the Michelinoceratida in having the siphuncle considerably removed from the venter.

The species previously assigned to the genus include the following:

Wolungoceras foerstei Kobayashi, 1931, Japanese Jour. Geol., Geogr., vol. 8, p. 166, pl. 18, fig. 1a-c. This is from the Wolung limestone of the Niuhsintai basin of southern Manchuria. The shell is slender, the rather large siphuncle is subcentral. Kobayashi's figure of the section is highly suggestive of the siphuncle of *Rioceras nondescriptum*, showing more than a suggestion of short necks supplementd by thick rings.

The section of the type shows calcite in the apical three fourths of the siphuncle, but the anterior limit of the calcite is irregular, and it fails to suggest an organic ventral rod.

Wolungoceras minor Kobayashi, 1931, Geological Surv. of Chosen (Korea), Bull., col. 11, no. 1, p. 40, pl. 6, fig. 1a-b, 2, 4a-b; pl. 8, fig. 6. This is a species of the Shorin bed of Shorin-ri, near Kenjiho, Korea. This form is slender, the cross section slightly compressed, the siphuncle moderatly large, located about halfway betwen the center and the venter.

The Shorin bed which contains piloceroids and *Coreanoceras*, is succeeded by the Maruyama beds, in which *Polydesmia* occurs with piloceroids, regarded as very latest Canadian.

Wolungoceras chiushuense Kobayashi, 1933, Tokyo Imp. Univ., Fac. Sci., Jour., sec. 2, vol. 3, part 7, p. 275, pl. 3, fig. 4. This species from the Wanwankou limestone of southern Manchuria is of uncertain position. It is a very slender, straight shell; the solitary specimen shows the siphuncle in a horizontal longitudinal section, showing the septa rather unusually straight and steeply inclined. Kobayashi describes the septal "funnels" as extending for one and a third camerae in length, notes a lining of the siphuncle. No forms with similar structure are known elsewhere in the Lower Canadian. If correctly interpreted, the species is atypical of any genus. If, as is suspected, the septal necks are short, the species may be referable to *Ectenolites*. Kobayashi states that the siphuncle is marginal; by definition, the siphuncle is central in true *Wolungoceras*. The slender form, marginal siphuncle, and compressed section are typical of *Ectenolites*.

Wolungoceras valcourense Flower, n. sp.

Pl. 19, fig. 15; pl. 27, fig. 25

This species is known from a portion of a phragmocone 40 mm long showing an increase in shell width from 11 to 14 mm in 30 mm, an increase of 1 mm in a length of 10 mm. Four camerae occupy a length equal to an adoral shell width of 12 mm. Septa are extremely shallow. The siphuncle is large and tubular; apically, it is 4 mm across at a shell width of 11 mm, and 4.5 mm at a shell width of 14 mm. The siphuncle, 4 mm in diameter, lies 3 mm from one side and 6 mm from the other and is presumably ventral in position. The siphuncle wall consists of very short septal necks and thick connecting rings. The surface, not clearly shown, is apparently smooth.

Discussion. Aside from the tiny *Baltoceras ? pusillum*, this specimen is the only baltoceroid so far known from the Fort Cassin beds. Here the section is circular and the large siphuncle is subcentral, while in *Baltoceras pusillum* the section is strongly flattened and the siphuncle is marginal adorally. A thinsection was prepared of the holotype, but some odd character, tramping into my office and expecting instant determination of undescribed species, dropped a large block of rock on it and broke it. The pieces subsequently disappeared, possibly thanks to the same individual. A poor photograph of the thinsection happily was made much earlier and is shown on Plate 27, Figure 25.

The holotype (collection of the writer; No. 339) is from the Fort Cassin beds exposed at the shore of Lake Champlain at Valcour, New York.

Genus BALTOCERAS Holm

Genotype: *Endoceras burchardi* Dewitz 1880

Baltoceras Holm, 1897, Geological Magazine, n. s., decade 4, vol. 4, p. 251.

——— Kobayashi, 1935, Geol. Soc. Japan, Jour., vol. 42, no. 506, p. 751.

——— Troedsson, 1937, Palaeontologica Sinica, ser. B., no. 2.

——— Schindewolf, 1942, Jenaische Zeitschr. für Med. und Naturw., Bd. 71, p. 342, fig. 2c, p. 331.

Baltoceras is a slender shell, subcircular in section, with rather distant, straight transverse sutures, a large siphuncle in contact with the venter, commonly interrupting the sutures of surfaces of internal molds. The septal necks are short but not vestigial, the rings appreciably thickened. The siphuncle is without known organic deposits.

As thus defined, *Baltoceras* differs from *Rioceras* in the much deeper camerae. The siphuncle wall has longer necks and rings somewhat thinner. *Murrayoceras* is similar but has shallower camerae and sutures describing broad lobes on the flattened ventral surface, and possesses a ventral rod in the siphuncle.

Schindewolf (1952), finding calcite in the apical part of the siphuncle and interpreting it as vestigial endocones, referred *Baltoceras* to the endoceroids. Study of a considerable series of specimens of the genotype has failed to yield calcite in the siphuncle which appears to be anything more than the calcite filling the upper side of the siphuncle where penetration of sediments is incomplete. Such calcite I have found to be lateral in some instances. However, it seems not beyond the bounds of possibility that ventral rods, such as are found in some other genera of the family might be developed in the genus. Schindewolf has described his material only in such general terms that it would be futile to even discuss his concept were it not that somewhat similar calcite in other Baltoceratidae have proved to be ventral rods of organic origin.

While the differences distinguishing *Baltoceras* from *Rioceras* are matters of proportion, the deeper camerae of *Baltoceras*, the thinner rings, the division appears to be one distinguishing the dominantly Canadian *Rioceras* from *Baltoceras* which ranges from Whiterock to Chazy. The species of *Baltoceras* known are few. *B. burchardi* is a Baltic species; I have not been able to ascertain its precise position; recent work on the "Orthoceras limestone" sequence seems to list trilobites and to neglect the cephalopods, but it is either Whiterock or Chazyan. No other European species seems to be recognized. In North America, *B. minor* Flower (1955, p. 810, pl. 80, fig. 5-6) occurs in the Day Point limestone, and *B. striatum* is here described from the upper Pogonip limestone of Nevada from beds of Whiterock age.

Baltoceras burchardi (Dewitz)

Pl. 24, fig. 1-6, 12

Endoceras Burchardii Dewitz, 1879, Gesell. Naturf. Freunde in Berlin, Sitzunber., p. 144.

——— Dewitz, 1880, Deutsch Geol. Gesell., Zietschr., Bd. 32, p. 371-372, fig. 1-2, p. 391-392, pl. 16, fig. 2, 2a, text fig. 1-2.

——— Holm, 1897, Geol. Foren. i Stockholm, Bd. 19, p. 171-174, fig. 1-2.

Baltoceras Burchardii Holm, 1897, Geol. Mag., n. s., dec. 4, vol. 4, p. 251-253, fig. 1-2.

A fine suite of specimens from the collection of the Academy of Natural Sciences of Philadelphia and one specimen in the collection of the writer serve as the basis for a restudy of this species. The shells are slender, circular in section, with rather deep camerae, spaced 2.5 to 3 mm in a length equal to the adoral shell diameter; some variation in rate of expansion and size of the mature individuals is evident, but the present material is not adequate to indicate whether more than one species is involved or whether the species is a variable one in this respect.

The sutures slope most slightly apicad from dorsum to venter; the septum is deeply and evenly curved, the siphuncle relatively large, 3 mm at a shell diameter of 9 mm, and 4 mm at stages ranging from 11 to 14 mm, and marginal. The septal necks are relatively long, slightly less than one third the length of a normal segment of the siphuncle. The connecting ring is thick. In opaque section, at least, no differentiation of structures is evident within it. Study of a good suite of specimens shows that the siphuncle is empty and without endocones. Many siphuncles are partially filled with matrix, the remainder being filled with inorganic calcite. The linear extension of matrix in the siphuncle may give a false impression of the presence of a very slender endocone, but study of a suite of specimens shows that it is oriented variously, depending upon the position of the shell in the sediments and not in accordance with the symmetry of the shell. More often than not, the matrix has been found to be lateral in position.

A relatively small and slender form is shown on Plate 24, Figure 1. This shell, 128 mm long, increases in the 76 mm of the phragmocone from 9 mm, where the siphuncle is 3 mm in diameter, to 14 mm, where the siphuncle is 4 mm. The septa slope slightly downward from dorsum to venter, and the siphuncle is plainly evident from the exterior of the internal mold. Camerae vary from 2.5 to 3 mm in a length equal to the adoral shell diameter, throughout most of the phragmocone, but the last two camerae are markedly shortened, so that four occur in a length equal to the adoral shell diameter of 14 mm. That this is an indication of maturity is further shown by the slight constriction in the living chamber, which occurs 23 mm beyond its base, is 4 mm in length, and extremely shallow. The living chamber, not quite complete adorally, is 60 mm in length and attains a diameter of 16 mm at its adoral end. It may be noted that as is common in mature living chambers, the rate of expansion of the shell is somewhat reduced. In the basal 60 mm, the shell expands from 6 to 12 mm.

A second living chamber, Plate 24, Figure 4, representing a growth stage comparable to that of the previous specimen, closely approximates it in length but shows more rapid and uniform increase in shell diameter and lacks the adoral constriction. The septum at the base has a depth of curvature of 4 mm, a siphuncle of 4 mm, and is 13 mm in diameter. The living chamber has a length, from suture to aperture, of 64 mm and increases to an adoral shell diameter of 16 mm. The aperture is transverse in dorsal view, but slopes apicad slightly on the ventral half of the shell, forming a broad, shallow, hyponomic sinus. Three other living chambers, incomplete adorally, agree with this form in rapid expansion and indicate forms attaining a larger size without showing the faint constriction and reduction of the rate of expansion noted in the first specimen.

The largest size is indicated by a fragment of the basal part of a large living chamber, 35 mm in length, increasing from 14 to 19 mm in diameter. Another specimen increases from 15 to 18 mm in a length of 50 mm, showing a slightly more slender condition and suggesting that these growth features are probably variable. A third fragment increases from 13 to 15 mm in the 50 mm of the living chamber but retains two camerae, of which the last is markedly shorter, suggesting a mature condition; the first camera is 4 mm deep; the last is 3 mm.

One relatively complete specimen in the collection of the writer (pl. 24, fig. 2), retaining a good portion of the shell, agrees closely in proportions with the first small form. The shell, 95 mm in length, increases from 8 to 14 mm in the 75 mm of the phragmocone and to 15 mm in the extant 25 mm of the living chamber. Trace of a very faint constriction is evident 4 mm from the anterior end and 4 mm in length. Camerae vary slightly in depth, 2.5 to 2.8 occurring in a length equal to the adoral shell diameter.

A phragmocone 57 mm long (pl. 24, fig. 5) increases from a basal diameter of 12 mm, where the siphuncle is 4 mm to 16 mm where the diameter of the siphuncle remains unchanged.

Septa show the usual adapical slope on the ventral half of the shell, camerae vary from two and half to three in a length equal to the adoral shell diameter. Adorally, the siphuncle is completely filled with matrix; at the middle of the specimen the matrix is confined to less than one lateral half, the remainder of the cavity being filled with inorganic calcite. A thin thread of matrix penetrated to the extreme apex of the specimen.

It should be noted that this form is a relatively large and rapidly expanding one. The adoral end of the phragmocone is slightly larger in diameter than is the base of any of the associated living chambers, indicating that the species could attain a still larger size. Assuming length and rate of expansion indicated by the other specimens, the living chamber was probably at least 60 mm long here and would have attained an adoral diameter of probably at least 20 mm, and more if there were no slight adoral decrease in the rate of expansion.

Discussion. The suite of specimens on which the redescription of the species is based is uniform in circular section, in the ventral circular siphuncle, and all essential features. The spacing of the camerae appears, except for marked gerontic contraction of adoral camerae, to be slightly variable. There is appreciable variation between a small form with a markedly slender living chamber and a larger one with a more uniform rate of expansion. The concept of one species in a "population," a word for an association which has crept into the literature from statistical studies, is of course nonsense, and study of a large suite of specimens from accurately known horizons is necessary to determine whether this variation within a single species is perhaps comparable to that which Flower (1936) described for *Striacoceras typus* (Saemann) of the Cherry Valley limestone, or whether two species are actually involved in this association. Indeed, from the present data, it is not even certain that these specimens are actually from a single association; one even encounters considerable perplexity in determining from exactly what horizon in the "Orthoceras limestone" *Baltoceras* is derived. Holm (1897) reports the species as common in the upper Grey Orthoceras limestone of Oeland.

Hypotypes. Philadelphia Academy of Natural Sciences; No. 1850, labeled *O. centrale*, N. Mockleby, Oeland. One specimen, Orthoceras limestone, Oeland is in the collection of the writer.

Baltoceras striatum Flower, n. sp.

Pl. 24, fig. 7-9

This is a shell subcircular in cross section, known from a portion expanding from 9 to 20 mm in 85 mm, the anterior end extending on one side for an additional 15 mm. The section at the base is circular, and shows a siphuncle 4 mm high and 4.5 mm wide in broad contact with the venter. The surface shows numerous fine, transverse, raised lines, faintly fasicular in arrangement, with no clear hyponomic sinus developed. A section of the basal part shows only one camera preserved, which is 2.5 mm in length. The plane of the section is slightly eccentric, and so shows some cameral space between the siphuncle and the venter, which would not be true of a perfectly median section. The necks are very short, the rings not clearly preserved. Apparently the remainder of the specimen represents a living chamber, but advanced recrystallization of the calcite leaves this interpretation subject to error. The basal septum is shallow, its suture straight and transverse.

Discussion. The proportions alone will characterize this species, and the surface markings are additionally distinctive, for no congeneric species are known with such prominent surface markings.

The holotype, No. 352 in the collection of the writer, was presented by Dr. James Lee Adams. It is from the sponge beds, zone N, of the Pogonip limestone from Ikes Canyon, Toquima Range, Nevada.

Genus BACTROCERAS Holm

Genotype: *Bactroceras avus* Holm

Bactroceras Holm, 1898, Geol. foren. i Stockholm, bind 20, p. 358.

This genus is erected for a very slender bactritiform shell of the Ordovician, the surface varying from smooth to rugose, the section circular, septa deeply curved, sutures transverse, the siphuncle small, marginal, septal necks orthochoanitic, relatively long, one third to one fourth the segment, rings relatively thick.

The genus is allied to *Baltoceras*, differing in the small size of the siphuncle. *Eobactrites* is comparable, but there the siphuncle is even smaller, the necks are reputedly shorter, and the rings are thicker, widening markedly toward their apical ends and forming segments which are significantly concave as a result.

Only four species have been referred to the genus. *B. avus* Holm and *B. angustisiphonatum* (Rüdiger) are from the Orthoceras limestone. The former is from the red Lituites limestone, the latter from the overlying gray Lituites limestone. For completeness, Holm's figures are reproduced here. In addition, two species briefly noted below have been described from Australia.

Bactroceras avus Holm

Pl. 27, fig. 1-6

Endoceras, nov. sp., Rüdiger, 1891 Arch. Ver. Freund. Nat. Mencklenburg, Jahr. 1891, p. 36, pl. 1, fig. 5a-b.

Bactroceras avus Holm, 1898, Geol. foren. i Stockholm, bind 20, p. 358, pl. 18, fig. 1-7.

This slender shell, figured and described by Holm, seems to have escaped mention or illustration in later works. Holm's figures are reproduced here. It is cited from the red Lituites limestone of Öland and Vastergötland.

Bactroceras angustisiphonatum (Rüdiger)

Pl. 27, fig. 7

Endoceras angustisiphonatum Rüdiger, 1891, Arch. Ver. Freund. Nat. Mencklenburg, Jahr. 1891, p. 37, pl. 2, fig. 10a-b.

This is a species with considerably deeper camerae than *B. avus*; it is from the gray Lituites limestone, the type from an erratic near Mencklenburg, Germany.

Bactroceras latisiphonatum Glenister

Bactroceras latisiphonatum Glenister, 1952, Australian Jour. Sci., vol. 15, no. 3, p. 84-91, 2 figs.

Glenister (1952) has described *Bactroceras latisiphonatum* from the Ordovician of New South Wales; he regarded the age as lower Chazyan. In the same paper he reviewed *Bactroceras* and designated *B. avus* Holm as the genotype.

Bactroceras gossei (Etheridge)

Teichert and Glenister (1952, p. 733) cite as a species of *Bactroceras (Orthoceras) gossei* Etheridge 1893 (Parlimentary Papers, Southern Australia, no. 52, p. 6-8, pl. 1).

Rod-Bearers

In some of the higher genera of the Baltoceratidae, the siphuncles contain rods of calcareous material, structures previously unrecognized. These rods lie against the ventral wall of the siphuncle, ending anteriorly in a point, also against the siphuncle wall. From this point they thicken apicad, showing the free surface as always strongly convex, and when fully developed they apparently fill the apical part of the siphuncle completely, without any tube or perforation extending to the tip.

In Figure 38 are shown some features of the rod and also features of some of the genera which possess this structure. A generalized rod is shown diagrammatically in Figure 38A. Figure 38J and K present longitudinal and cross sections of *Rhabdiferoceras annuliferum*, the first form in which this sort of rod was recognized. The internal molds of such shells are quite nondescript, being slightly depressed, with straight transverse sutures, and the siphuncle may not show on the surface of the internal mold, as in Figure 38H. The siphuncle segments are faintly convex in outline, and the surface of the rod shows corresponding annulations when seen in longitudinal section. Further observation showed that the rod is present in some species of *Cyptendoceras*, though it is apparently not developed in the Jeffersonian species at all, but only in the younger, Cassinian forms. This genus (here shown diagrammatically in Text Figure 38B-G) shows, in addition to the rod, rings of appreciable thickness and also cameral deposits which are markedly concentrated ventrally.

Once such rods were suspected, they served as an explanation for some calcite in siphuncles, the nature of which was formerly obscure. Plate 19, Figures 19 and 20, represents a longitudinal thinsection made in a horizontal plane through the phragmocone of *Murrayoceras multicameratum* (Hall). Quite evidently, the calcite in the center of the siphuncle, which shows a sharp regular boundary on each side, faintly undulate in outline, represents a rod as it might well appear in such a section. Further vertical sections from the same suite of specimens (pl. 27, fig. 9; pl. 28, fig. 1-3) show the rods in sagittal sections through the phragmocones. Cross sections showed the type of cross sections in Text Figure 38D, E, and K.

The holotype of *Cyptendoceras ruedemanni* shows a phragmocone broken in such a way that there is an essentially longitudinal section through the siphuncle, but one which lies roughly in a plane inclined 45 degrees from the vertical, as shown in Plate 23, Figures 18-20. The surface of the siphuncle is shown in Text Figure 39B. Clearly, a ventral rod was encountered again in this form, though in an oblique section, as shown in Figures 39C-E.

The holotype of *Cyptendoceras mesleri* is a silicified shell. In its anterior half, the siphuncle is empty and plainly escaped silicification through some quirk in preservation. The anterior end of the apical filling of the siphuncle shows evidence of a ventral rod, seen here in cross section. The silicified surface shows a rod which is somewhat more elevated than those previously noted, and it is also unusual in that the lower sides are extended out to the siphuncle wall. It further shows evidence of growth lines in the rod, indicated in Figure 39A. Owing to the depth of the silicified siphuncle filling from the anterior end of the specimen, the photographs made to show this structure (pl. 23, figs. 14 and 15) were not altogether successful, though they did serve to show the texture of the anterior end of the siphuncle filling.

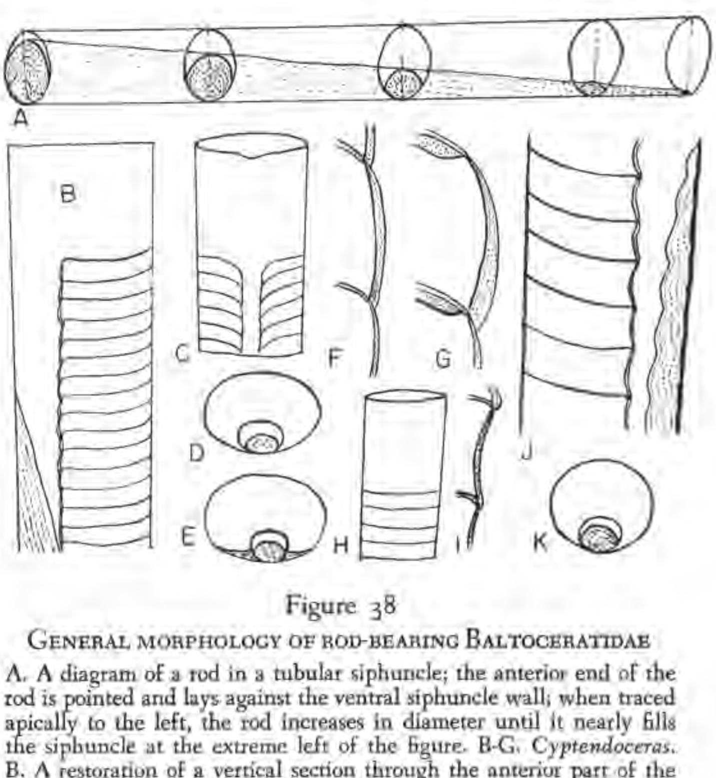

Figure 38

General morphology of rod-bearing Baltoceratidae

A. A diagram of a rod in a tubular siphuncle; the anterior end of the rod is pointed and lays against the ventral siphuncle wall; when traced apically to the left, the rod increases in diameter until it nearly fills the siphuncle at the extreme left of the figure. B-G. *Cyptendoceras*. B. A restoration of a vertical section through the anterior part of the phragmocone of *C. ruedemanni*, showing a rod which enlarges unusually rapidly apically. C. Ventral view of a steinkern of the same species, showing the exposed siphuncle and the ventral lobes. D. A cross section, showing the rod about half filling the siphuncle of this species. E. A more apical section, showing the rod nearly filling the siphuncle, and ventrally concentrated cameral deposits. F. A horizontal section through the dorsal part of a siphuncle segment, showing vestigial necks and moderately thick rings. G. A horizontal section through the same portion of the shell, cutting the siphuncle wall close to the venter; here the ring is appreciably thicker and some cameral deposits are shown. H-K. *Rhabdiferoceras annuliferum*. H. Ventral view of an internal mold; unless the siphuncle is exfoliated, the sutures are straight and transverse. I. Section through a siphuncle segment, showing slightly convex segments and moderately thick rings. J. Vertical section through an interval of phragmocone, showing the slightly convex siphuncle segments and corresponding undulations on the surface of the rod. K. cross section at apical end of J, showing rod nearly filling the siphuncle.

With the recognition of the rods in these forms, further search revealed them elsewhere. Cross sections were made through the holotype of *Murrayoceras primum* Flower (1955) and showed the calcite filling the siphuncle over much of the length of the specimen reduced to a cross section much like that in Text Figure 38D near the anterior end of the specimen. Subsequent search brought out ventral rods in a number of species from the El Paso limestone, including *Cyptendoceras floridaense* (pl. 19, fig. 22) in which a rod is shown in

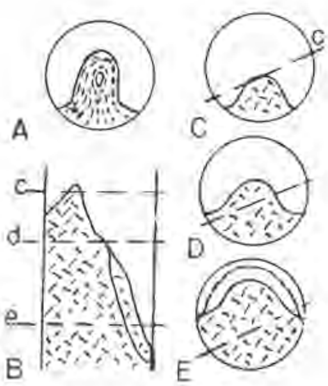

Figure 39

THE VENTRAL ROD IN *Cyptendoceras*

A. Cross section as seen at the anterior end of the siphuncle filling, in the holotype of *Cyptendoceras mesleri* (see pl. 23, fig. 14-15) showing the rod unusually high in the center, the lower margins unusually extended to meet the siphuncle wall, and growth lines preserved. B. Drawing of the siphuncle surface as exposed by a largely longitudinal break, inclined about 45 degrees from the vertical, in the holotype of *Cyptendoceras ruedemanni*. C. through E. are diagrammatic cross sections at the intervals indicated by c-e in B, showing the interpretation of the structure as a rod. The oblique lines show the position of the natural break in the holotype resulting in the section shown in B.

a natural weathered section from the ventral side of the shell. *Cyptendoceras* (?) sp. (pl. 24, fig. 10, 11), *Rhabdiferoceras* sp. (pl. 20, fig. 15-19), and *Cartersoceras shideleri* (pl. 26, fig. 3-5, 8) show similar rods, in addition to the forms discussed above.

Oddly, while the rod is apparently general in the genera *Rhabdiferoceras, Murrayoceras,* and *Cartersoceras,* it is present in some but not all species of *Cyptendoceras.* Though some species are known only from such short portions of phragmocones that they may represent regions anterior to the development of rods, *C. campbelli* from a Cotter horizon in Virginia and *C. genevievense* are known from reasonably long portions of phragmocones and *C. depressum* is known from a series of several specimens; the absence of the rods in these forms is, if not strictly certain in the absence of really complete shells, certainly highly probable. Additional material from the lower Cassinian portion of the El Paso, consisting of silicified steinkerns, failed to show any trace of rods but is perhaps less conclusive in view of the coarse and rather poor preservation.

Potentially these Baltoceratidae with rods are distinctive enough to be regarded as a separate family, but several objections are encountered when such a course is considered. First, the rods are difficult to demonstrate, and quite possibly our knowledge of their range is still imperfect. Second, such a separation would apparently either split the genus *Cyptendoceras* or require arbitrary grouping together in one of these two families of species both with and without demonstrable rods. It is my belief that it is within *Cyptendoceras* that the rods developed; they are unknown in Jeffersonian species altogether and may not be present in all the Cassinian forms. Third, Schindewolf has presented a figure, suggesting what might possibly be a similar rod for *Baltoceras* (Schindewolf, 1942). This he interpreted as an odd sort of endocone. My material of *Baltoceras burchardi* has failed to show any such rod and suggests that what Schindewolf saw was only calcite which thickens apically in a siphuncle in which sediment penetrated imperfectly from the anterior end. Quite possibly what Schindewolf had was one of these other rod-bearing genera, but the identity of the specimen is not known. It nevertheless is an additional deterrent to such a nomenclatorial proposal, for from our present evidence we would be tempted to use the name Baltoceratidae for forms with empty siphuncles and a new name for the rod-bearing genera; but if Schindewolf's structure is a rod, and the form in which he found it is a true *Baltoceras*, the name Baltoceratidae would have to be given to the rod-bearing genera instead.

Genus CYPTENDOCERAS Ulrich and Foerste

Genotype: *Cyptendoceras ruedemanni* Ulrich and Foerste

Cyptendoceras Ulrich and Foerste, 1935, Denison Univ. Bull., Sci. Lab., Jour., vol. 30, p. 270.
——— Ulrich, Foerste, Miller, and Unklesbay, 1944, Geol. Soc. Amer., Special Papers, no. 58, p. 113.
——— Flower, 1955, Jour. Paleont., vol. 29, no. 3, p. 365.

This genus was erected for straight slender shells, slightly depressed in cross section, with a large ventral siphuncle composed of tubular or faintly concave segments, sutures forming a broad conspicuous lobe on the ventral side. Faint dorsal lobes are reported in some species, but the genotype has sutures transverse dorsally. The siphuncle wall is composed of short septal necks supplemented by connecting rings which may show indication of layering. The genus has previously been regarded as an endoceroid, but lacks endocones. Instead, a ventral rod is formed lying against the ventral wall of the siphuncle, which enlarges apically more rapidly than does that of *Rhabdiferoceras.* Cameral deposits, confined to the extreme ventral part of the shell and adjacent to the siphuncle, are developed; such deposits are clearly episeptal, and hyposeptal deposits may be present also.

Discussion. The absence of endocones, the development of thin, ventrally concentrated cameral deposits and the demonstration of a ventral rod in the siphuncle requires the removal of *Cyptendoceras* from the Endoceratida and shows its affinities to *Rhabdiferoceras* and *Murrayoceras* of the Baltoceratidae.

Early work on the Canadian cephalopods involved the assumption that holochoanitic siphuncles prevailed throughout the endoceroids and were, indeed, found in other of the archaic groups, but subsequent investigation has required the abandonment of this concept. Early in the investigation of *Cyptendoceras,* it was known from a second specimen of *C. ruedemanni* and from a thinsection of *C. rhythmicum* that the septal necks were short and were supplemented by connecting rings; however, such a feature did not preclude the possibility that the genus might belong to the Proterocameroceratidae of the Endoceratida. However, the material described below involved a considerable suite of specimens failing to show any indication of endoceroid endosiphuncles, and the suspicion arose that the genus might not be an endoceroid at all. An inquiry to Dr. G. A. Cooper as to whether any of the types showed evidence of such structures resulted in the loan of the entire suite of material. No endocones were found, but instead, evidence of a ventral rod was found in *C. ruedemanni* and in *C. mesleri.* Further, in the light of the clearly preserved rod in *C. ruedemanni,* the calcite in the siphuncle of the hypotype was reasonably interpreted as a similar rod, and the same section showed (pl. 22, fig. 10) evidence of ventrally concentrated cameral deposits similar to those previously observed in *Murrayoceras*. As yet, clear evidence of rods is confined to *C. ruedemanni*, *C. mesleri*, and two species from the El Paso, *C. floridaense* and C. sp. In *C. mesleri* (pl. 23, fig. 14 and 15 and Text Fig. 39A), the material in the apical half of the siphuncle of the holotype (the anterior half is empty) shows a cross section of a rod which is rather more narrow and more elevated than that observed elsewhere; also there are traces of growth lines in this material. It is shown more fully in Text Figure 39A. *C. ruedemanni* was represented by a type in which the phragmocone and siphuncle were broken obliquely; it failed to supply good evidence of the details of the rod as it would appear in cross section; the species is redescribed below and reillustrated here on Plates 22 and 23. (*See also* Text Figure 39B-E.) Evidence of a ventral rod was found also in *C. floridaense*, in particular the specimen here figured, which is weathered from the ventral side, and similar material, with ventrally concentrated cameral deposits, was found in C. sp., a specimen from the highest El Paso.

Of the other known species, some are represented by such short fragments of phragmocone that the apparent absence of the rod is inconclusive. However, two species are known from specimens showing such long intervals of phragmocone that it is evident that either the absence of rods is real or else such rods are greatly delayed in development in relation to the growth of the shell wall and septa. In *C. ruedemanni* the anterior limit of the rod is found roughly at a point in the phragmocone the distance of which from the base of the living chamber is equal to twice the shell width at the base of the living chamber. However, in *C. campbelli* there is plainly no rod in the preserved part of the phragmocone in a length of 80 mm of phragmocone apicad of a living chamber which measures 22 mm in width at its base in the holotype; a paratype shows 80 mm of phragmocone with no evidence of a rod in the siphuncle, apicad of a living chamber with a basal width of 33 mm. The holotype of *C. wellsense* shows a length of 70 mm of phragmocone with no evidence of a rod in the siphuncle, apicad of a living chamber with a basal width of 20 mm. The ventral side of the siphuncle is exposed, and some material is removed from its ventral surface in the apical part. Such lost material may have involved the anterior end of a rod, but the surface of the cavity is irregular, and it could be completely the result of adventitious weathering.

The species and their known ranges may be summarized as follows:

- *C. ruedemanni*. Fort Cassin beds, Champlain valley.
- *C. bridgei*. Jefferson City beds, Missouri.
- C. sp. (*ruedemanni* of Stauffer). Shakopee dolomite, Minnesota.
- *C. campbelli*. Cotter horizon, Virginia.
- *C. depressum*. Powell dolomite, Arkansas.
- *C. genevievense*. Powell dolomite, Arkansas.
- *C. mesleri*. Powell dolomite, Arkansas.
- *C. veterator*. Middle (?) Canadian, Oxford township, Ontario.
- *C. wellsense*. High Canadian (Powell?), Wells Basin, Tennessee.

In the present work are added the following:

- *C. rhythmicum* and *C. kirki*, from the Pogonip of Nevada, a horizon of somewhat uncertain position, but possibly Cassinian.
- *C. richardsoni* from low in the Cassinian of the El Paso.
- *C. floridaense* from high in the Cassinian of the El Paso.
- C. sp. from the highest El Paso (Odenville equivalent).

It should be noted that *C. whitfieldi* UFM&U, 1944, has essentially transverse sutures and the ventral side of the siphuncle shows faintly expanded segments. Only the holotype is known, and material for adequate investigation of the details of the structure is not available. However, it is evident that the suture pattern is quite remote from that of typical *Cyptendoceras*, and the species is possibly assignable to *Rhabdiferoceras*.

Cyptendoceras ruedemanni Ulrich and Foerste

Pl. 22, fig. 2, 10, 11; pl. 23, fig. 18-20

Text Figure 38B-E; text figure 39B-E

Cyptendoceras ruedemanni Ulrich and Foerste, 1935, Denison Univ. Bull., Sci. Lab., Jour., vol. 30, p. 270, pl. 38, fig. 5.

——— Ulrich, Foerste, Miller, and Unklesbay, 1944, Geol. Soc. Amer., Special Papers, no. 58, p. 113 (pars), pl. 60, fig. 1-3, not pl. 27, fig. 16.

It is superfluous to repeat the proportions of the holotype, previously given. The specimen is small, slender, with the depressed section and ventral lobes of the genus. It is worth noting that apicad of the living chamber, which is 19 mm wide and 16 mm high at its base, are 50 mm of phragmocone with an empty siphuncle, apicad of which there is a ventral rod which enlarges rapidly apicad, and while the oblique section exaggerates the apparent rate of expansion of the rod, it appears in that section to fill the siphuncle 10 mm apicad of its tip, another 5 mm of siphuncle with calcite material being retained.

Text Figure 39 shows the plane of the broken section in relation to the real structure.

The siphuncle wall here illustrated for *C. ruedemanni* is based upon a small portion of a phragmocone of my own collecting; originally, it showed the ventral side of the phragmocone, containing a portion of siphuncle, but the dorsal side was incomplete. Two thinsections were made from this fragment; one is shown in two parts on Plate 22, Figures 2 and 11; another, more ventral in position (pl. 22, fig. 11), shows septa thickened by additional calcitic material on their anterior surfaces, largely episeptal, but with possibly some thinner hyposeptal cameral deposits, and a large mass of calcite in the siphuncle. This calcite may well represent a section through such a rod as is seen in the holotype, the section being nearly transverse, the right side more nearly ventral than the left. The specimen was so extremely fragmentary that the nature of the rod (the presence of which was not suspected when the specimen was cut) was not clearly evident either from external examination or from examination during and after cutting.

The species is known only from the Fort Cassin beds of the Champlain Valley. The holotype is No. 92688 in the U.S. National Museum; the hypotype, here figured to show the siphuncle, is No. 293 in the collection of the writer.

Cyptendoceras richardsoni Flower, n. sp.

Pl. 19, fig. 16-18, 21; pl. 21, fig. 24-32

This is a *Cyptendoceras* of rather strongly depressed cross section, with a ventral siphuncle, also conspicuously depressed in cross section, sutures transverse dorsally, with lobes occupying most of the surface as seen from the venter, steepening as they approach the siphuncle.

The holotype is a portion of phragmocone 70 mm long, broken obliquely at both ends. It is slender, the height increasing in 60 mm from 12 to 16 mm, with the width 18 mm where the height is 15 mm. At the base, the siphuncle is 5 mm wide and 4 mm high where the shell is 12 mm high and 14 mm wide. Adorally, the siphuncle is 6 mm wide and 5 mm high where the shell height is 17 mm and the width is estimated at 20 mm. Camerae are spaced three in a length of 5 mm basally, at a shell width of 13 mm, and four in the same length at a width of 16 mm near the anterior end.

A paratype 60 mm long shows a later growth stage, but the basal 30 mm is slightly crushed. In the adoral 30 mm the shell increases from 16 and 19 mm to 17 and 21 mm, with the siphuncle 6 mm high and 8 mm wide adorally and separated from the venter enough so that it is not exposed everywhere along the length of the specimen. Sutures and septa are obscure but agree in general with those of the type.

A second paratype shows the siphuncle and ventral part of the shell at an earlier growth stage. The specimen, 42 mm long, shows only the siphuncle over the apical 12 mm, which is depressed in section and 3 mm high, 4.5 mm wide where it joins the shell, which is 8.5 mm high and 10.5 mm wide at this point. Sutures are obscurely preserved, but the basal septum shows the ventral lobes of the species and genus. In the adoral 20 mm, the camerae occur three in a length of 5 mm, but the rate of expansion is poorly shown as the adoral part is weathered below the middle of the shell. However, in the basal 15 mm, the shell width increases from 10.5 to 12 mm.

Several fragments represent late portions of the phragmocone, but are poorly preserved. An adoral view of one such fragment shows a siphuncle 6 mm wide, 5 mm high, in a shell 17 mm high with an estimated width of 19 or 20 mm. Another fragment shows the siphuncle cavity open to the exterior; this fragment, which increases in height from 16 to 18 mm in 16 mm, shows the marked adoral shortening of the camerae and is probably a late portion of a phragmocone from a mature specimen.

Discussion. All material of this species, from near the top of the dolomites comprising the lower part of B2b of Cloud and Barnes, is strongly silicified and rather fragmentary, and silicification has obscured fine details. It is apparent, though only a series of phragmocones, all fragmentary, are known, that adoral mature parts do not exceed 18 × 21 mm and that the living chamber probably extended 30 to 40 mm farther orad.

The proportions of this form are distinctive. It is more strongly depressed in cross section than *C. depressum* of the Powell formation of Arkansas, but rather similar in aspect to mature parts of this form in spacing and slope of the septa on the venter. *C. bridgei* of the Jefferson City formation of Missouri shows much deeper ventral lobes and much more closely spaced septa. Other species are not closely comparable. *C. campbelli* is a much more slender shell; *C. ruedemanni* is smaller, rather similar in the depressed cross section, but the ventral lobes of the suture are broader and shallower; *C. mesleri* has relatively distant septa which are much more steeply inclined on the ventral side.

None of the material shows clear evidence of a rod in the siphuncle. Some fragments show siphuncles filled with matrix, others show silica within, but preservation is coarse, and the contact of matrix and silica, which might show the anterior end of a rod, is not clearly observable.

Types. Holotype and five paratypes, collection of the writer, Nos. 870 to 875.

Occurrence. From a layer of black dolomite from near the top of bed 8 of Cloud and Barnes (1946) in the lower part of the Cassinian, unit B2b, of the El Paso limestone, from the southern end of the Franklin Mountains at El Paso, Texas.

Cyptendoceras floridaense Flower, n. sp.

Pl. 19, fig. 22

This is a shell known from natural weathered sections, the most significant of which, the holotype, is a specimen weathered from the ventral side, increasing in width from 7 to 9.5 mm in 30 mm, with an apparently strongly depressed cross section and a ventral siphuncle containing a ventral rod. Six camerae occur in a length of 10 mm. The septa are quite deeply curved, the depth slightly greater than the length of a camera. The siphuncle is tubular, weathered in relief so that the partially weathered rod lies above the part filled with matrix in the adoral portion, enough so that the character of the rod is unmistakable. The suture pattern is not definitely known, but in section septa are shallower ventrally at midheight of the shall, suggesting the development of ventral lobes.

The holotype, No. 886, is from a layer of calcilutite from near the top of the El Paso limestone at the Capitol Peak section, on the northwest side of the Florida Mountains. It is clearly high in the equivalent of B2b of Cloud and Barnes of the El Paso section, about 30 feet below the calcilutites of the *Buttsoceras* horizon. Ironically, this form, so preserved that the sutures and cross section are not clearly shown, exhibits with remarkable clarity the rod in the siphuncle, which is ordinarily an extremely elusive structure. Collection of the writer.

Cyptendoceras sp. (Highest El Paso)

Pl. 24, fig. 10, 11

Under this name is figured a most peculiar straight cephalopod known only from a ventral portion of the shell retaining the siphuncle. The specimen is 94 mm long. In this length, the siphuncle expands from a blunt tip to a width of 4 mm in the basal 5 mm and in 20 mm more has expanded to 6 mm; and close to the anterior end it is 8 mm wide and 6 mm high. The siphuncle segments are plainly tubular, and a section of the apical part shows short septal necks. The straight shell was evidently depressed in section as is the siphuncle, but there is too little of its ventral side preserved to permit any reliable estimate of height-width relationships, for only the ventral third or quarter of the shell is preserved. The siphuncle is filled with calcite, which is interpreted as the completed development of a ventral rod; the absence of any vestige of an endosiphocone opposes the alternate interpretation that endocones were present. The septa describe only broad, shallow, ventral lobes. Adorally, where the septa are clearest, there are clearly four camerae in a length of 10 mm, a relationship maintained over the anterior two thirds of the specimen. Apparent apical thickening of the septa is clearly the result of the development of episeptal deposits which are confined to the extreme ventral part of the shell flanking the siphuncle. Though the lateral limits of the cameral deposits are natural, the extreme ventral concentration of the deposit is unusual in orthoconic nautiloids in general, though there is some evidence of a similar pattern developed in *Eobactrites*. Apically, the deposits are so thickened close to the siphuncle that they nearly fill the camerae; adorally, they thin, as is to be expected from the normal growth relationships of these structures, and it is difficult to say whether the deposits are present but thin at the anterior end of the specimen or whether they are wanting, though the former interpretation seems the more probable of the two.

Discussion. There seems little point in giving a name to a species known from such a fragmentary specimen that there is little more to go by for identification than the rate of expansion of the siphuncle and the spacing of the septa. However, the form is of particular interest in that it shows the apparent apical part of a baltoceroid in which the rod has completely filled the siphuncle and shows a marked development of cameral deposits which are episeptal and confined to the extreme ventral part of the shell adjacent to the siphuncle. The generic position of this form poses some problems. Septa show very broad, shallow, ventral lobes, and though they are not so inclined as in typical *Cyptendoceras*, they are much more inclined than in *C. whitfieldi* which, from the essentially transverse sutures and the evidence of slightly expanded siphuncle segments, has been removed, though tentatively, to *Rhabdiferoceras*.

It is not impossible that this species, when better known, may be separated as a genus as yet undefined, a genus with a tubular siphuncle containing a rod, a depressed section, cameral deposits concentrated on the ventral side, and relatively simple sutures having, as is apparent from this specimen, very broad, shallow, ventral lobes.

Figured specimen. Collection of the writer No. 887, from the highest beds, unit C, of Cloud and Barnes, from the El Paso limestone, from near the crest of the Scenic Drive, at the southern limit of the Franklin Mountains at El Paso, Texas.

Cyptendoceras rhythmicum Flower, n. sp.

Pl. 22, fig. 1, 3-9; pl. 23, fig. 1-4, 16, 17

This is a small, slender *Cyptendoceras*, notable for the rather rhythmic variation in the spacing of the septa, particularly in the later growth stages. The shell is very slender, the cross section subcircular or perhaps slightly depressed in section, there being some question as to the effects of weathering and perhaps slight distortion on our material. A series of fragmentary specimens indicates that the shell attained a maximum diameter of 26 mm and was probably 240 mm long. One specimen shows a calcite-filled siphuncle extending apicad from a bit of phragmocone 16 mm in height, probably not representing quite the maximum height of the shell. This siphuncle extends perfectly straight and tubular for 35 mm apicad, beyond which point its ventral profile becomes slightly convex, extending for another 25 mm, and probably reaching a blunt tip about 7 mm farther apicad. This shows that the apex of the siphuncle is of the general form of that found isolated from the phragmocone, for which the genus *Manitouoceras* was erected.

Septa are transverse on the dorsal side, but on the ventral side slope apicad forming a broad, rounded lobe; where exfoliation or weathering bring the exposed surface down so that the siphuncle is exposed, the depth of the lobe is materially increased.

The siphuncle is circular in section and narrowly separated from the ventral wall of the shell. The forward slope of the septum from the center toward the ventral margin of the shell is pronounced, and a siphuncle seen on a curved septal surface appears materially compressed in cross section.

Septa are closely spaced, so that on an average, camerae are spaced six in a length of 10 mm. However, while in early growth stages, up to a shell diameter of 18 mm, the camerae are fairly regular in length, later ones are particularly prone to wide variation, from 0.8 to 3.0 mm, and the spacing of short and long camerae seems to recur somewhat rhythmically so that one or a group of several short camerae recur between longer ones in every 10-mm interval of shell length.

The latest growth stage noted is shown by the holotype (pl. 22, fig. 3) with a living chamber 55 mm in length expanding from 24 to 27 mm in width; at the base there are seven attached camerae occupying a length of 14 mm.

A thin vertical section made of one specimen (pl. 22, fig. 1, 4, 5) shows an empty siphuncle 19 mm long. Its ventral wall is lost, but on the dorsal side are 26 camerae, in which there is a peculiar and seemingly erratic distribution of matrix and calcite. The dorsal wall of the siphuncle shows some vicissitudes of preservation, in spite of which it is evident that the septal necks are very broadly curved apicad, the greater part of their curvature lying outside the connecting ring. The necks are slightly less than half the length of a siphuncle segment and are supplemented by rings in which a differentiation of inner and outer layers is apparent. A curious feature of the section is the apparent thickening of several of the septa as they are traced from the siphuncle to the dorsal side of the shell. However, closer examination shows that what appears to be one thick septum is actually two closely spaced septa with inorganic calcite between; this is seen most clearly on the fourth septum from the anterior end; in many places, recrystallization of calcite has obscured the distinction between calcite replacing shell parts and that filling closed camerae.

One paratype, No. 139840, Plate 22, Figures 7-8, is weathered from the ventral side, exposing the siphuncle in which there is an apparent longitudinal structure that is adventitious, being made up of two portions of matrix differing slightly in hue. One specimen referred to the species with question, USNM No. 139849, Plate 23, Figures 16-17, consists of a living chamber, one attached camera, and a considerable length of siphuncle, the whole specimen exposed in an essentially sagittal section. Sectioning of the apex exposes what is believed to be the true apex of the siphuncle which is blunt, convex ventrally, straight dorsally. An adventitious species of an endoceroid lies in the living chamber.

Types. The holotype and figured paratypes, U.S. National Museum, Nos. 139838-139844, and the specimen tentatively assigned to the species, No. 139849, are all from one association, USNM loc. 2175, from the Pogonip limestone "above the the *Receptaculites*" from the north end of the Ely Springs Range, Highland Peak quadrangle, Nevada. The cephalopod association suggests Cassinian rather than Whiterock. A *Receptaculites* horizon is noted in the Whiterock, but there are several lower horizons of sponges to which this generic name has been applied.

Cyptendoceras kirki Flower, n. sp.

Pl. 23, fig. 5-11

This is a large *Cyptendoceras* with rather deep camerae and a large siphuncle which, from internal molds, appears to be broadly flattened and in contact with the ventral wall of the shell. The holotype is a fragment 122 mm long, with 34 mm of phragmocone and 80 mm of living chamber. At the base, a maximum shell width of 44 mm occurs, increasing to 46 mm at the base and 54 mm at the adoral end of the living chamber. The dorsal side is modified by weathering, and reconstruction of the original cross section is approximate; it appears, however, that the shell was circular or nearly so in cross section, and that the present apparent flattening involves both weathering of the dorsum and very slight flattening. Sutures are straight laterally, forming broad ventral lobes. The siphuncle is large, 14 × 11 mm apparently flattened and in contact with the ventral shell wall. The six camerae shorten adorally, the first being 9 mm long, the last two 5 and 4 mm, respectively, an indication of maturity.

A paratype is a portion of phragmocone, again with the dorsum lost by weathering, 50 mm long, apparently circular in original section, increasing from 29 to 35 mm in diameter, camerae averaging 5 to 6 mm long, the large ventral siphuncle in broad contact with the venter, the siphuncle 20 mm wide and 14 mm high at the base of the specimen.

A second paratype shows similar proportions; it is a portion of six camerae, 35 mm long, increasing in width from 31 to 34 mm. Slight flattening has affected the shell and has possibly increased the ventral obliquity of the sutures. The siphuncle is in broad contact with the venter, plainly somewhat distorted by its cross section but with a maximum width of 19 mm. A thinsection was prepared of this species. Though preservation is poor, it shows the short necks of the genus. This was done in the light of the discovery in the Whiterock Antelope Valley limestone of Nevada of a true endoceroid having the ventral lobes of *Cyptendoceras*, but good endocones and considerably larger septal necks. This form is to be published later and is given the generic name of *Trinitoceras*.

A third specimen is a fragment of the base of a living chamber and three camerae showing similar sutures and a similarly large siphuncle, but somewhat shorter camerae. It has a width of 34 mm, a siphuncle 9 mm high and 12 mm wide, and camerae decreasing adorally in depth, the three measuring 6, 5, and 4 mm, respectively. The incomplete cross section suggests a shell of circular cross section.

Types. Holotype and three paratypes, from USNM loc. 2175, from the north end of the Ely Springs Range, Highland Peak quadrangle, Nevada, listed as from above the *Receptaculites* zone and lower Chazyan, which would be Whiterock in modern terminology. The cephalopods themselves suggest a horizon high in the Canadian rather than Whiterock.

Cyptendoceras? tennesseense UFM&U

Bathmoceras? tennesseense Ulrich, Foerste, Miller, and Unklesbay, 1944, Geol. Soc. Amer., Special Papers, no. 58, p. 130, pl. 8, fig. 3-8.

Tentatively assigned to *Bathmoceras* is this puzzling species represented by a number of siphuncles showing essentially tubular segments, strongly oblique septal ridges, and a conical structure tapering forward in the siphuncle. The material, which is all silicified, does not lend itself to study by sections, and for a time *Bathmoceras* seemed the only form with which affinities could be suggested. However, in the light of the ventral rods known in *Cyptendoceras*, *Murrayoceras*, and *Rhabdiferoceras*, an alternate explanation is proffered, for these siphuncles seem to show a single anteriorly pointing cone, rather than a series of conical elements, one beginning in each segment as in *Bathmoceras*.

Obviously, a form such as this, with a very large siphuncle with very steeply inclined septal ridges, is not readily reconciled with any of the genera known to contain rods in the Baltoceratidae. Certainly there is no close relationship with *Rhabdiferoceras* or *Murrayoceras*. Isolated siphuncles of a large *Cyptendoceras* might show such steeply inclined septal ridges, but no form is yet known equaling this one in proportions, and such proportions are, from the general delay in development of the rod beyond the septa and siphuncle, to be found only some distance from the living chamber. Thus this species, as compared to known *Cyptendoceras*, is about twice the size of most of the species so far known. Of course, without more of the shell, generic assignment can only be tentative; the gross features of the shell might easily prove to be quite different from those of *Cyptendoceras*, and the ventral bending of the sutures in that genus makes it unlikely that an isolated siphuncle of this genus would show such steeply inclined septal ridges as this species shows. Such steep ridges suggest, on the contrary, a shell in which the sutures are transverse ventrally, with very steeply inclined and very deeply curved septa, or else a form in which there are ventral saddles. It seems, however, that the rod-bearing Baltoceratidae suggest affinities for this unusual cephalopod which before were unsatisfactory.

The known material is from near Jefferson City, Tennessee, coming from beds regarded as Chepultapec, Gasconadian in age. The apparent occurrence of this form in the Lower Canadian is anomalous in relation to the known rod-bearing Baltoceratidae. Can it be that a shell with a compressed section and lateral lobes, such as would be considered an *Ellesmeroceras* on the basis of gross features, developed a rod such as is elsewhere known only from Jeffersonian, Cassinian, and younger species? It is possible, but while the suggestion can be made, more material is, of course, needed before this can be more than a conjecture. Oddly, the apparent Lower Canadian age is even more anomalous for a *Bathmoceras* than for a relative of *Cyptendoceras*, for while the rod-bearing Baltoceratidae appear in the Jeffersonian, *Bathmoceras* ranges from beds which are apparently very late Canadian into the Ordovician.

Genus RHABDIFEROCERAS n. gen.

Genotype: *Rhabdiferoceras annuliferum* Flower n. sp.

This is an orthoconic shell, circular in section, with apparently a smooth surface and straight transverse sutures. The genotype has, however, thus far been observed only from sections, and further confirmation of the simplicity of the gross features is desirable. The siphuncle is rather large, typical of the Baltoceratidae in this respect, slightly removed from the venter. Septal necks aneuchoanitic, rings layered, outlining segments which are very slightly expanded and very gently convex. Within the siphuncle there is a calcareous rod, lying against the ventral wall of the siphuncle. Th rod is subcircular in section, very slightly depressed, and in longitudinal section shows a surface which is undulate, the spacing of undulations conforming to the segments of the siphuncle. The rod thins and terminates adorally against the ventral wall of the siphuncle.

Discussion. Only two named species of this genus are known as yet, but the features of the siphuncle, combining slightly rounded segments and a ventral rod, are distinctive. The holotype is from the Pogonip group, and of somewhat uncertain horizon as far as records go, but the association suggests overwhelmingly a Cassinian age. Some confirmation of this supposition is found in the specifically unnamed form here figured and described, from the Cassinian portion of the El Paso group.

Cyptendoceras whitfieldi UFM&U is tentatively assigned to *Rhabdiferoceras*, as the expanded siphuncle segments suggest this genus most strongly.

Our collections contain a small fragment of a moderately expanding orthocone with a ventral siphuncle of slightly expanded segments from the sponge bed of the Pogonip group of Nevada, which may be an additional species of *Rhabdiferoceras*, but the present fragment is inconclusive. It shows straight transverse sutures, ventrally interrupted by the expanded siphuncle segments. A second form, showing proportions too poorly preserved for analysis at the specific level, is described from the highest (latest Cassinian) beds of the El Paso succession.

Rhabdiferoceras annuliferum Flower, n. sp.

Pl. 20, fig. 4-7, 12-14

Text Figure 38

Shell straight, circular or nearly so in section, sutures apparently transverse or nearly so, siphuncle circular in section, slightly removed from the venter, septal necks very short, rings thick, layered, outlining segments which are very faintly convex. Calcite within the siphuncle is a rod, circular in cross section, and lying against the ventral wall, leaving a dorsal crescent-shaped cavity filled with matrix.

The type, thus far the only specimen encountered, was discovered in sectioning a limestone block, from which the cephalopods could not have been removed by other means. A surface was exposed which is a longitudinal section, about 30 degrees from the horizontal, passing through the lunate matrix-filled cavity of the siphuncle. The section exposed shows a shell expanding from 12 to 14 mm in 24 mm. Apically, it shows a siphuncle 3 mm across and 2 mm from the venter; adorally, the distance from the venter remains the same, but segments expand from 4 to 4.8 mm in the camera. Apically, four segments occupy a length of 10 mm; adorally, three segments occur in the same length.

A cross section across the apex of this specimen reveals the siphuncle to be 3 mm across and 1.2 mm from the venter, and it is about half-filled by a calcite rod, round, subcircular, very slightly depressed, lying against the venter. The above-mentioned longitudinal section was mounted for sectioning and ground; in the process, when the obverse surface passed through the siphuncle cutting the calcite rod, a photograph was taken. In this section, calcite in the camerae and calcite in the siphuncle were poorly differentiated, but slight etching of the surface brought out faint dark bands of the polished section as septal necks. In this section, a peculiar feature is the undulate surface of the calcite rod, which conforms in spacing of the undulations to the segments of the siphuncle.

A cross section at the base of this specimen shows the removal of the siphuncle from the venter, but it is oblique, giving a deceptive compressed aspect to the form. Apicad of this section, the phragmocone extends for a very short distance but is poorly preserved, complicated by calcite veins, and its interpretation is dubious.

Discussion. This species has, at the present, the characters of the genus and is distinguished from the forms described below in details of proportions.

Type. Holotype, U.S. National Museum, No. 139851.

Occurrence. USNM 2175, from slab of fine-grained limestone with *Cyptendoceras rhythmicum*, from beds regarded as Cassinian, in the Pogonip group, from the northern end of the Ely Springs Range, Nevada.

Rhabdiferoceras? whitfieldi Ulrich, Foerste, Miller, and Unklesbay

Cyptendoceras whitfieldi Ulrich, Foerste, Miller, and Unklesbay, 1944, Geol. Soc. Amer., Special Papers, no. 58, p. 116, pl. 59, fig. 7.

This form is known only from the holotype, a portion of a phragmocone so slender as to be essentially tubular, with close transverse sutures and a rather large ventral siphuncle, the ventral surface of which is exposed and is faintly annular, being expanded slightly but definitely in the camerae. It is 67 mm long, increasing in width from 20 to 23.5 mm, and slightly wider than high in cross section. In form, this species is very close to *Rioceras tubulare*, the main difference being the annular ventral surface of the siphuncle. Anomalously, this feature suggests a possible assignment of the species not to *Rioceras* but to *Rhabdiferoceras*. The species is certainly not an endoceroid, and its sutures are remote from those of *Cyptendoceras*, to which genus it was originally referred. Though the species is distinctive among those of the Fort Cassin fauna, it remains so inadequately known morphologically that, while its position in the Baltoceratidae is reasonably certain, its assignment to either *Rioceras* or *Rhabdiferoceras* requires more evidence than the solitary known specimen affords.

The holotype, No. 476, in the American Museum of Natural History, is from the Fort Cassin beds of Fort Cassin, Vermont.

Rhabdiferoceras sp.

Pl. 20, fig. 15-19

Under this name is described a single specimen from the Cassinian part of the El Paso, a portion of a phragmocone 73 mm long, increasing in width from 5 to 12 mm. The phragmocone is filled with coarse calcite which has obscured the septa so that neither their spacing nor the course of their sutures can be ascertained. A cross section at the anterior end (pl. 20, fig. 16, 17) shows the cross section of the shell to be slightly depressed, with a ventral siphuncle of circular section. The anterior side of the cut shows a cross section of a rod, now composed of coarsely crystalline calcite, slightly depressed in section, rounded above, lying against the ventral side of the siphuncle. The opposite side of the cut (pl. 20, fig. 17) shows the rod slightly larger. A section near the apical end (pl. 20, fig. 19) shows the siphuncle filled with calcite, lying in matrix, the ventral side of the phragmocone wanting, but with calcite in the dorsal part of the phragmocone. A longitudinal section was made of the intervening portion. The matrix lying above the rod in the siphuncle is seen tapering apicad from the anterior end to a slender point. The dorsal side of the siphuncle shows faint indication of annular, slightly convex segments, and near the apical end, where the siphuncle is preserved but the ventral wall of the phragmocone is wanting, a similar annular outline of siphuncle segments is indicated. The annuli show the camerae to be about 2 mm in length apically, but their spacing is more obscure adorally, though apparently somewhat farther apart.

Discussion. While this specimen is of interest in showing clear evidence of a rod in a slender straight shell from the Cassinian of the El Paso limestone, and the evidence of faintly annular siphuncle segments suggests reference to *Rhabdiferoceras*, it is felt that without clearer indication of gross proportions and of the spacing and course of the sutures, recognition of this species would be most difficult, and for this reason the species is not named, such a procedure being delayed in the hope of obtaining better-preserved material.

Figured specimen. No. 885, from the Cassinian portion of the El Paso, B2b of Cloud and Barnes, from McKelligon Canyon, southern Franklin Mountains, at the edge of El Paso, Texas.

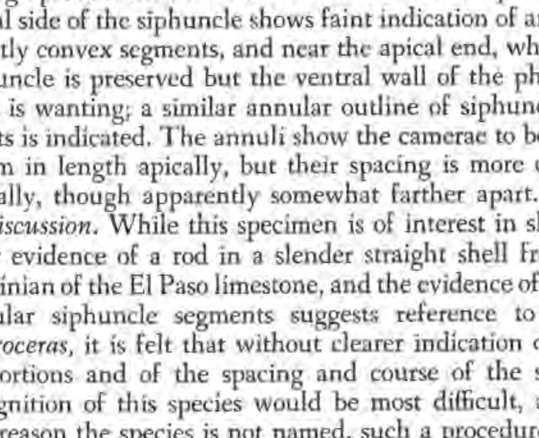

Figure 40

GENERAL FEATURES OF *Murrayoceras*

A. Portion of a shell viewed from the venter. B. Lateral view, venter on right. C. Cross section, showing rod in siphuncle and ventral cameral deposits. D. Section through a more apical part of the siphuncle, showing the rod larger. E. Section through siphuncle wall of a typical form. F. Section through siphuncle wall, showing rings outlining faintly undulate segments, approaching the condition of *Cartersoceras*.

Genus MURRAYOCERAS Foerste

Genotype: *Orthoceras murrayi* Billings

Murrayoceras Foerste, 1926, Denison Univ. Bull., Sci. Lab., Jour., vol. 21, p. 312.
——— Foerste, 1932, ibid., vol. 27, p. 120.
——— Flower, 1952, Jour. Paleont., vol. 26, no. 1, p. 29.

This genus contains orthoconic shells, usually of moderate size, the section depressed, the venter more flattened than the dorsum, with sutures describing broad lobes over the ventral surface. The siphuncle is relatively large, its wall composed of very short necks supplemented by thin rings, the segments sinuate in outline, varying from subtubular to varyingly expanded; some appear cyrtochoanitic. Calcite commonly present in the siphuncles involves the secretion of an organic rod close to the venter of the siphuncle.

Discussion. Murrayoceras makes its earliest known stratigraphic appearance in the Day Point limestone, which should possibly be grouped with the Whiterock rather than with the Chazy. It is represented there by *M. primum* Flower. Additional sections of this form show that the calcite in the siphuncle represents a ventral rod. No true Chazyan forms are known. It is widespread in the true Lowville (excluding beds put in the Lowville on the basis of lithology, which only serve to confuse the picture of the history of deposition) of New York, adjacent Ontario, and in the Ottawa and St. Lawrence valleys. In beds of Chaumont age it is known from *M. carletonense* from the Ottawa Valley; possibly the same species is present in the Chaumont of northwestern New York. I have collected the genus there. *M. murrayi* (Billings) and *M. ehlersi* Foerste are from St. Joseph Island.

Formerly included in *Murrayoceras* is a group of forms in which, as in *M. noveboracense* of the Amsterdam limestone of New York, the siphuncle segments assume a slightly convex outline. Such specimens are here separated into the genus *Cartersoceras.*

There can be little doubt but that *Murrayoceras* is closely related to *Cyptendoceras* and quite probably to the little known *Cyptendocerina;* these genera are quite similar in the depressed section and the development of a lobe on the venter. In *Cyptendoceras* the siphuncle is larger, commonly in contact with the venter, and the ventral lobe is narrow and steepens as it approaches the rather large siphuncle. *Cyptendocerina* is not adequately known; it could prove to be a synonym of *Murrayoceras,* but in view of the general distinctness of most Canadian and Ordovician genera, future work may provide differences not now apparent. The genus lacks the strongly depressed section and close sutures of true *Murrayoceras,* not fundamental differences, to be sure. Our present sections suggest that *Murrayoceras* shows a reduction in thickness and layering of the rings not shared in general by the Canadian genera.

Foerste (1926) suggested that *Orthoceras semiplanatum* Whiteaves of the Red River beds of Manitoba might be a *Murrayoceras,* but later made it the type and the sole species of the genus *Garryoceras,* regarded as having a depressed cross section with the siphuncle close to the dorsum, which is angled, the section being subtriangular. Re-examination of the genotype shows this supposed siphuncle to be adventitious, and the species is almost certainly a *Kindleoceras;* indeed, it is very close in proportions to *K. aequilaterale* Flower (1946) of the Richmond of the Cincinnati arch.

Fragments indicate that *Murrayoceras* is possibly rather widespread in the Mohawkian in eastern North America. I have seen fragments from various localities in the Appalachians, and both *Murrayoceras* and *Cartersoceras* are present in the Carters limestone of Tennessee.

Murrayoceras multicameratum (Emmons)

Pl. 19, fig. 19, 20; pl. 27, fig. 9; pl. 28, fig. 1-6

Orthoceras multicameratum Emmons, 1842, Geology of New York, Rept. on the 2nd district, p. 382, fig. 93.
——— Hall, 1843, Paleontology of New York, vol. 1, p. 45, pl. 11.
Cameroceras multicameratum Foerste, 1932, Denison Univ. Bull., Sci. Lab., Jour., vol. 27, p. 64, pl. 8, fig. 1-3; pl. 9, fig. 1.
Michelinoceras multicameratum Shimer and Shrock, 1943, Index Fossils of North America, p. 537, pl. 219, fig. 1-2.
Murrayoceras multicameratum Flower, 1952, Jour. Paleontology, vol. 26, p. 29-30.
Michelinoceras multicameratum Wilson, 1961 (pars), Canada Geol. Surv., Bull. 67, p. 19, fig. 11-13.

It is pointless here to review the specific proportions of this species on which Foerste has provided accurate information. Possibly closer analysis on large suites of Lowville material might be profitable, but there is little reason to doubt the generally widespread presence of a single species in the Lowville of northwestern New York, Ottawa, and the St. Lawrence Valley. It is, however, highly doubtful that the species ranges from the Pamelia to the Cobourg, as Wilson (1961) has indicated.

Material of this species was used as a basis of a morphological study, rather than for study of the strict proportions upon the basis of which this species is distinguished from its congeners. On Plate 19, Figures 19-20, is shown a horizontal longitudinal thinsection through a siphuncle which shows the center of the siphuncle occupied by calcite; this structure is now clearly interpreted as a cross section through a ventral rod, but when this section was made, before such structures were suspected, it proved a complete puzzle, for the structure was obviously organic, but there was no indication of the true nature of this calcite which was separated on either side from the siphuncle wall.

A section shown on Plate 27, Figure 9, is a portion of a phragmocone 102 mm long, enlarging from 14 and 18 mm to 21 and 31 mm. The siphuncle, shown on the left, is filled with calcite apically, but adorally, the calcite surface slopes steeply forward from the dorsal to the ventral side, and shows the anterior limit of a ventral rod. A further unfigured anterior portion expands from 21 and 31 mm to a height, incomplete from weathering, of 26 mm and a width of 41 mm. This portion contains eleven camerae in the basal 35 mm, and a basal 25 mm of an incomplete living chamber. It is of interest to note that the anterior tip of the rod lies 45 mm from the base of the living chamber, and the rod is apparently complete, attaining the dorsal side of the siphuncle, about 40 mm apicad of its anterior tip. The camerae are fairly even in spacing; both at the base and at the anterior end, eleven camerae occupy a length of 35 mm. The shell shows a depressed cross section, the venter markedly more flattened than the dorsum, with sutures describing broad, prominent lobes on the ventral face.

A short portion of phragmocone is shown in Plate 28; again, the calcite in the siphuncle represents a ventral rod, which is imperfect anteriorly in Figure 1, Plate 28, though in Figure 2, the opposing surface, the section is slightly off-center, and the anterior tapering of the rod on one of its lateral slopes is seen. This is more clearly seen in the further enlargement in Figure 3. The surface shown in Figure 1 was used for a thinsection, and enlargements of the siphuncle wall are shown in Figures 4 to 6 of the same plate. In Figure 4, which is relatively anterior, calcite fills the camerae; probably this was originally a cameral deposit. The calcite in the siphuncle represents the ventral rod. Septa are steeply inclined, with no further bend for vestigial necks, and the rings show some appreciable thickness and form segments of a faintly sigmoid outline. Farther apicad (fig. 5), the rings tend to outline more uniformly concave segments, show some appreciable thickness, and the anterior ring shows a suggestion of layered structure. Others show light interiors and dark surfaces, the inner surface slightly thicker than the outer one, but so involved with carbonaceous material in the ventral rod that the details cannot be ascertained. On the dorsal side of the siphuncle, where matrix fills both the siphuncle and the camerae, septal necks appear to be longer, but it is not quite certain whether, with recrystallization, parts of the rings are not apparently incorporated with the septal necks.

Hypotypes. The specimens here figured and described are in the collection of the writer; Nos. 353, 394, 395, from the Lowville of Margaret's quarry, Ottawa, Ontario.

Occurrence. M. multicameratum is common in the Lowville of northwestern New York and the Ottawa Valley. It has been reported from the St. Lawrence Valley. The writer has had no material from this region. The species has been cited even more widely in the Appalachians and east central interior. Such citations possibly involve this species in part, but also involve other species of *Murrayoceras*. Within the group of cephalopods of the general aspect of this form, slender, closely septate orthocones with sutures forming broad lobes over the flattened venter, other species were not recognized except *O. murrayi* Billings, prior to 1926, and the relationship of *O. multicameratum* with such species was not recognized prior to 1952.

Genus CARTERSOCERAS Flower, n. gen.

Genotype: *Cartersoceras shideleri* Flower, n. sp.

This genus is erected for species formerly assigned to *Murrayoceras* in part and in part to "*Sactoceras*." They are typical of *Murrayoceras* in all features except that the siphuncle segments are convex in outline. The genotype shows clearly the ventral rod in the siphuncle, and a thinsection shows thick rings with fibrous texture, but not the usual layered structure of the older Ellesmeroceratida.

The genotype is a new species and is described below. In addition, the following species are here placed in the genus:

C. noveboracense (Flower, 1952, Jour. Paleontology, vol. 26, no. 1, p. 30, pl. 6, fig. 9, as *Murrayoceras*). This is a species of the Amsterdam limestone of New York, known from a portion of phragmocone, weathered, exposing the siphuncle which is filled with calcite. There is now little doubt that the calcite represents a ventral rod, which here fills the siphuncle.

C. cf. *ottawaense* (Billings). This form Wilson (1961, p. 65, pl. 26, fig. 5) referred with question to *Sactoceras*. It, too, is a portion of phragmocone weathered from the venter, exposing a siphuncle with broad segments, the outlines faintly convex, and filled with calcite. It is from the Paquette Rapids of the Ottawa River. There is, however, some doubt as to whether this is properly conspecific with *Orthoceras ottawaense* of Billings, as the septa, though somewhat similar in spacing, show definitely relatively slight curvature. It is not clear from the present illustrations whether the Ottawa forms, which are true *ottawaense*, are all one species; the extended range (Pamelia to Middle Trenton) makes this doubtful. The only Ottawa specimen showing a siphuncle (Miss Wilson's pl. 26, fig. 6) is a considerably weathered specimen. It shows deposits in the siphuncle leaving a central tube of matrix; such a pattern as is shown here could be developed either in true actinoceroids or in Michelinoceratida with expanded siphuncles, such forms as were formerly placed in the Stereoplasmoceratidae, but for which later the family name Proteoceratidae was proposed, owing to uncertainty of the structure of the syntypes of *Stereoplasmoceras pseudoseptatum* Grabau.

Cartersoceras is certainly a modification of *Murrayoceras* and seems to be developed largely, perhaps completely, in beds of Rockland or supposedly Rockland age. *Rhabdiferoceras* is similar in the expansion of the siphuncle segments, but in that genus the section is more nearly circular, there are clearly no prominent ventral lobes of the sutures, and cameral deposits, though apparently present, show less advanced development.

Cartersoceras shideleri Flower, n. sp.

Pl. 26, fig. 3, 4, 8-11

This species is known from several fragments of phragmocone. It is a fairly rapidly expanding orthocone of depressed section. The holotype, a portion of phragmocone 65 mm long, originally weathered from the venter, partially exposing the siphuncle, later ground down to expose the siphuncle more fully, expands in width from 17 to 22 mm in 50 mm; this expansion probably approximates the ventral siphuncle, to the level of which the specimen is ground, and does not lie at the level of greatest shell width. The incomplete adoral end shows a width of 25 mm and suggests a height of 18 mm. Throughout the specimen there are three camerae in a length of 10 mm; septa are shallow in curvature, the depth slightly less than the length of a camera, and about one eighth of the shell width. Episeptal deposits are developed but are clearly present only on the venter. The siphuncle, shown clearly in the adoral part, lies above the plane of the ground section apically. Adorally, a segment 3 mm long expands from 3.5 to 4.4 mm. Outlines are rounded, expanded slightly more in the adoral than in the adapical end. Necks are short and obscure. The ring is thick, but in opaque section its structure cannot be made out. The horizontal section shows a median band of calcite in the middle of the siphuncle over the adoral two thirds of the specimen, clearly a cross section through a ventral rod. It is not nummuloidal in outline. In the apical portion of the specimen, the section passes obliquely through the dorsal part of the siphuncle, and at the apex, dorsad of the siphuncle. In the apical segments the section passes dorsad of the ventral rod, for only matrix is apparent in these camerae (pl. 26, fig. 3, 4).

A paratype is a portion of a phragmocone ground horizontally through the siphuncle and reduced to a thinsection, in all, 40 mm long, expanding from 10 to 16 mm. Camerae are somewhat shorter as would be expected in a more apical portion, ranging from 2.2 to 2.6 mm in length. The siphuncle segments expand from 3.5 to 4.2 mm adorally, are convex in outline, but show at this stage only a very slightly greater convexity in the adoral than in the apical end. Constriction at the septal foramina is fairly sharp. The siphuncle is completely filled with calcite; presumably the specimen, which represents an earlier growth stage than the holotype, is an early portion of a well-developed individual, and in this relatively apical portion, the rod shows more advanced development. Calcite fills most of the camerae, but on either side of the siphuncle there is some matrix in the adoral portions of the camerae; the matrix widens as the camerae are traced adorally; evidently episeptal deposits are developed, so advanced in growth apically at the horizontal level of the siphuncle as to nearly fill the camerae, but they decrease adorally in thickness, the usual growth relationship (pl. 8, fig. 8-11).

Enlargements of the siphuncle wall (pl. 26, fig. 9-11) show the septal necks very short, very slightly recurved, pointing obliquely apicad and outward. The rings are relatively thin apically, composed of dark material, without a clearly ascertainable structure. Adorally, however, the rings are materially thickened, showing in general fibrous, longitudinal structure. On Plate 26, Figures 10 and 11, are shown two essentially adjacent portions of the rings, showing such structure. On Plate 26, Figure 11, it is clear that the apical end of the ring curves around the septal neck, somewhat suggesting the annular bullettes of the Discosorida and similar annular structures developed in incipient phases of actinosiphonate deposits of the Oncoceratida. Here the contact of the neck with the adoral end of the next apical connecting ring is not evident, but probably such a condition exists peripherally, but the ring, growing by addition of material to its inner surface, has its inner portion pushed apicad of the level of the neck by the similar growth of the next adoral ring. However, it must be noted that the implication of gradual growth of the ring is not to be taken as having such extent in time as the cameral deposits or most siphonal deposits; rather, each ring is clearly secreted in a relatively short period of time, and growth is completed soon after the formation of the new septum and the ring connected with it, for the rings show adoral thickening, not such adoral thinning as characterize the siphonal and cameral deposits.

Discussion. It is not evident what previous identification has been given to this species; however, the complete shells would have much the aspect of *Murrayoceras*, and such shells have been broadly identified in terms of Hall's *Orthoceras multicameratum* which is a proper member of the genus.

Types. Holotype and paratype, collection of the writer; Nos. 390, 391, from the Carters limestone, Beach Grove, Tennessee.

Cartersoceras cf. *shideleri*

Pl. 26, fig. 5

An earlier portion of a phragmocone tentatively referred to this same species is shown on Plate 26, Figure 5. This is a specimen in all 55 mm long, seemingly expanding from 6 to 13 mm, but the specimen is weathered and broken obliquely so that the dimensions probably do not represent the real maximum shell width apically. The siphuncle is typical in form, occupied by calcite throughout, which thins on the right, dorsolaterally, at the extreme anterior end. Camerae are spaced nearly four in a length equal to the adoral width of 13 mm. The section ground on the anterior part is oblique, ventrolateral on the left, dorsolateral on the right. On the left of the siphuncle, cameral deposits are indistinct on the broken surface but advanced, nearly filling the camerae. On the dorsolateral region they are materially thinner, and both episeptal and hyposeptal deposits are evident, the latter less developed adorally than the former.

This specimen, No. 392, is from the same locality as the holotype and paratype. Difficulty in evaluating proportions, and slight apparent differences in proportions, evidently not conclusive, are responsible for the tentative reference of this specimen.

FAMILY CYCLOSTOMICERATIDAE

Foerste

Text Figures 41, 42, 43

The family Cyclostomiceratidae is here defined as essentially straight shells, possibly showing either faint endogastric or exogastric curvature, breviconic, fairly rapidly expanding over the phragmocone, the aperture typically somewhat contracted but never markedly constricted, the cross section subcircular or slightly depressed, the siphuncle ventral, of aneuchoanitic necks with concave segments mainly outlined by the rings which are thick and show layering.

Foerste (Notes on cephalopod genera, chiefly coiled Silurian forms, 1925, p. 2, 14) proposed the family Cyclostomiceratidae, without any precise definition, but was influenced by the belief that this genus, together with most other Canadian forms, had a holochoanitic siphuncle. He referred to it *Cyclostomiceras* and *Eremoceras*. Later Ulrich and Foerste (1935) added the genus *Amphoroceras*, based upon *Cyclostomiceras minimum*. UF&M, 1943, reduced *Amphoroceras* as a synonym of *Cyclostomiceras* and used the family Cyclostomiceratidae to contain *Cyclostomiceras Buehleroceras*, and *Bridgeoceras*. They figured thinsections of siphuncles of *Cyclostomiceras*, showing the aneuchoanitic necks and thick layered rings. Cecioni (1953) has added the genus *Paracyclostomiceras*, distinguished from *Cyclostomiceras* by the oblique aperture and containing forms of a slightly more slender form. Additional sections showing more fully the wall structure of the siphuncle are a valuable contribution.

Logically, the Cyclostomiceratidae is a family of essentially straight breviconic shells, a late Canadian, essentially Cassinian development, derived from the Baltoceratidae. Something of a transition is supplied by the genus *Metabaltoceras*, which

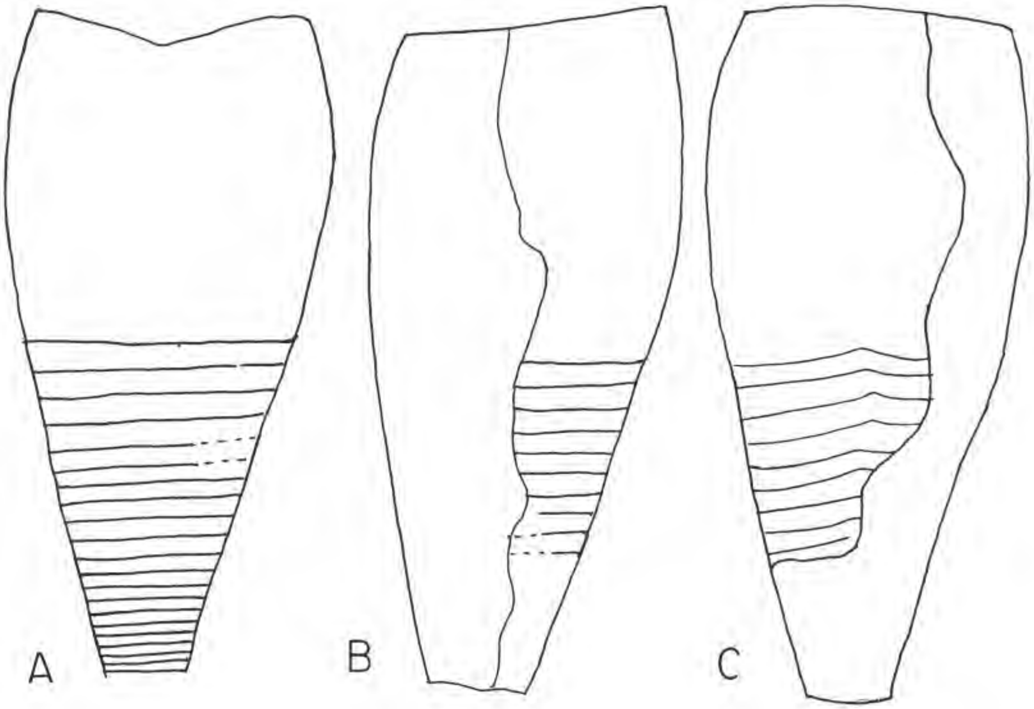

Figure 41

Cyclostomiceras cassinense (Whitfield)

Outline drawings showing A. ventral view, B. lateral view, venter on left, C. dorsal view. After Ruedemann, 1906. Natural size.

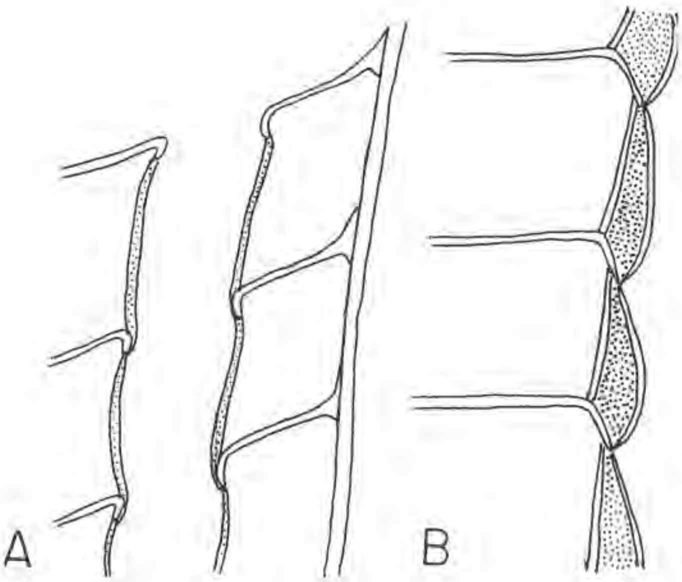

Figure 42

Siphuncle walls in *Cyclostomiceras*

A. *Cyclostomiceras minimum* (Whitfield). This is a small species, and as usual in small species or early growth stages, layering in the ring is not evident. B. *Cyclostomiceras cassinense* (Whitfield), showing layering of the rings. Both after UF&M, 1943.

is really intermediate between the two families in form but departs from the generalized pattern in the large size of the ventral siphuncle and the ventral lobes of the sutures.

Genus CYCLOSTOMICERAS Hyatt

Genotype: *Gomphoceras cassinense* Whitfield

Cyclostomoceras Hyatt, 1900, Cephalopoda, in Zittell-Eastmann Textb. Paleont., vol. 1, 1st ed. (reprinted in later editions with different pagination), p. 530.

——— Ruedemann, 1906, New York State Mus., Bull. 90, p. 500.

——— Grabau and Shimer, 1910, North American Index Fossils, vol. 2, p. 119.

——— Foerste, 1924, Denison Univ. Bull., Sci. Lab., Jour., vol. 20, p. 205.

——— Foerste, 1925, ibid., vol. 21, p. 12.

Amphoroceras Ulrich and Foerste, 1935, ibid., vol. 30, p. 263.

Cyclostomiceras Ulrich, Foerste, and Miller, 1943, Geol. Soc. Amer., Special Papers, no. 49, p. 55.

Cyclostomiceras is an essentially straight shell, the early portion fairly rapidly expanding, the profile becoming convex over the living chamber, and the aperture moderately contracted. The cross section is slightly depressed, though circular in the young. Sutures are straight and transverse. The siphuncle is close to the venter, composed of concave segments in which aneuchoanitic necks and concave thick rings showing layering are involved. Diaphragms or other structures in the siphuncle are not known.

The species known are as follows:

- *C. cassinense* (Whitfield). The genotype is a moderate-sized shell, specimens assigned to it range from 35 to 55 mm across. The type is from the Fort Cassin limestone of the Champlain Valley. UF&M have assigned to the same species a somewhat larger form from the St. Armand limestone of the Phillipsburg section of Quebec.
- *C. minimum* (Whitfield). This is a very small vasiform species of the Fort Cassin limestone. Ulrich and Foerste erected for it the genus *Amphoroceras;* the writer is in agreement with UF&M, 1943, in reducing this genus as a synonym of *Cyclostomiceras.*
- *C. depressum* UF&M. This is a moderately small form of slightly depressed section from the Smithville formation of Arkansas.
- *C. depressius* Cecioni, 1953, from the Arenig of Chile.

UF&M assigned to the genus also *Cyrtoceras vasiforme* Dwight of the Middle Canadian Rochdale limestone of southern New York. This is a shell known only from a natural section, and obliquity of the weathered section is probably responsible for the apparent apertual contraction. The generic position of the type cannot be ascertained with certainty, but a horizontal section through a *Bassleroceras* would produce the kind of surface shown by the type, and *Bassleroceras* is common in the Rochdale limestone.

Genus PARACYCLOSTOMICERAS Cecioni

Text Figure 43

Genotype: *Paracyclostomiceras floweri* Cecioni

Paracyclostomoceras Cecioni, 1953, Museo Nacional de Historia Natural (Argentina), Bol., t. 25, no. 2, p. 98.

This genus is distinguished from *Cyclostomoceras* by the obliquity of the aperture and the development of slight ventral and dorsal lobes. Only two species are known, both from the Arenig of the Serrania de Zapla, Argentine, from the horizon with *Hoekaspis schlagintweiti* Harrington and Leanza.

P. floweri. This shell is figured but only a part of the phragmocone is shown, which is quite slender. Sections showing the short necks and thick layered rings are provided.

P. depressum. This species is represented by material showing the gently contracted mature aperture; sections of the siphuncle are also presented.

There is no doubt as to the affinities of this genus with *Cyclostomiceras,* in spite of the extremely poor reproduction of the plates in the publication under discussion, a matter for which certainly the author is in no way responsible. It is unfortunate that the mature living chamber and contracted aperture are not figured for the genotype.

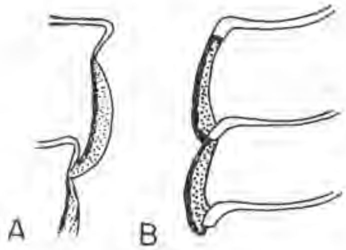

Figure 43

Siphuncle walls of *Paracyclostomiceras*

A. *Paracyclostomiceras floweri*, after Cecioni, 1953.

B. *Paracylostomiceras depressum*, after Cecioni, 1953.

FAMILY SHIDELEROCERATIDAE

This family is erected for apparently endogastric slender shells with subcentral tubular siphuncles, showing aneuchoanitic necks and thin rings. The shell of the only known genus is depressed in section, sutures are transverse.

Genus SHIDELEROCERAS Flower, 1946

Genotype: *Shideleroceras sinuatum* Flower

Shideleroceras Flower, 1946, Bull. Amer. Paleontology, vol. 29, no. 116, p. 508.

Shell cyrtoconic, slender, slightly depressed in cross section, elliptical, growth lines of prominent striae and lirae describe a broad dorsal crest, a broad sinus on the venter, and are markedly sinuate laterally. Sutures are essentially transverse, the siphuncle subcentral.

The genus is as yet known only from three species, *S. sinuatum*, *S. simplex*, and *S. gracile*, all described in the same work (Flower, 1946) and all from the upper Richmond of the Cincinnati arch. *S. sinuatum* and *S. simplex* are from the cephalopod bed in the Lower Whitewater formation; *S. gracile* is from the Saluda. None of the material has shown very well-preserved interiors. The best interiors have been found in the Lower Whitewater material, in an argillaceous limestone in which, unfortunately, while siphuncle outlines and septa may be retained, the calcitic shell parts are commonly largely removed by solution, and the material so far known is unsatisfactory for thinsection examination, as conch, septa, and possibly the connecting rings also are not only commonly extensively replaced but also reduced in width.

No comparable endogastric slender cyrtocones are known beyond the close of the Canadian, and in searching for affinities of this form, there is nothing really close known in the Canadian genera; possibly the closest form is *Woosteroceras* of the Ellesmeroceratidae, an endogastric shell of subcircular to depressed section, but this form has a ventral siphuncle. As yet, no forms connecting *Shideleroceras* morphologically and stratigraphically with the Ellesmeroceratida have been found, but the endogastric form and aneuchoanitic tubular siphuncle indicate affinities with this order. That it may be homeomorphic with the Ellesmeroceratida has been given consideration, but in the absence of any genus belonging to the more advanced orders from which it could be derived, the hypothesis is resumed, more or less by default. We have considered whether this may be an exogastric shell with a ventral crest instead of the usual sinus, but even such an interpretation of the orientation does nothing to suggest possible affinities. Ordovician exogastric shells of this general aspect so far known are Oncoceratida, and their siphuncles remain ventral and marginal, tubular in the small family Graciloceratidae, expanded in the Oncoceratidae, Valcouroceratidae, and Diestoceratidae.

Shideleroceras sinuatum is here refigured (pl. 32, fig. 6-8) to reillustrate the essential features of this genus. Since the description of the three species (Flower, 1946), no others have come to notice, nor has any materially better material of these forms come to light. Unfortunately, the only really good section of a siphuncle found was revealed by grinding the holotype from the ventral side, and the resultant surface, which was ground to two different levels, does not yield itself well to photographic reproduction. The section shows a tubular or rodlike body in the center of the siphuncle, which is believed to be adventitious.

FAMILY PROTOCYCLOCERATIDAE

Kobayashi

Protocycloceratidae Kobayashi, 1935, Geol. Soc. Japan, Jour., vol. 42, p. 746.

Protocycloceratidae Flower and Kummel, 1950, Jour. Paleont., vol. 24, p. 606.

Endocycloceratidae, Ulrich, Foerste, Miller, and Unklesbay, 1944, Geol. Soc. Amer., Special Papers no. 58, p. 30.

Rudolphoceratidae, Ulrich, Foerste, Miller, and Unklesbay, ibid., p. 55.

The family Protocycloceratidae consists of annulated slender shells, within which genera range from straight to faintly endogastric and faintly exogastric. Siphuncles show in general short necks and layered rings characteristic of the Ellesmeroceratina and vary from ventral to subcentral, from small to relatively large. Some forms, however, show rings becoming relatively thin. The lineage was regarded (Flower *in* Flower and Kummel, 1950) as one derived from the Ellesmeroceratidae through *Walcottoceras*, a genus so intermediate between the two families as to supply a true transition, having the annuli of the Protocycloceratidae, but the compressed section and lateral lobes by which it can be considered as little more than an *Ectenolites* which developed annuli, very much as annuli develop in *Annoceras*, which is similarly allied to *Ellesmeroceras* and *Eremoceras*. Gross features show a close relationship among the several genera approaching intergradation, and suggest that the group is largely a unified one, which in evolution develops a broader cross section with loss of lateral lobes, and in which there is variation in the size of the siphuncle which may also come to be appreciably removed from its primitive ventral position.

Inasmuch as annuli are known to develop independently in several different lineages in younger orthoconic stocks, one may question whether the Canadian genera grouped in the Protocycloceratidae are necessarily a unified stock. Teichert and Glenister (1954) raised this question in relation to their genus *Notocycloceras*, which, from its subholochoanitic necks, they assigned to their family Thylacoceratidae. Glenister (*fide litt.*) has found endocones in typical members of this family, and its assignment to the Endoceratida will necessarily follow, but it is not evident that similar cones are found in *Notocycloceras*; it seems reasonable that in this genus there is possibly elongation of the necks such as has been found in a few specialized Ellesmeroceratidae.

Quite apart from the length of the necks, there are features suggesting that the Protocycloceratidae as at present conceived may include homeomorphic stocks of diverse origin. Ellesmeroceroid affinities, and, indeed, derivation from the Ellesmeroceratidae, are indicated by the sections shown in the present work, which demonstrate the presence of diaphragms in *Protocycloceras* from the Fort Cassin fauna. However, there are other and different siphonal structures reported, not all of which could be investigated properly in the present work for want of material. It should be noted that Ulrich and Foerste (1935) report for *P. lamarcki* and *P. mendax* a deposit in the siphuncle, the anterior surface of which slopes strongly forward from the dorsal to the ventral wall, and which seems to be thicker centrally than at the margin, the surface convex in cross section. From this description, a structure comparable to the ventral rod of the higher Baltoceratidae is suggested. UFM&U (1944) mention no such structure for *P. lamarcki*, but for *P. mendax* report a "spiculum" bounded by an oblique ventral surface within which there is a median groove. This structure, not illustrated, suggests instead of a ventral rod, such ventrally prolonged endocones as are developed in *Mcqueenoceras*. Unfortunately, the specimen studied by UFM&U is in the British Museum and, being figured, is regarded as a type and therefore not subject to loan. The identity of the specimen of *P. lamarcki* on which Ulrich and Foerste based their statement is not certainly known but is possibly the original of Ruedemann, 1906, pl. 15, fig. 4. This specimen shows a vertical weathered section in which calcite filling the siphuncle apically thins in the adoral part but remains close to the ventral side, as in the rods of the Baltoceratidae, but a calcite filling supplementing material incompletely invading the siphuncle from the anterior end can produce a quite similar effect. This specimen does, however, show a suggestion of a convex dorsal surface of the anterior end of the calcite and thus seems to be an organic rod, but supplementary material showing this sort of structure, desirable for further testing of this interpretation, has been wanting.

UFM&U (1944, pl. 42, fig. 10) have figured for a specimen assigned to *Protocycloceras affine* of the St. Armand limestone of the Phillipsburg region of Quebec what appears to be a thick lining in the siphuncle, suggestive of that of *Buttsoceras* of the Troedssonellidae.

Examination of the specimen in question (Text fig. 44A, B) shows that some misinterpretations are involved. First, the specimen was figured and presumably interpreted in reverse; the upper part of the figured specimen is apical, not adoral, as can be seen plainly from the curvature of the septa. Second, at the anterior end there is shown a relatively small calcite-filled siphuncle, with the camerae mainly occupied by matrix, which is quite consistent with the siphuncle as generally recognized in the species but inconsistent with the interpretation of the siphuncle as large and in contact with the venter, as is required for acceptance of the siphuncle as filled with a lining; one side of this lining is the calcite at the left of Figure 44B, the other side is the true siphuncle, here calcite-filled. Difficulty stems from the fact that the longitudinal section, as shown in Text Figure 44B, shows no septa to the left of the siphuncle; marginally, there is irregular calcite in which cameral deposits may be involved, and between that band and the siphuncle there is a region filled with matrix. The siphuncle shows in longitudinal section several finely defined thin transverse bands which, in the light of our material of *P. whitfieldi*, can be interpreted as diaphragms.

Sections in a suite of unfigured paratypes of the same species, *P. affine*, show a very different structure, as shown in Text Figure 44C-F. One specimen was ground down to expose a longitudinal section of the siphuncle nearly in the sagittal plane. This, shown in Text Figure 44C, shows the siphuncle occupied by a ventral rod; the venter is here to the left. On the dorsal side there remains a cavity dorsad of the rod. At the extreme anterior end this is occupied by matrix, but this matrix is terminated apically by a straight transverse boundary suggestive of a diaphragm. Farther apicad in the siphuncle are several other bits of dark matrix; two near the apical end show sharp but oblique terminations, again suggestive of diaphragms but not strictly conclusive. They suggest the odd possibility that perhaps diaphragms may grow in this form, supplementing the ventral rods and thus being analogous to the diaphragms crossing the cavity left where the siphonal lining of *Buttsoceras* is fully developed (Flower, 1962A, pl. 2, fig. 9). A transverse section of another paratype shows a cross section through a ventral rod in the siphuncle showing the otherwise convex dorsal surface of the rod faintly excavate in the middle. It is this sort of structure which suggests the grooving of the rod resembling a ventral prolongation of an endocone such as is developed in *Mcqueenoceras*; in *P. affine*, certainly the homologies are evident, and that the ventral rod may show such markings on its surface is clearly no indication of affinities with an endoceroid endosiphuncle.

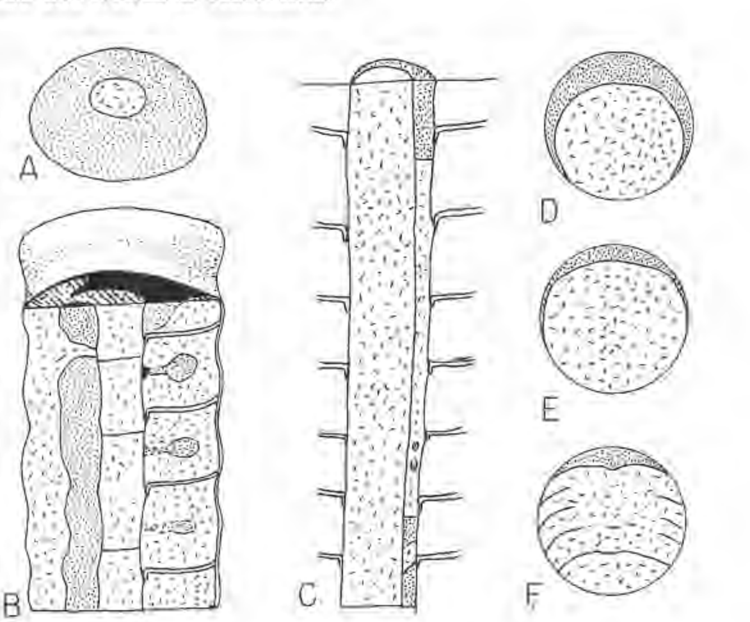

Figure 44
Protocycloceras affine UFM&U

A-B. Reinterpretation of specimen showing an apparent lining (UFM&U, 1944, pl. 42, fig. 10). A. Sketch of section at anterior end of the specimen, the section slightly distorted, but showing a small siphuncle well removed from the venter and occupied by calcite. B. Sectioned portion, showing on right, camerae, largely occupied by cameral deposits, with small dark cavities remaining; the siphuncle calcite-filled and crossed by diaphragms; on the left of the siphuncle is matrix, and beyond, at the extreme left, calcite, both representing part of the phragmocone and not the matrix within a lining. USNM No. 109517.

C. Longitudinal section of a siphuncle of the same species, venter on left, showing oblique view of cross section at anterior end; an evident ventral rod leaves a space in which distribution of calcite suggests inconclusively the development of diaphragms.

D. Cross section at anterior end of C.

E. Cross section at apical end of C.

F. Cross section from another specimen, showing some growth lines in the rod, which shows also a shallow median depression not noted elsewhere. C.-F. from a series of unfigured paratypes, USNM No. 109518. All from the St. Armand Limestone, Phillipsburg, Quebec.

The discovery of a ventral rod in *P. affine* suggests that perhaps this form is derived, not through a general lineage of annulated shells with the siphuncles empty or retaining diaphragms, but through the Baltoceratidae containing similar rods. Yet this seems unlikely, though not impossible, if the clear transverse bands in Text Figure 44B are real organic diaphragms; such diaphragms would suggest instead derivation of this *Protocycloceras* through the Protocycloceratidae as here conceived, a lineage of annulated shells stemming from the Ellesmeroceratidae.

The matter of diverse possible origins of shells presently included in the Protocycloceratidae cannot now be settled; more and better material is needed. However, it is possible to state that the evidence suggesting a lining like that of the Troedssonellidae (*see* Flower, 1962A) is erroneous. Our Text Figure 44F shows that the surface of the rod can bear grooving, and thus the suggested affinities with such endoceroids as *Mcqueenoceras* may be dismissed. However, there remain possibilities, as shown by three structural types, of three possible lineages in this group: (1) forms with small empty siphuncles derived through *Walcottoceras* from the Ellesmeroceratidae; (2) forms with diaphragms, which might be a distinct lineage or might be only members of this same stock with larger siphuncles within which diaphragms are demonstrable; their absence in the first group may yet be more apparent than real; and (3) forms with a ventral rod, possibly derived from the rod-bearing genera of the Baltoceratidae. A fourth possibility, less conclusively indicated, may be added, that such forms as our *Protocycloceras* sp. (pl. 29, figs. 1, 4, 5) could be derived from the Michelinoceratida. From the large diameter of the siphuncle and its ventral position, this interpretation seems unlikely; perhaps instead some of the younger Protocycloceratidae show a simplification and a thinning of the rings, a tendency already noted as occurring independently in several other lineages, as indicated in Text Figure 1. The apparent presence of both diaphragms and a ventral rod in specimens from a single association, and identified as a single species, *P. affine*, presents an additional problem. Our material of this species is limited, and only a suggestion can be made. The material certainly supports its identification as a single species, and the general transverse condition of septa, as seen in longitudinal sections, and the slight curvature both suggest a relationship of these forms with *Protocycloceras whitfieldi*, within which only diaphragms are known. The possibility is this: Can it be that diaphragms, though initially suppressed in both the Endoceratida and in the early Michelinoceratida, nevertheless remain as persistent supplementary structures occupying the endosiphotubes of the Endoceratida and the tubular cavity within the lining of *Buttsoceras*, and may also be retained as structures crossing the cavity left by the incomplete development of a ventral rod? In the Endoceratida I have found specimens, as yet unfigured, showing that in apparently mature endosiphuncles the growth of endocones is stopped, but the diaphragms continue to develop to such an extent that they may occupy not only the endosiphotube but also the endosiphocone. With a similar development in rod-bearing Protocycloceratidae, it is conceivable that the diaphragms might outstrip the rods in development and appear anterior to them in otherwise empty parts of the siphuncle, and might even persist as such where the rods are suppressed, as seems to be true for *Protocycloceras whitfieldi*. Material is inadequate to prove or disprove this hypothesis. Of course, the rod is not essential as a criterion; it might develop coenogenetically in both the higher Baltoceratidae and the Protocycloceratidae; the situation is puzzling, and the present evidence does not support any of these possibilities to the strict exclusion of the others.

Shells of the aspect of the Protocycloceratidae appear first in the Gasconadian, but there only *Walcottoceras* is common; species of broader section and exogastric curvature, here assigned to *Rudolfoceras*, are known only sparingly and only from the Smith Basin limestone as yet. In the Middle Canadian, shells of the aspect of Protocycloceratidae are not uncommon, and they persist into the Jeffersonian but seem to reach their real peak of abundance in the Cassinian. Apparently these shells were thin and fragile, for most of the known specimens are quite fragmentary, and much of the material now known is either poorly preserved internally or represented by specimens showing such advanced silicification that details of internal parts are altered or lost. It is, indeed, necessary to admit that very much of the known material is too fragmentary and too poorly preserved to be treated decisively and critically at the specific level. Unfortunately, such vexation is particularly great in species of the aspect of *Protocycloceras* and surrounds in particular the host of specimens which have been identified as *Protocycloceras lamarcki*, the genotype. From previous interpretations, material identified as *P. lamarcki* is widespread in eastern North America, involving several localities in Quebec and Ontario where the precise stratigraphic position is not beyond question, but also includes material from Newfoundland, the Mingan Islands, the Phillipsburg section, and the Fort Cassin formation of the Champlain Valley, which is clearly Cassinian in age; but it also includes specimens, as those from the Spellman and Kirby ledges of the northern Champlain Valley, which are certainly Middle Canadian, while it is believed (Wilson, *fide litt.*) that only Middle Canadian beds are involved in the Canadian beds exposed in Oxford Township of Ontario, which has supplied some significant material. Experience in other cephalopods and, indeed, in other Canadian major fossil groups, suggests that this broad identification may be erroneous, for no other Canadian species are known to range from the Demingian into the Cassinian. Regrettably, it is thus necessary to admit that *Protocycloceras* is based upon a species so approximately known that there is real doubt as to its true identity, and in view of the possibility of homeomorphy within the genus as now delimited, this is particularly unfortunate. The situation may require drastic nomenclatorial revision, but at present so many uncertainties are involved that such proposals would now be premature and might only serve to augment the confusion.

The history of the concepts surrounding the Protocycloceratidae is almost as curious as the present perplexities. Kobayashi, accepting the then prevalent idea that *Protocycloceras* was holochoanitic, proposed the Protocycolceratidae for holochoanitic shells with annuli and empty siphuncles.

UFM&U (1944) assigned the genera here included in the group to three families and fail to even mention the family Protocycloceratidae. The endogastric or supposedly endogastric genera *Endocycloceras* and *Vassaroceras* were placed in the Endocycloceratidae, regarded as annulated derivatives of the smooth endogastric Stemtonoceratidae. The exogastric genera *Rudolfoceras* and *Ectocycloceras* were placed in the Rudolfoceratidae, regarded as derived from the Bassleroceratidae. The orthoconic genera *Protocycloceras*, *Catoraphiceras*, and *Walcottoceras* were placed in the family Syproceratidae of Shimizu and Obata, 'and the family was used here for orthochoanitic orthocones with annuli, ignoring the fact (Flower, 1939) that *Spyroceras* itself is not orthochoanitic but has an expanded siphuncle and is properly assigned to the family Pseudorthoceratidae.

Flower (*in* Flower and Kummel, 1950), reuniting these three groups of Canadian genera and deriving them from the Ellesmeroceratidae, was influenced in postulating this derivation by the specimens here figured showing diaphragms, features unknown in the Baltoceratidae, as well as by the evident close similarity between the annulated *Walcottoceras* and the smooth *Ectenolites*. At that time, though the possibility of homeomorphy was considered, the genera seemed rather closely united in gross features, and no reason existed for regarding the stock as a group of homeomorphs. Oddly, while Teichert and Glenister concluded that *Notocycloceras* belonged to a different lineage, the basis for this, the elongation of the necks, is a feature which is known to develop individually in a few species in the Ellesmeroceratidae, and that family, as developed in the Lower Canadian, stands alone, for other groups within which neck elongation could occur had not developed at that time, except of course for the then-declining Plectronoceratidae. It is only now that evidence is assembled, based on endosiphonal structures, suggesting three, and possibly four, origins for species of the general aspect of *Protocycloceras*.

A considerable amount of material available for the present study was deemed too fragmentary or too poorly preserved to merit description or illustration. Protocycloceratidae are present, though generally the specimens are inadequate, from the first endoceroid zone of the El Paso to its top, but the material has failed to contribute much morphological information, and only four specimens are figured. Likewise, Pogonip material proved largely unrewarding morphologically and too fragmentary for close comparison at the specific and, in some instances, even at the generic level.

Genus WALCOTTOCERAS Ulrich and Foerste

Genotype: *Endoceras? monsensis* Walcott, 1932

(Smiths. Misc. Coll., vol. 67, no. 9, p. 529, pl. 126, fig. 4)

Walcottoceras Ulrich and Foerste. 1935, Denison Univ. Bull., Sci. Lab., Jour., vol. 30, p. 289.

——— Ulrich, Foerste, Miller, and Unklesbay, 1944, Geol. Soc. Amer., Special Papers, no. 58, p. 88.

Shell slender, with prominent annuli, section compressed, siphuncle ventral, tubular, small, sutures with lateral lobes. Shells vary from straight to faintly endogastric.

Discussion. This genus is widespread in the Gasconade of North America and is particularly well developed and perhaps confined to the upper half of that interval. The shells are small and remains, though common, are usually quite fragmentary and supply, on the whole, a poor basis for critical analysis at the specific level.

This genus may be regarded as an *Ectenolites* with the addition of prominent annuli, and as such could be referred either to the Ellesmeroceratidae or to the Protocycloceratidae. Simplicity of definition would suggest assignment to the Protocycloceratidae, but possibly this course would not have been followed had it not been found that the Lower Canadian has yielded also two species assignable to the dominantly younger and more advanced genus *Rudolfoceras* of that family also.

The siphuncle of *Walcottoceras* has not been studied thoroughly from sections. It is small, tubular, and close to the venter.

The described species are as follows:

W. monsensis (Walcott, 1924). Typically, this is from material from the Mons formation of Alberta. Paratypes, however, include specimens from the Garden City formation of Blacksmith Fork Canyon, nine miles east of Hyrum, Cache County, Utah. The Mons is known to contain fauna of Gasconade age. The Garden City ranges from the beginning to the close of the Canadian. There are no records of the position of the *Walcottoceras* in relation to the faunal zones (A through L) recognized now in the Garden City. One would expect them to be described from zone C.

W. obliquum UFM&U, 1944. The forms included in this species show some diversity of obliquity of annuli and sutures, and possibly more than one species may be involved, but most specimens, and numerous specimens are known, are fragmentary and do not lend themselves well to strict specific analysis. The matter seems to be of little faunal or stratigraphic consequence, for all the known forms are from beds of Gasconade age. In the experience of the writer, such material is confined to the upper half of the Gasconade, but records are insufficient to demonstrate that this confinement is of universal application. *Walcottoceras* cf. *obliquum* (pl. 30, fig. 5-6) of the Smith Basin limestone is figured, showing the gross features of the genus.

W. helleri Unklesbay, 1954. This is a species known from the upper 75 feet of the Tanyard formation of central Texas, having the sutures transverse with shallow lateral lobes, but the annuli slope very strongly orad from venter to dorsum.

It should be noted that the fragmentary specimen figured as *Walcottoceras?* sp. from the upper Cambrian Signal Mountain formation of Oklahoma (UFM&U, 1944, p. 90, pl. 45, fig. 1, 2) is not a cephalopod but belongs to the genus *Kygmaeoceras* Flower 1954, which is of uncertain position but is an aseptate shell possibly related to the Hyolithidae, themselves of dubious phyletic position.

Genus ECTOCYCLOCERAS Ulrich, Foerste, Miller, and Unklesbay

Genotype: *Orthoceras cataline* Billings

Ectocycloceras Ulrich, Foerste, Miller, and Unklesbay, 1944, Geol. Soc. Amer., Special Papers, no. 58, p. 58.

This genus was erected for exogastric annulated cyrtocones, compressed in cross section, with straight transverse sutures, a small marginal siphuncle of concave segments.

Discussion. This genus is accepted here without emendation and is thus confined to forms with narrow cross sections. Species with marked to moderate curvature of broader section and ventral siphuncles are referred to *Rudolfoceras*, though the genus more typically includes forms with the siphuncle appreciably removed from the venter. The known species are as follows:

E. cataline (Billings), known from a good series of specimens from the Hastings Creek limestone, apparently early Middle Canadian, of the Phillipsburg sequence of Quebec.

E. cato (Billings) is less adequately known but appears typical of the genus. It is also from the Hastings Creek limestone of Quebec.

I should regard *Vassaroceras henrietta* of the Rochdale limestone of southern New York a member of this genus, and have had fragments of this or a similar small, slightly curved shell from the Fort Ann limestone of the Fort Ann region of New York, but they are too poor for certain determination.

Genus RUDOLFOCERAS Ulrich, Foerste, Miller, and Unklesbay

Genotype: *Orthoceras cornu-oryx* Whitfield

Orygoceras Ruedemann, 1906, New York State Museum, Bull. 90, p. 449 (not *Orygoceras* Brusina, 1882).

Rudolfoceras Ulrich, Foerste, Miller, and Unklesbay, 1944, Geol. Soc. Amer., Special Papers, no. 58, p. 55.

This generic group was originally set apart as an orthoconic genus remarkable for internal annulations and a smooth exterior. The siphuncle was close to the venter and regarded as holochoanitic. As revised by Ulrich et al., the shells are annulated, moderately rapidly expanding, slender exogastric cyrtocones. The section is described as circular but may actually be slightly wider than high. The siphuncle is typically slightly removed from the venter, but forms with marginal siphuncles have been included in it.

The previously described species may be summarized as follows:

R. cornu-oryx (Whitfield). Conically expanding, very faintly exogastric, siphuncle small, of slender segments. Septa close, showing some variation in spacing and lobation; possibly more than one form is at present included under this name. Fort Cassin beds of the Champlain Valley.

R. kindlei UFM&U, 1944, of the Levis boulders, is a nearly straight conical shell with rather distant annuli and a small siphuncle somewhat removed from the venter.

R. levisense UFM&U, also from the Levis boulders, is distinctive in its strong curvature, annuli which are largely transverse but outline a definite hyponomic sinus on the convex side. The siphuncle is small and almost in contact with the ventral wall. Sutures are close and transverse.

R. subarcuatum UFM&U is a slender form from the Levis boulders, the mature living chamber gently contracted adorally, the siphuncle small, ventral, annuli faintly inclined apicad on the venter, but nearly transverse.

Rudolfoceras annulatum (Unklesbay, 1961) is a slender exogastric shell with low but definite annuli and a small ventral siphuncle referred by Unklesbay to the smooth-shelled genus *Stylocyrtoceras*, which belongs in the Bassleroceratidae rather than the Cyclostomiceratidae. It is from the Honeycut formation of central Texas.

To these species are added two new species from the late Gasconade Smith Basin limestone of eastern New York. Both agree with the genus in exogastric curvature, but one, *R. antiquum* is anomalous in the strong forward slope of sutures on the venter; there is, however, little to be gained in proposing a new genus for this species. A specifically unnamed fragment from the first endoceroid zone of the El Paso limestone is also figured and described.

Rudolfoceras antiquum Flower n. sp.

Pl. 7, fig. 17-18

This is a slender faintly exogastric shell of subcircular section, showing rather close transverse sutures, a small ventral siphuncle, and annuli which slope markedly apicad from dorsum to venter. The type expands from 10 to 16 mm in a length of 55 mm. Two annuli occur in a length of 9 mm apically and in 10 mm adorally. The basal 25 mm of the specimen represents the phragmocone. Camerae average 1 mm in length. The specimen was ground from the ventral side showing a siphuncle which is ventral and tubular, though not particularly well preserved; the rings appear surprisingly thin. There is, in addition to the part thus far described, a basal poorly preserved part 14 mm long.

Discussion. The close transverse septa and rather more distant oblique annuli characterize this species. It is somewhat suggestive of *R. subarcuatum* from the Levis boulders but shows markedly oblique annuli where those of that species are essentially transverse.

Type and occurrence. Holotype, collection of the writer, No. 183, from the Smith Basin limestone, from the section exposed just east of Smith Basin, New York.

Rudolfoceras praenuntium Flower, n. sp.

Pl. 7, fig. 15, 16

This is a slender, gently arcuate, exogastric shell of subcircular section associated with the preceding form and distinguished by the lower, slightly closer, annuli which are essentially transverse and sutures which slope forward markedly from dorsum to venter. The type expands from 11 to 14 mm in a length of 49 mm, annuli transverse, low, rounded, spaced approximately 2.5 in a length of 10 mm; with two in 7 mm apically and in 8 mm adorally. In a length of 5 mm there are 3.7 camerae apically and 5.5 adorally. Sutures slope strongly forward ventrally, and one may just intersect three annuli. The siphuncle is quite poorly preserved basally, is small, and slightly removed from the venter. Breaks in the specimen show the interior to be largely destroyed, and indicate that a section would be unrewarding. No previously described form agrees with this one in showing sutures sloping ventrorad and annuli more distant and transverse.

Type and occurrence. Holotype, collection of the writer, No. 184, from the Smith Basin limestone, from the section east of Smith Basin, New York.

Rudolfoceras sp.

Pl. 29, fig. 6, 7

This is a small slender form, known from a portion 18 mm long, very slightly depressed in cross section, increasing from 6 and 6.2 mm to a width of 8 mm and a height of 7.5 mm in the 13 mm of the phragmocone, in which there are seven camerae. Sutures transverse and straight except for a very slight middorsal saddle. Siphuncle very small and close to the venter. There are 8 mm of a living chamber preserved which is probably incomplete adorally. Seven annuli occur in the length of the specimen, they are more sharply elevated and narrower basally than adorally. The shell shows a very slight exogastric curvature.

Figured specimen. No. 398, from the first endoceroid zone of Rhodes Canyon, San Andres Mountains, New Mexico.

Genus KYMINOCERAS Teichert and Glenister

Genotype: *Kyminoceras forresti* Teichert and Glenister

Kyminoceras Teichert and Glenister, 1954, Bull. Amer. Paleont., vol. 35, no. 150, p. 42.

Straight annulated shells, generally small, subcircular in section, sutures straight and transverse, siphuncle small and ventral, in the type showing fairly short orthochoanitic necks supplemented by apparently thin homogeneous rings.

Discussion. This genus, as defined by Teichert and Glenister, will contain some species formerly included in *Protocycloceras,* and they suggest that in addition to the genotype the following species be assigned: *K. doniphonense* UFM&U, of the Roubidoux formation of Missouri; *P. furtivum* (Billings) of probably Middle Canadian beds of Kitley township, Lee County, Ontario, Canada; *P. manitouense* from the Manitou formation of Colorado; *P. repens* (Billings) of the Naylor ledge limestone of Phillipsburg, Quebec; *P. smithvillense* UFM&U of the Smithville formation of Arkansas. The writer would add *P. odenvillense* UFM&U. These are all fairly small species, and the siphuncle is small and ventral. It has been found that in Ellesmeroceratidae of this sort the thickening of the ring and its layering, general in the family, are not developed; the same is possibly true of this genus and is indicated by the section of Teichert and Glenister for the genotype, which is from the Middle Canadian portion of the Emanuel limestone of Australia.

Kyminoceras sp.

Pl. 30, fig. 7, 8

Under this designation is figured a small portion of a straight annulated shell from the first endoceroid zone of the El Paso limestone. The shell is tiny, 11 mm long, circular in section, and essentially tubular, 5 mm across at the base. Five annuli, low and rather distant occur in the length of the specimen; they are transverse. One camera occurs at the base; the suture is straight and transverse, the camera 2.5 mm long. The siphuncle is small, close to the venter, and obscure.

Figured specimen. No. 397, from the first endoceroid zone of the El Paso limestone, from Rhodes Canyon, San Andres Mountains, New Mexico. Oddly, this is the only annulated orthocone observed from this horizon as yet, *Rudolfoceras* sp. being very slightly curved.

Genus ENDOCYCLOCERAS UFM&U

Genotype: *Endocycloceras wilsonae* UFM&U

Endocycloceras Ulrich, Foerste, Miller, and Unklesbay, 1944, Geol. Soc. Amer., Special Papers, no. 58, p. 31.

This genus contains moderately rapidly expanding endogastric shells with well developed annulations on the surface. The siphuncle is ventral, of concave segments, apparently with thick rings typical of the Ellesmeroceratina, as known from the genotype. The previously known species are as follows:

E. wilsonae UFM&U. A typical form, from the boulders of the Levis conglomerate. Fortunately the siphuncle is figured and described.

E. legorense UFM&U. This is a more gently expanding endogastric shell with annuli, known only from one fragmentary specimen from apparently Gasconade beds near Le Gore, Maryland.

E. perannulatum UFM&U. This species from the Longview limestone of Tennessee is moderately curved and moderately expanding; however, the siphuncle is not known, and assignment to *Ectocycloceras* or *Rudolfoceras* seems equally provable.

E. subcurvatum UFM&U. This is a species from the Cotter of Missouri, showing the anterior part of a moderately large species. Apparently the phragmocone is not known, so again the question may be raised as to whether this is properly an endogastric instead of an exogastric shell.

Of these species, the position of the siphuncle close to the concave side of the shell is known only for *E. wilsonae* and *E. legorense.* The species described below from the El Paso limestone shows, oddly, no definite indication of the siphuncle but it must be close to the concave side of the shell, for it is definitely wanting against or close to the convex side, nor can it be central.

Oddly, the question has never been brought up as to how *Endocycloceras* can be distinguished from the little known genus *Smithvilloceras. Smithvilloceras* UF&M, 1943, has priority but is known only from one species, *S. thompsoni,* from the Smithville formation of Arkansas. The structure of its siphuncle is not known. It differs only in being circular instead of slightly depressed and in that the siphuncle, inadequately known, is slightly removed from the ventral wall of the shell.

Endocycloceras gracile Flower, n. sp.

Pl. 30, fig. 1-4

This is a moderate-sized, slender, endogastric cyrtocone marked by low, rounded, rather distant annuli and fine transverse lirae. The shell is circular in section in the young, a condition which is apparently maintained throughout. The type, 210 mm long, has the convex side lost by weathering over the anterior three fourths of its length, but the extant part suggests a shell which is circular throughout. The shell shows a gradual reduction of the rate of expansion as growth progresses, diameters at intervals of 20 mm being successively 9, 19, 19, 20, and 21 mm. The sutures are straight and transverse. Septa are quite poorly preserved, and only a small and indistinct septal foramen at the base indicates the position of the siphuncle close to the concave side of the shell. Camerae are spaced four in a length of 5 mm and are confined to slightly less than the apical half of the specimen.

Annuli are low, rounded, separated by broader flat interspaces; their crests average 5 to 6 mm apart throughout most of the shell, but annuli are less distinct and slightly more crowded in the anterior 15 mm of the specimen. In addition, finer raised transverse lirae are spaced eight in a length of 5 mm. The radius of curvature of the venter is about 200 mm but is slightly increased at the extreme adoral end of the shell. This and the crowding of the anterior annuli suggest that the type approaches close to the anterior end of a mature individual.

Discussion. This species is one of the few cephalopods and, indeed, one of the very few identifiable fossils from the gastropod reef above the oolite in the El Paso limestone. The genus is one known from only a few species and does not appear to be diagnostic of any part of the Canadian.

The present species does not resemble any of the others very closely in aspect. *E. wilsonae* has more elevated and more broadly rounded annuli rather more distantly spaced in proportion to the shell diameter. *E. subcurvatum* is like *E. gracile* in being a slender form, but annuli are much lower and more closely spaced. *E. perannulatum* has the annuli broader and more elevated.

Holotype. No. 653, New Mexico Bureau of Mines.

Occurrence. From the "*Orospira*" (*Bridgeites* Flower ms.) reef above the oolite of the El Paso limestone, from the section at Mud Springs Mountain, New Mexico.

Genus DIASTOLOCERAS Teichert and Glenister

Genotype: *Diastoloceras perplexum* Teichert and Glenister

Diastoloceras Teichert and Glenister, 1954, Bull. Amer. Paleont., vol. 35, no. 150, p. 44.

This genus contains very faintly exogastric shells, nearly tubular, circular in section, with small marginal siphuncles and straight transverse sutures. The distinctive feature of the genus is the development of low, closely spaced transverse flanges or frills on the shell surface. The siphuncle shows vestigial necks and moderately thick rings, outlining segments ranging from tubular to most faintly convex in outline.

Discussion. Both the writer and Teichert and Glenister have been puzzled as to the affinities of this form, which is extremely generalized in most shell features, and distinctive mainly for the short, closely spaced flanges or frills. Assignment to the Protocycloceratidae rests upon the similarity of such frills with annuli, but we have all recognized that this may prove to be incorrect. It may be noted that origin in the Baltoceratidae seems also possible, but in such a generalized form, there is no certain indication of the true relationships. The development of frills here is possibly comparable to those of *Barnesoceras*; if so, the genus might better be placed in the Baltoceratidae.

D. perplexum of apparently Upper Canadian beds in the Emanuel limestone of Australia is the only species yet known.

Genus NOTOCYCLOCERAS Teichert and Glenister

Genotype: *Notocycloceras yurabiense* Teichert and Glenister

Notocycloceras Teichert and Glenister, 1954, Bull. Amer. Paleont., vol. 35, no. 150, p. 56 (202).

This is a straight shell with transverse annuli, much as in *Protocycloceras*, and apparently straight transverse sutures. The siphuncle is ventral, rather large, comparable to that of *Protocycloceras* in relative diameter, located in contact with the venter. Septal necks are subholochoanitic, forming segments which would be most faintly concave in outline, supplemented by rings which are seemingly thick anteriorly, forming triangular areas between the tip of one neck and the base of the next one, but thinning apically, and very thin on the inside of the tip of the septal neck.

Discussion. The position of this genus remains doubtful. Teichert and Glenister referred it to the Thylacoceratidae, and it may indeed prove to be bound up with this family, but the elongation of the neck is a feature known to develop in the Ellesmeroceratidae, and it seems likely that such a development is possible also in the Protocycloceratidae. It seems well, therefore, to note this genus at least in connection with this family, though the present fragmentary material is inconclusive for demonstration of the position of this genus.

As yet, only the genotype *N. yurabiense*, from the Upper Canadian portion of the Emanuel limestone of northwestern Australia, is known, and apparently it was described only from the holotype, a portion of shell 43 mm long.

Genus PROTOCYCLOCERAS Hyatt

Genotype: *Orthoceras lamarcki* Billings

Protocycloceras Hyatt, 1900, Cephalopoda, in Zittel-Eastmann Textbook Paleont., vol. 1, 1st ed., p. 518.
——— Ruedemann, 1906, New York State Museum, Bull. 90, p. 438.
——— Grabau and Shimer, 1910, North America Index Foss., vol. 2, p. 55.
——— Foerste, 1921, Denison Univ. Bull., Sci. Lab., Jour., vol. 19, p. 268.
——— Foerste, 1924, ibid., vol. 20, p. 202.
——— Croneis, 1926, Amer. Jour. Sci., vol. 12, p. 185-192.
——— Miller, Dunbar, and Condra, 1933, Nebraska Geol. Surv., ser. 2, vol. 9, p. 69.
——— Ulrich and Foerste, 1933, Science, n. s., vol. 78, p. 288.
——— Kobayashi, 1935, Geol. Soc. Japan, Jour., vol. 42, p. 746.
——— Ulrich, Foerste, Miller, and Unklesbay, 1944, Geol. Soc. Amer., Special Papers, no. 58, p. 78.

Protocycloceras as here employed contains orthoconic shells of circular or depressed section, sutures relatively transverse, siphuncle rather large and typically somewhat removed from the venter, though some species with large marginal siphuncles are tentatively included, and also some forms with small siphuncles removed appreciably from the venter, though in this last group species are not very well known morphologically, and the tentative assignment is followed because there is no other proper repository for such species. Typically, siphuncle segments are slightly concave, composed largely of the layered rings; septal necks are short.

As noted under the discussion of the family, *Protocycloceras*, as used here, is possibly a group of homeomorphic shells rather than a natural group; the scope given to the genus here is that of Teichert and Glenister (1954), who restricted the genus somewhat beyond the scope given it by UFM&U, 1944, by the removal of species with small ventral siphuncles to the genus *Kyminoceras*. Even so we have certainly species with diaphragms, here figured and described. Such diaphragms are a heritage from the ancestral Ellesmeroceratidae in what I have conceived as the main lineage of the Protocycloceratidae. Other species have ventral rods indicative of possible origin in the Baltoceratidae.

Also, among species with large ventral siphuncles there are some additional oddities of structure. One, here figured (pl. 29, fig. 1, 4, 5), shows a siphuncle distinctive in having tubular rather than concave segments; the rings here are puzzling, but much of their thickness seems to result from probable inorganic calcite secreted on their exterior, extending also onto the adoral faces of the septa.

The species currently assigned to the genus are listed below. As noted in the discussion of the family, apparent variation in structure suggests that much more careful investigation at the specific level is needed, but that such study is at present almost impossible due to the fragmentary nature of most of the known specimens found in limestones, and the representation of other species only by silicified material, in which the preservation of fine structures is poor or wanting.

P. lamarcki (Billings). This species is widely identified in eastern North America and has included specimens from the Cassinian of the Champlain Valley, the Mingan Islands, the Phillipsburg region of Quebec, and the St. George beds of Newfoundland; in addition, Middle Canadian specimens from the Spellman and Kirby ledges are included, as well as material from the supposedly Middle Canadian of Oxford township, Ontario. The selected type (Foerste, 1938, p. 83), which seems to be the original specimen of Billings and is probably thus the true holotype, is from "Lot 12, Concession 12, Godmanchester township, Huntington County, Quebec," and there is no certain information from what part of the Canadian this specimen is derived. The present work includes description of some Fort Cassin materials which I have regarded for a long time as this species, but they seem in measurements to be intermediate between this species and the associated *P. whitfieldi* and are therefore here designated instead as *Protocycloceras* cf. *whitfieldi*. With uncertainty as to the true characters of *P. lamarcki* and its proper range, the proposal of new species, genus, and family might be justified, but in view of the fact that that species would still remain too broad, and we would either have to confine the new genus to this one species or else return to the inclusion in it of possible homeomorphs, there can be no point now in complicating the present puzzle in relationships by new names. A possible ventral rod was figured by Ruedemann in a Fort Cassin specimen attributed to this species.

P. abnorme UFM&U of the St. Armand limestone of Quebec is a fairly large species with prominent annuli with a large siphuncle located between the center and venter, the structure of which is not known in detail. The known material is somewhat crushed, and distortion may account for the prevalently oblique appearance of the annulations.

P. affine UFM&U is also from the St. Armand limestone. This species is again known from rather fragmentary material. One paratype shows what was interpreted as an apparent lining in the siphuncle (UFM&U, 1944, pl. 42, fig. 10). The structures have been discussed under the family and are shown in Text Figure 44. A ventral rod is present.

P. arkansasense UFM&U of the Smithville of Arkansas is a small, slender species; no specimens are known more than 9 mm in diameter. The siphuncle is described as small but not marginal in position. Known material is silicified and unpromising for morphological details. Possibly this form could be assigned to *Kyminoceras* rather than *Protocycloceras*.

P. becki (Billings) of the Romaine formation of the Mingan Islands is apparently known only from the single type, a straight shell with annuli and a rather large siphuncle of typically concave segments slightly removed from the venter.

P. levisense UFM&U from the Levis boulders is known only from a single specimen showing a fairly large siphuncle slightly removed from the venter. Details of structure are not known.

P. mendax (Salter) of the Durness limestone is typical in the rather large siphuncle well removed from the venter. It is in this form that UFM&U describe a structure which is possibly allied to the ventrally extended endocones of *Mcqueenoceras* but is more probably a ventral rod, with slight grooving on its free surface.

P. odenvillense UFM&U of the Odenville limestone of Alabama has a small ventral siphuncle and is possibly better placed in *Kyminoceras*. The species is apparently known only from the quite fragmentary holotype.

P. ordinatum (Billings) is a form with low, rather obscure annuli and a siphuncle of moderate size well removed from the venter. Reputedly from Ste. Anne de Bellevue, Quebec, but this material (Wilson, *fide litt.*) and that of Oxford Township, Ontario, has been mixed and re-collecting is necessary to sort out the species properly.

P. phillipsburgense UFM&U of the St. Armand limestone has a fairly small siphuncle but one well removed from the venter. Details of internal structure are unknown.

P. whitfieldi Ruedemann is a species of the Fort Cassin beds, based upon material which Whitfield originally identified with the Mohawkian species "*Orthoceras*" *bilineatum*. It has seemingly lower and closer annuli than the associated specimens identified as *P. lamarcki*, but from the extant descriptions, much material seems to fall between the two forms in proportions. Probably our specimens showing diaphragms belong to this species.

Teichert and Glenister have removed to *Kyminoceras* the following species referred by UFM&U to *Protocycloceras*: *doniphonense*, *furtivum*, *manitouense*, *repens*, and *smithvillense*. Possibly as noted above the same disposal should be made for *odenvillense*. *P. xerxes* (Billings) is a gigantic species, known only from one fragment, and reputedly from the St. Armand limestone of Phillipsburg. The writer has an *Anthoceras*, somewhat smaller, from the Luke Hill limestone similar enough to suggest a similar generic assignment for this species, and to suggest that possibly the St. Armand designation may be too high.

P. catulus (Billings) of the Naylor ledge limestone is known only from the brief description; the type cannot be located or recognized. Without knowledge of the phragmocone, the position of *P. geronticum* remains highly uncertain.

Western Canadian beds have yielded a few fragments of the aspect of *Protocycloceras* with large ventral siphuncles. One of these, figured on Plate 29, Figures 1, 4, 5, shows an anomalously tubular siphuncle and may represent a genus as yet unrecognized.

Previous descriptions are quite approximate as to measurements and far from detailed enough to permit close critical comparison. In the present work, based upon material which is not much better, the figured specimens are designated only tentatively if at all at the specific level, as it is felt that such work requires more and better material than is now available.

Cecioni (1953) has described species from the beds with *Hoekaspis schlagenweiti*, probably Upper Canadian, of the Zapla region of Argentina. His species show fairly large siphuncles ranging from those slightly removed from the venter to those of ventral position. His work includes studies of the siphuncle wall, and he shows concave, rather thick, rings with variable traces of layering and essentially aneuchoanitic necks. The tips of the necks are pointed in some instances and blunt and obscurely bifurcated in others. Unfortunately, the plates accompanying this work show extremely poor reproduction.

His work includes studies of the siphuncle wall and is illustrated by a series of drawings. There is shown some considerable variation in the form of the segments, some definitely concave, some straight, in the necks, which are all short but pointed in some instances, bluntly expanded and obscurely bifurcated in others, and in the rings, which are commonly thick and show a suggestion of layering but are, as in his text figure 3, occasionally quite thin and outline essentially tubular segments.

The species described are *P. stephaninii*, *P. harringtoni*, *P. bonarelli*, with some specimens tentatively assigned to these species and a few not determined specifically.

Protocycloceras cf. *whitfieldi* Ruedemann (1)

Pl. 30, fig. 14, pl. 31

This is a portion of phragmocone of which the apical 29 mm containing 11 siphuncle segments was sectioned. This part of the phragmocone is calcite-filled, and septal surfaces are largely lost by recrystallization, but spots of coarse calcite probably indicate the centers of camerae, and the segmentation of the siphuncle is clear from the concave elements, while adorally, septal necks are retained. In the anterior 20 mm the shell increases from 10 to 12 mm in width and contains seven and a half camerae and shows the same spacing of the annulations of the conch. Necks are short, their slope suggesting rather steeper septa than the associated forms. Rings are concave, moderate in thickness, and show consistent layering. Calcite fills the siphuncle.

An anterior portion is sectioned and shown on Plate 30, Figure 14; it is 12 mm long, shows three annuli, and adorally is 14 mm across, though evidently somewhat distorted. Here calcite in the camerae represents the deposits; matrix has penetrated the remaining cavities. The siphuncle shows calcite against one side which thins adorally, suggesting a portion of a ventral rod thinning anteriorly, but can only be adventitious, the complement of sediment penetrating the siphuncle to a decreasing extent from the adoral end. An additional adoral portion, not figured, extends for 20 mm more, contains five camerae, and is 16 mm wide adorally. It is cut in a different plane and shows no calcite in the siphuncle, and cameral deposits are obscured by calcite and possibly wanting here altogether.

Figured specimen. No. 403, from the Fort Cassin beds, shore of Lake Champlain, Valcour, New York.

Protocycloceras cf. *whitfieldi* Ruedemann (2)

Pl. 30, fig. 9-12

This is a portion of a *Protocycloceras* phragmocone only partly exposed when found. The section, normal to the plane of bedding, proved to cut the shell horizontally, and showed a slight curvature normal to the plane of the section, as shown by the appearance of the siphuncle at the two ends of Figure 9. The shell expands from 5 to 11 mm in width in 45 mm, and the siphuncle increases from 1.2 to 3 mm. Annuli are obscure in the sectioned surface, but show two in 4 mm basally and are scarcely farther apart adorally. Camerae show four in a length equal to an adoral shell width of 9 mm. Septa are only most shallowly curved in the horizontal plane; cameral deposits are advanced in development and show a holoseptal distribution, particularly evident by the cavities within, which show on one side of the siphuncle clearly at midlength as dumbbell-shaped areas. Siphuncle segments are faintly concave, necks are very short. The siphuncle is traversed by a number of diaphragms, shown best in the adoral half of Figures 11 and 12, which is one surface; they are present, though not so clearly differentiated apically.

Figured specimen. No. 401, from the Fort Cassin beds, at Valcour, New York.

Protocycloceras cf. *whitfieldi* Ruedemann (3)

Pl. 30, fig. 13

The single illustration is an enlargement of a portion of phragmocone 60 mm long increasing in width from 5 to 11 mm. Here there are four annuli and four camerae in a length equal to the adoral width of 11 mm, though 2.5 camerae occur in a similar proportion at midlength, and three at the base where some anomalously short camerae appear. The siphuncle is missed in much of the sectioned surface, but shows apically and adorally. Only in the apical 10 mm are there diaphragms which are slightly concave adorally and irregular in spacing; the regions between them are filled with white calcite. Cameral deposits are evident, holoseptal apically, the mural part thinner and less evident adorally.

This fragment lies at the apical end of another piece of phragmocone, not figured, 50 mm long and expanding to 14 and 15 mm, with the siphuncle 5 mm across, 3 mm from the venter, 6 mm from the dorsum. In the 50 mm there are 18 camerae. Doubtfully, from the same specimen is a possibly anterior part of a living chamber, 30 mm long and expanding from 15 to 17 mm in width, showing seven annuli.

Figured specimen. No. 402. Same occurrence as the preceding.

Protocycloceras (?) sp.

Pl. 29, fig. 1, 4, 5

This figured specimen is a portion of a shell 40 mm long expanding in width from 17 to 20 mm; probably the section was slightly depressed, but the dorsum is wanting. There are nine annuli in the length of the shell, low, rounded, merging into concave interspaces; in the basal 7 mm there are eight camerae, averaging a little less than 4 mm in length. The siphuncle, not apparent on the ventral surface is large, very close to the venter. A section removing the ventral surface shows it 6 mm wide with segments slightly broader than high. A thinsection was made from a piece cut from the ventral surface. It shows short orthochonanitic necks, rings which show evidence of thickening apically, though there is clearly some adventitious calcite on their outer surfaces which continues along the adoral face of the next apical septum. There appears, however, to be a dense, thin, dark, inner layer and a lighter, more granular, outer layer; it is the outer layer which widens adapically.

Discussion. This *Protocycloceras* is a little puzzling and rather distinctive in the large marginal ventral siphuncle in which the segments do not show the usual concave outlines. The rings are somewhat difficult of interpretation in view of evident excessive calcareous material deposited on their outer surfaces, which continues along the adoral faces of the septa; how such material could be formed, with the camerae later filled with coarse matrix, is a puzzle.

Figured specimen. Collection of the writer; No. 400. From the highest 30 feet of the El Paso, the beds with *Buttsoceras*, from the east side of the Florida Mountains, New Mexico.

Genus CATORAPHICERAS Ulrich and Foerste

Genotype: *Catoraphiceras lobatum* Ulrich and Foerste

Catoraphiceras Ulrich and Foerste, 1935, Denison Univ. Bull., Sci. Lab., Jour., vol. 30, p. 266.
—— Ulrich, Foerste, Miller, and Unklesbay, 1944, Geol. Soc. Amer., Special Papers, no. 58, p. 75.

This is a straight shell with annuli, much as in *Protocycloceras*, with a fairly large siphuncle which is ventral and may be exposed on the surfaces of internal molds, being in flattened contact with the ventral wall, or may be slightly removed from the venter. Sutures describe broad lobes on the venter which steepen as they approach the siphuncle; dorsal lobes may also be present.

The group of species previously assigned to the genus from North America all agree with the above definition, and the genus is distinctive and readily recognized among the annulated shells wherever the sutures are visible. The described species from North America are as follows:

C. lobatum Ulrich and Foerste 1935. From a Powell Horizon, Wells Creek Basin, Tennessee. In this form, the siphuncle is slightly removed from the venter. Its structure is not known. Camerae are moderate in depth and show the ventral lobe prominently. The species is regrettably known only from a few fragments.

C. colon (White, 1874). This species, described in the Wheeler Survey, is known from a living chamber only but shows acceptably the features of the genus. It is from the Pogonip group, from the Fish Springs Range of Juab County, Utah. The associated fauna and position within the Pogonip are not known. Specimens which are congeneric have been found in Zone J by Hintze (1952) but as the type is known only from a living chamber, identification with it of portions of phragmocones is necessarily somewhat inferential. The species should not have been named.

C. cushingi UFM&U, 1944. This is from the Ogdensburg area from beds formerly regarded as Cotter on the basis of *Eccyliopterus planidorsalis*. The subsequent description of this, a manuscript species of Ulrich, as *Leseurilla planidorsalis* by Cullison (1944) involves a change of interpretation; this species is regarded as derived from the Theodosia formation, the upper half of the former Jefferson City formation, instead of from the overlying Cotter.

C. foerstei (Butts, 1926). This is a species known from a considerable series of fragmentary specimens, characteristic of the Odenville limestone of Alabama. Unlike some species, the siphuncle is slightly but definitely removed from the venter.

C. osagensis UFM&U, 1944. This is based only on a fragment from the Cotter of Osage, Missouri, but is distinctive in the rather long camerae and the faintly concave siphuncle segments.

C. resseri UFM&U, 1944. The type is a rather long portion of a shell in which the siphuncle is not quite in contact with the venter. It is from the Sarbach formation of Alberta; its precise position is not known, as the Sarbach formation ranges over a good part and possibly all of the Canadian interval.

C. sordidum (Billings, 1859). This is a species of the Romaine formation of the Mingan Islands. The type shows rather low annuli, a large siphuncle apparently in contact with the ventral shell wall, flanked by the two sides of a prominent ventral lobe.

UFM&U figured on Plate 34, Figures 1 and 2, a specimen which they attributed to Schlotheim's species *Orthoceras vaginatum*, and which they consider a *Catoraphiceras*. This conclusion is certainly warranted by the features shown by their figured specimen. A second specimen of this species* is here sectioned. It shows holochoanitic necks within which thick rings of dark amorphous material are well displayed. The structure of the siphuncle wall is not yet known for any other species, but the specimen here figured as *Catoraphiceras* sp., though silicified, was partially sectioned and shows a somewhat ambiguous structure, but one suggesting short necks more typical of the Ellesmeroceratida.

Catoraphiceras presents interesting problems if one attempts to interpret it as a genus derived from a smooth-shelled form of similar aspect. *Cyptendoceras* agrees closely with *Catoraphiceras* in gross features, and in particular is similar in the ventral lobes of the sutures. This genus is now known to be a member of the Baltoceratidae with short septal necks and with a ventral rod in the siphuncle. Though the material of *Catoraphiceras* known is largely too fragmentary for the apparent absence of any rod to be conclusive, no indication of such a structure has been found. Two other genera agree closely in gross features and agree further with *Catoraphiceras? vaginatum* in having long septal necks. One is the genus *Thylacoceras* of Teichert and Glenister, 1952, and the other is *Lobendoceras*. However, *Lobendoceras* is reputedly an endoceroid with endocones, and current investigations of Glenister (*fide litt.*) indicate the same condition for *Thylacoceras*. As yet, no material of *C. vaginatum* has been reported as possessing endocones, and thus an origin from these genera, which should probably both be considered Endoceratida, is not possible.

Catoraphiceras sp.

Pl. 29, fig. 2, 3

This form is a *Catoraphiceras* fragment 32 mm long, the adoral end very incomplete. At the base the shell shows strong midventral flattening, is 9 mm high, 11 mm wide, with a siphuncle in broad contact with the venter, 3 mm high, 4.7 mm wide. There are 11 camerae in the basal 15 mm of the shell; sutures are transverse laterally and dorsally and describe the usual lobe over the venter. A section was made at the adoral end, but was inconclusive as to the structure of the siphuncle wall; it suggests short necks supplemented by rings as in most Ellesmeroceratina. This specimen is from the Cassinian part of the El Paso (B2b of Cloud and Barnes, 1946) at El Paso, Texas. No. 399.

Catoraphiceras (?) vaginatum (Schlotheim)

Pl. 29, fig. 8-10

Catoraphiceras vaginatum (Schlotheim)? Ulrich, Foerste, Miller, and Unklesbay, 1944, Geol. Soc. Amer., Special Papers No. 58, p. 75, pl. 34, fig. 1-2.

I have not attempted to give the full synonomy of this spe-

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*One must make the reservation that the specific name may not be proper. A confusing lot of various cephalopods have been assigned to this species, and while this form seems consistent with Schlotheim's description, the matter can be settled only by recourse to the type if it is extant.

cies which, as indicated by Foord, involved quite a number of different things, including the species which he separated as *Orthoceras wahlenbergi*. Jaanusson in several recent papers has cited the species as belonging to *Cyclendoceras*, an indication at least that it is recognized as having well-developed annuli on the surface. The species is apparently one characteristic of the Glauconitkalk, beds which from their fauna the writer is inclined to regard as late Canadian.

The specimen here figured is a portion of a phragmocone 80 mm long, circular in cross section, expanding in a length of 50 mm from 22 to 27 mm. Sutures transverse dorsally and laterally form a lobe over the venter. The siphuncle is narrowly separated from the venter, increasing from 6 to 8 mm in diameter in the adoral 60 mm of the specimen. Camerae range from 3 to 4 mm in length, with some slight irregularity, but with only a very slight adoral increase.

A thinsection shows the siphuncle segments, which are slightly concave in outline, to be made of holochoanitic necks, their outlines forming concave segments, and the bending of the septum to form the neck being quite gentle. Rings are relatively thick, parallel-sided, curving to conform with the necks, extending from the tip of one neck to that of the next, and not widened materially at the basal (adoral) ends, as is found in some Endoceratida.

Annuli are low, rounded, eight in the anterior portion (pl. 29, fig. 8), transverse dorsally and laterally, sloping faintly apicad over the ventral surface.

Discussion. While it is possible to present the known facts concerning this (a species of the Glauconitkalk of the Scandanavian and Baltic regions), it is not possible to enter critically into the problem of the true identity of Schlotheim's species. An attempt to consider this species as independent from *Catoraphiceras* and derived from such forms as *Thylacoceras* and *Lobendoceras* is, as noted in the generic discussion, unsatisfactory in the absence of evidence of endocones in this form.

Figured specimen. Collection of the writer: No. 404. From the Orthoceras limestone, apparently the Glauconitkalk, of Oeland, Sweden.

FAMILY APOCRINOCERATIDAE Flower

This small family contains annulated orthocones like the Protocycloceratidae, with relatively thick rings showing some indication of layering, and differing from the Protocycloceratidae in that the siphuncle segments are expanded in the camerae, so that these forms resemble younger cyrtochoanitic cephalopods. The three genera known are each known from a single species, and the species are quite possibly still known from single specimens. All are small, they are known from rather short lengths of phragmocones, and no deposits are yet known on the inside of the siphuncle. Teichert and Glenister (1954) attributed the genus *Apocrinoceras* to the Discosorida. The family was described by Flower *in* Flower and Teichert, 1957, as an appendix to the monographic treatment of the order Discosorida. The genera are only summarized briefly below for the sake of completeness, and the illustration showing the wall structure of the siphuncle of the three known genera is reproduced. Since the erection of the family in 1957, no new information and no new material relevant to it have come to light.

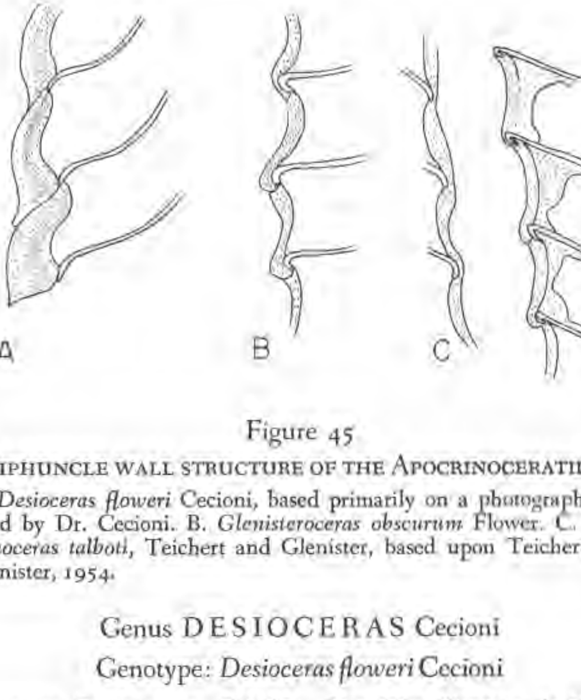

Figure 45

SIPHUNCLE WALL STRUCTURE OF THE APOCRINOCERATIDAE

A. *Desioceras floweri* Cecioni, based primarily on a photograph supplied by Dr. Cecioni. B. *Glenisteroceras obscurum* Flower. C. *Apocrinoceras talboti*, Teichert and Glenister, based upon Teichert and Glenister, 1954.

Genus DESIOCERAS Cecioni

Genotype: *Desioceras floweri* Cecioni

Desioceras Cecioni, 1953, Bol. Mus. Nac. Hist. (Santiago de Chile), t. 26, no. 2, p. 93.

A small annulated orthocone, with the siphuncle about one third of the shell diameter, showing thick layered rings of sinuate outline; sutures with rounded ventral saddles.

The only known species is from the Canadian of Rio San Lorenzo, nearly Jujuy, Argentina.

Genus GLENISTOCERAS Flower

Genotype: *Glenisteroceras obscurum* Flower

Glenisteroceras Flower, 1957, Univ. of Kansas, Paleont. Contrib., Mollusca, art. 6, p. 137.

This is a small, nondescript, annulated shell, the exterior as yet poorly known. Necks are short, but slightly recurved, the rings moderately thick, showing a suggestion of layering, outlining slightly convex segments, the siphuncle subcentral in position. The one species is from the Fort Cassin beds of the Champlain Valley, collected at the Champlain Lake shore at Valcour, New York. The siphuncle is large and only slightly eccentric.

Genus APOCRINOCERAS Teichert and Glenister

Text Figure 45C

Genotype: *Apocrinoceras talboti* Teichert and Glenister

Apocrinoceras Teichert and Glenister, 1954, Bull. Amer. Paleont., vol. 35, no. 150, p. 75.

This is a slender, straight, annulated orthocone, externally generalized, sutures with faint lateral lobes, low dorsal and ventral saddles. The siphuncle is small and close to the venter, segments gently expanding and faintly suggesting the subquadrate segments of *Westonoceras*; there are short recurved necks, rings thick, showing layering, and the subquadrate form of the segments is accentuated by a deposit on the outside, at least on the dorsal portion; this may be a further outgrowth of the rings, as seems likely, or a true cameral deposit. The one species is from horizon 3 in the Emanuel limestone, Upper Canadian, from Emanuel Creek, Kimberly Division, western Australia.

Suborder Cyrtocerinina

In this suborder are united those Ellesmeroceratida in which the ring is thickened and extended as a lobe or process into the cavity of the siphuncle. The three genera known are oddly disparate in general aspect and discontinuous as to distribution, so much so that a family is made for each of them. The first genus to be made known is the remarkable *Bathmoceras*, an orthoconic shell of slightly depressed section. The large ventral siphuncle contains forward-projecting processes the nature of which was not at first apparent, but Holm (1899) showed them to be forward-projecting lobes of the connecting ring.

Dwight found in the Rochdale limestone of southern New York a very few specimens showing similar lobes extending into the siphuncle, though they did not project forward as in true *Bathmoceras*. This material, which long lay undescribed, was the basis of some citations, notably that of Ruedemann (1906, p. 517-518) who followed Hyatt in regarding *Bathmoceras* a synonym of *Conoceras*. This material was not described until 1944 (UFM&U) when it was properly made the basis of a new genus, *Eothinoceras*, and the family Eothinoceratidae. However, the specimens known were so fragmentary that it was uncertain (and still is) whether the shell was endogastric, exogastric, or straight, and the cross section and suture pattern remain unknown. Teichert and Glenister (1954) described *E. maitlandense* from Australia, a species which is a slender exogastric cyrtocone. Balashov (1960) has figured and described *E. marchense*, a species which is essentially orthoconic, though very faintly exogastric. The last occurrence is of somewhat uncertain age, but the American and Australian occurrences are of Middle Canadian age.

Oddly, the youngest of the three genera is *Cyrtocerina*, a small, compressed, rapidly expanding, endogastric cyrtocone with a conically expanding siphuncle, the wall of which is very much like that of *Eothinoceras*. However, in form this genus is closely duplicated by the Lower Canadian *Levisoceras*, which has a siphuncle wall quite typical of the Ellesmeroceratidae.

So disparate are these three genera in form that a family is required for each of them, and the question may be raised legitimately as to whether the Cyrtocerinina is a natural group or whether the three families and genera which it includes are independent in origin, and the thickening of the rings was developed in three distinct lineages. The evidence shows that, disparate as these three genera are, an attempt to postulate discrete origins for them involves anomalies either in structure or in stratigraphic distribution or in both.

Eothinoceras of the Middle Canadian is a simple, slender shell of subcircular section, transverse sutures, and a ventral siphuncle, and such shells might possibly be developed from the Baltoceratidae, a family which comes to prominence for the first time in the Middle Canadian. However, *Eothinoceras* appears to be slightly but consistently faintly exogastric, a condition not found in these older Baltoceratidae; the septa are extremely close, and no suggestion of anything approaching the extension of the rings into the siphuncle cavity has yet been found in that family. Derivation from the exogastric Bassleroceratidae seems unlikely, for this family of exogastric cyrtocones appears in the Middle Canadian, but all these older forms show either extremely compressed cross sections or, where the shell is somewhat broader, a definite narrowing of the section on dorsum or venter or both. Bassleroceratidae more similar to *Eothinoceras* in cross section are late Upper Canadian types. It is nevertheless clear that *Eothinoceras*, as the oldest of the Cyrtocerinina, must be derived either from Baltoceratidae or the still older Ellesmeroceratidae of the Lower Canadian, some members of which approach *Eothinoceras* in the breadth of the cross section; such genera are *Pachendoceras* and *Robsonoceras*, and an origin from this part of the family is not impossible. Our *Ellesmeroceras* sp. from Alaska figured on Plate 26, Figure 12, and Plate 27, Figure 8, shows rings of unusual thickness which, with relatively slight further extension of the siphonal surface, might develop into those of *Eothinoceras*. This section is, however, from a shell with the compressed section and lateral lobes of true *Ellesmeroceras*.

Cyrtocerina, which is known to range from the Lowville to the Richmond, is very close in general aspect to the Lower Canadian genus *Levisoceras*, which is now known to have faintly concave siphuncle segments with rings typical of the Ellesmeroceratidae, but not thickened beyond the general condition found in that family. Thickening of any ellesmeroceroid ring could develop, of course, into that of *Cyrtocerina*, but while the morphological gap does not appear serious, the stratigraphic gap does, for there is nothing to connect these two genera from the top of the Gasconade to the base of the Lowville. The genera differ further in that in *Levisoceras* the venter is more narrowly rounded than the dorsum, while the reverse is true for *Cyrtocerina*. Such differences do not form insuperable barriers for the belief in the derivation of the one genus from the other, but do suggest, when morphology indicates an alternate possibility, that homeomorphy rather than a real relationship may be involved. It should be further noted that the form of the rings in *Eothinoceras* and *Cyrtocerina* is practically identical, and though the shells contrast strongly in form, origin of *Cyrtocerina* in *Eothinoceras* seems possible. Alternate possible ancestors require greater stratigraphic or morphological gaps.

Bathmoceras, ranging from late Canadian into the Chazyan, is fundamentally a simple orthocone of depressed section, distinguished by the sharp ventral saddles of the sutures and the forward-projecting lobed inner surfaces of the rings. As an orthocone of depressed section, origin in the Baltoceratidae might be postulated, but it is necessary to admit that there is nothing in the Baltoceratidae known which is any closer in aspect, or really as close, as *Eothinoceras*. No Baltoceratidae are known showing any indication of a ventral saddle of the sutures, though many forms are slightly depressed shells with rather large ventral siphuncles. Nowhere in the family, however, is there any indication of such thickening of the rings as one finds occasionally in the Lower Canadian Ellesmeroceratidae. An origin in *Eothinoceras* is suggested by the rather similar cross sections. Though Canadian species of *Bathmoceras* are essentially orthoconic, *B. norvegicum* is exogastric, and though the youngest of the known species, it reduces the contrast between the genera. A further similarity is found in the rather close spacing of the sutures. Postulating an origin of *Bathmoceras* in *Eothinoceras* involves the slightly greater flattening of the cross section, the development of a ventral saddle, extension of the rings forward into the siphuncle cavity and lengthening and thickening of the septal necks. The anomalously long and thick necks of *Bathmoceras* have no counterparts in any of the other Canadian cephalopod genera so far known. Where necks lengthen, elsewhere in the Ellesmeroceratida or in the Endoceratida, they remain quite thin. Origin of the Bathmoceratidae in *Eothinoceras* is logical, for such a hypothesis requires fewer morphological changes than are required by other hypotheses involving other Canadian genera as ancestral types.

FAMILY EOTHINOCERATIDAE
UFM&U, 1944

This family, to which only *Eothinoceras* is assigned, may be best defined as slender, faintly exogastric shells of subcircular section, with the siphuncle close to the venter, the siphuncle wall of vestigial necks, and with rings extended as triangular lobes pointing toward the center of the siphuncle.

Genus EOTHINOCERAS Ulrich, Foerste, Miller, and Unklesbay, 1944

Text Figure 46A-F

Eothinoceras Ulrich, Foerste, Miller, and Unklesbay, 1944, Geol. Soc. Amer., Special Papers, no. 58, p. 130.

——— Teichert and Glenister, 1954, Bull. Amer. Paleont., vol. 35, no. 150, p. 49.

E. americanum, the genotype, is known only from extremely fragmentary material. It is evident that the siphuncle, which shows lobes, obviously the connecting rings, extending into the cavity of the siphuncle, is marginal, that the shell is slender and either straight or very gently curved, and that septa are closely spaced, but beyond that, the gross features of the shell are not known. Teichert and Glenister (1954) described *E. maitlandicum*, based upon considerably more complete material, which shows that the shell is slender, faintly exogastric, with the section subcircular, and a rather large ventral siphuncle. Sutures are close and transverse or nearly so. Balashov (1960) has described *E. marchense* from the Chun' stage of the Siberian Platform. The American and Australian occurrences are of Middle Canadian age; the Chun' stage is less precisely dated, but the age range of these beds probably embraces the Middle Canadian. As yet, the genus is known only from these three occurrences.

FAMILY CYRTOCERINIDAE
Flower, 1946

The family Cyrtocerinidae was erected for endogastric breviconic shells with ventral siphuncles of short necks and rings extended as lobes into the siphuncle cavity. It was pointed out that while the siphuncle structure of *Eothinoceras* was similar, and the family Eothinoceratidae had been proposed, it was most unsatisfactory to attempt to assign *Cyrtocerina* to a family based upon a genus the form of which was highly uncertain. Now *Eothinoceras* is known to be a slender, faintly exogastric shell.

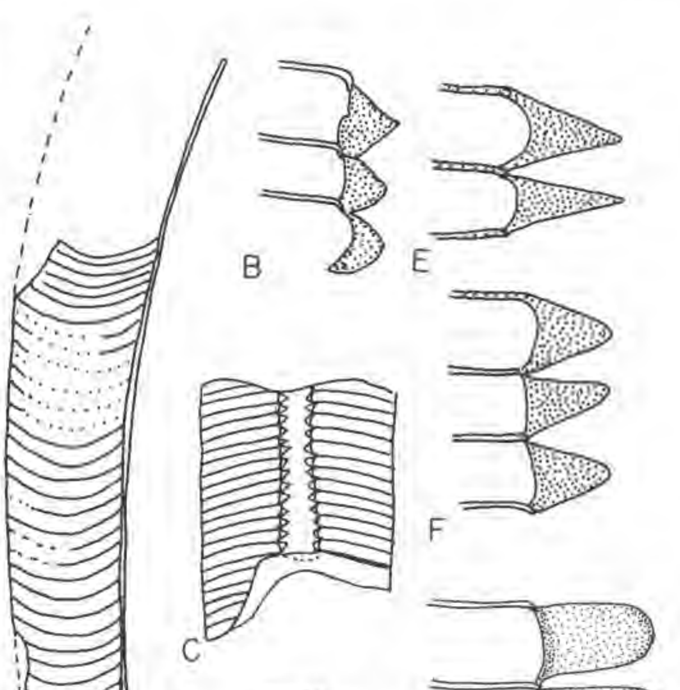

Figure 46

STRUCTURES IN PRIMITIVE *Cyrtocerinina*

A. Natural weathered longitudinal section of *Eothinoceras maitlandi*. Irregularity of septa suggests slight distortion; the venter is lost apically by styliolitic solution; original 94 mm. long. B. Thinsection from siphuncle wall of the same, showing wedge-shaped rings in section. C. Ventral view of a portion of a phragmocone, showing close septation and appearance of rings on either side of siphuncle, here exposed by weathering. D. Cross section. (A.-D. after Teichert and Glenister.) E.-F. Two sections from *Eothinoceras americanum*, after UFM&U, 1944, showing variation in outline of the rings. G. Portion of dorsal wall of siphuncle of *Cyrtocerina madisonensis* showing vestigial necks, variation in shape of the rings as seen in section, and variable differentiation of marginal dark regions. (After Flower, 1946.)

The only genus of this family is *Cyrtocerina*, which has essentially the characters of the family.

Genus CYRTOCERINA Billings

Pl. 32, fig. 1-5; text fig. 46G

Genotype: *Cyrtocerina typica* Billings

Cyrtocerina Billings, 1865, Geol. Surv. Canada, Paleozoic Fossils, vol. 1, p. 178.

——— Barrande, 1867, Système Silurien du centre de la Bohême, vol. 2, Céphalopodes, pt. 1, p. 451.

——— Hyatt, 1883, Boston Soc. Nat. Hist., Proc., vol. 22, p. 266.

——— Miller, S. A., 1889, North American Geol., Paleont., p. 436.

——— Holm, 1892, Geol. Fören. i Stockholm, Förh., vol. 14, p. 126, 209.

——— Clarke, 1897, Geol. Minnesota, vol. 3, pt. 2, p. 774.

——— Hyatt, 1900, Cephalopoda, *in* Zittel-Eastman Textb. Paleont., vol. 1, 1st ed., p. 517 (reprinted with varying 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, p. 51-54.
——— Flower, 1946, Bull. Amer. Paleont., vol. 29, no. 116, p. 504.
——— Wilson, 1961, Canada Geol. Surv., Bull. 67, p. 102.

This genus contains generally small shells, rapidly expanding endogastric cyrtocones, compressed in cross section, the cross section showing the dorsum usually more narrowly rounded than the venter. The few forms for which living chambers are known show a reduction in expansion at mature apertures, but no real contraction of the shell there. *Cyrtocerina* was originally separated from *Levisoceras* because the latter genus was believed to be holochoanitic, an impression which is now long since happily corrected. It was not until 1943, however, that a thinsection study of *Cyrtocerina* showed the remarkable lobed extensions of the connecting rings into the siphuncle.

The species so far known range from Lowville to late Richmond in age and are confined to North America. The species are listed below in stratigraphic order.

Cyrtocerina sp. Flower, 1952, p. 27, pl. 8, fig. 19-20. This is a fragmentary specimen from the Lowville of Ottawa; apparently the single figured specimen has not yet been duplicated. No such *Cyrtocerina* was found by Wilson (1961).

Cyrtocerina typica Billings, 1865. This is a species of the Paquette Rapids beds of the Ottawa River. This locality yielded a fine silicified shell. Wilson (1961) has presented a drawing showing the internal thickening of the rings in the siphuncle.

C. crenulata Flower, 1952, here refigured on Plate 32, Figures 4 and 5, is a relatively large form with sutures crenulate, from the Platteville dolomite of Beloit, Wisconsin.

C. schoolcrafti Clarke (1897) is a species from the Decorah formation of Minnesota. It was refigured and redescribed by Foerste (1932, pl. 32, fig. 10A-C, 1933, p. 138).

C. kimmswickense Flower (1952) is a small species from the Kimmswick limestone of Missouri. (*See* Flower, 1952, p. 28, pl. 8, fig. 3-5, 9, 10.)

C. foerstei Flower (1952) is a somewhat larger species from the Kimmswick limestone of Missouri with rather prominent even transverse striae and lirae (Flower, 1952, p. 29, pl. 8, fig. 1, 2, 6-8).

C. madisonensis (Miller, 1894) is from the Hitz bed, Upper Whitewater, of the region of Madison, Indiana. (*See* Flower, 1946.) Pl. 32, fig. 4-5.

C. patella Flower, 1943, is an extremely rapidly expanding species from the same horizon and locality. (*See* Flower, 1946.)

C. modesta Flower, 1943, a small species from the Hitz layer of Madison, Indiana.

C. (?) carinifera Flower, 1946, is a larger species with the mature living chamber angulate, the ventral wall of the living chamber marked by a raised linear rounded ridge, flanked by two grooves. Though the phragmocone is unknown and the species is thus tentatively placed in *Cyrtocerina*, there is little doubt of the validity of the assignment, as no other late Ordovician genus is known which has a shell or living chamber of similar proportions. This species is also from the Richmond, from the Saluda beds of McDill's Mills, near Oxford, Ohio. The type is as yet the only known specimen.

Cyrtocerina mercurius Billings, of the Levis conglomerate boulders, is the only formerly assigned species now removed; it is the genotype of *Levisoceras*, of the Ellesmeroceratidae.

FAMILY BATHMOCERATIDAE
Holm, 1899

This family is now known to contain rather large straight or faintly exogastric shells with sutures simple except for a high, sharp midventral saddle. The large siphuncle is close to the venter and in many specimens is exposed by weathering, thus obscuring the ventral saddle. The siphuncle is made up of segments slightly sinuate in outline, with rather long septal necks, rings which are thickened, the lobes being drawn strongly forward, so that they may extend for the length of two or three segments, and are more produced ventrally than dorsally.

Genus BATHMOCERAS Barrande

Pl. 32, fig. 9-20

Genotype: *Orthoceras complexum* Barrande 1856

Bathmoceras Barrande, 1865, Défense des Colonies, III, Étude sur nos étages G-H, p. 367.
——— Barrande, 1865, Syst. Sil. du Centre de la Bohême, vol. 2, Céphalopodes, Texte, i, p. 74.
——— Barrande, 1867, *ibid.*, Texte 3, p. 792-7.
——— Barrande, 1877, *ibid.*, suppl. texte, p. 92.
——— Holm, 1899, Geol. Fören. i Stockholm, Förh., bd. 21, p. 67-84, pls. 7-14.
——— *Conoceras* Hyatt, 1900, Cephalopoda, *in* Zittel-Eastmann Textb. Paleont., vol. 1, 1st ed., p. 517; reprinted with different pagination in later editions.
——— *Conoceras (Bathmoceras)* Ruedemann, 1906, New York State Museum, Bull. 90, p. 517-8.
Bathmoceras Teichert, 1939, Royal Soc. Australia, Trans., vol. 63, p. 384.
——— Flower, 1941, Palaeontographica Americana, no. 13, p. 37-38.
——— Mutvei, 1956 (1957) Ark. f. Min. och Geologii, bd. 2, nr. 8, p. 183-4.
——— Flower, 1957, N. Mex. Inst. Min. and Tech., State Bur. Mines and Mineral Res., Mem. 2, p. 13-14.
——— Sweet, 1958, Norsk Geol. Tiddskr., bd. 38, h. 1, p. 30.

The essential feature of this genus is found in the steep, sharp, ventral saddle of the sutures, and the chevronlike forward-projecting lobes within the siphuncle. The siphonal structure was a puzzle until the study of Holm (1899), who showed that these chevronlike structures were connecting rings, immensely thickened and extended into long forward-projecting lobes. The intersection of the septa and siphuncle produces segments which slope most strongly forward from dorsum to venter, a condition which is in a large part responsible for the chevronlike appearance of the rings as seen in siphuncles weathered from the ventral side, as on Plate 32, Figures 18 and 19. Holm's interpretation of the siphonal structure is shown on Plate 32, Figures 10 and 11, with some of his sections shown in Figures 12-16. Vexingly, *Bathmoceras* occurs more commonly in sandy sediments, and specimens are commonly internal molds from which shell parts have been dissolved; this condition is universal for the Bohemian species. Holm's specimen of *B. linnarsoni* (Angelin and Lindstrom) is the only specimen so far found suitably preserved in limestones and studied from a series of sections. Holm devotes several pages to an account of his search for the one adequate specimen upon which this study is based. His sections are somewhat confusing, for the rings (*see* pl. 32, fig. 12, 13) are represented by dark material which at first one might mistake for matrix, while light calcite fills the spaces between the lobes of the rings. It is not perfectly clear whether such calcite is completely inorganic or whether possibly some supplementary deposit is involved.

The interpretation of the structures is shown more clearly by Holm's drawings, a few of which are reproduced here on Plate 32, Figures 14-16, which show the thickened rings, the light calcite between them, the long thickened necks, and the sinuate outline of the siphuncle segments.

The gross aspect of *Bathmoceras complexum* is shown on Plate 32, Figures 17-20. Figure 17 shows the ventral side of an internal mold, showing the high-angled ventral saddles. Figure 18 shows the aspect of a specimen weathered into the siphuncle; properly, impressions of the rings rather than the rings themselves are shown here; the calcareous rings are dissolved. Figure 19 shows a fragment with a ventral surface showing the suture anteriorly, impressions of the rings basally. Figure 20 shows the depressed section and the large ventral siphuncle.

As pointed out (Flower, 1941), thinsection studies are desirable to confirm the identity of the lobes with the connecting rings. Mutvei (1956, 1957?) has stated categorically that these lobed structures are deposits, and he regards all deposits as the result of secretion of what Flower (1939) called a siphonal mantle; that is, secreted on the surface of a siphonal strand which must shrink as the deposits grow. Mutvei has not presented evidence supporting his view.

Bathmoceras differs from other genera assigned to the Cyrtocerininae in that the septal necks are unusually long; further, Holm's sections show them to be curiously thickened, and he shows siphonal segments which are faintly concave apically and faintly convex anteriorly; it is not hard to see how, with further exaggeration of such curvature and reduction of the apical concave portion, the siphuncle segments of *Polydesmia* could be developed. (*See* Flower, 1941, 1957.)

The yield of *Bathmoceras* for the world is, so far, five species, two from the Sárka beds of Bohemia, one from the Vaginatenkalk of Sweden, one from the *Orthoceras* shale of Norway, one from the Larapintine group (not yet subdivided stratigraphically) of central Australia. With so few species, division of the genus would be pointless, but it is necessary to point out that the known materials show considerable diversity of form, and the differences are comparable to those on the basis of which genera have been separated in other cephalopod groups. Barrande's figures of *B. complexum* and *B. praeposterum* show simple smooth orthocones. However, UFM&U have figured (their pl. 36, fig. 1 and 2) two specimens showing strongly rugose surfaces; furthermore, one (fig. 2) represents an apparently mature living chamber which develops faintly convex profiles and shows a faintly contracted aperture. Another specimen figured by the same authors (their pl. 36, fig. 7) shows an orthoconic internal mold of a living chamber bearing a prominent constriction at midlength, apparently an internal thickening of the shell such as is developed prior to the mature aperture in many orthoconic cephalopods. Sweet (1958) has added to the extent of variation in describing as *B. norvegicum* a shell which is gently but quite clearly faintly exogastric, as well as rather more rapidly enlarging than any of the other known forms.

The known species may be summarized as follows:

B. complexum (Barrande, 1856) Sárka beds, Czechoslovakia.

B. praeposterum Barrande, 1867. Same general occurrence.

B. linnarsoni Angelin and Lindström, 1880 (pl. 32, fig. 17-20), Glauconitkalk (Vaginatenkalk, lower grey Orthoceras limestone), Sweden. (*See* pl. 32, fig. 9-16.)

B. norvegicum Sweet, 1958, Cephalopod shale, Helgya, Nes-Hamar district, Norway.

B. australe Teichert, 1939, 2200 feet below the top of the Larapintine group, western Mcdonald Ranges, central Australia.

Teichert (1939) concluded that the forms then known appeared to be of essentially the same age, late Skiddavian, which would be our present late Canadian, possibly Cassinian. However, the form which Sweet described is clearly younger, as the Cephalopod shale is probably Chazyan in age and from its fauna would be, if anything, younger rather than older. This form is peculiar in the exogastric curvature, rapid expansion, and the cross section which is higher than wide; all other forms are depressed in cross section. It could, of course, be set apart from the other species as a separate genus, and future work may well show that such a course is desirable.

Considerable confusion resulted from Hyatt's (1900) identification of *Conoceras* Bronn with *Bathmoceras*. *Conoceras* is based upon a fragment unidentifiable beyond the obvious fact that it is an endoceroid, from beds of Mohawkian age of Drummond Island, Lake Huron. Topotype material, if it could be identified with the type with certainty, would show it to be either an *Endoceras* or a *Vaginoceras*.

UFM&U (1944) described as *Bathmoceras? tennesseense* some siphuncles from the Chepultapec beds near Jefferson City, Tennessee. These siphuncles show strongly oblique septal ridges; one of them is weathered so that part of the interior is exposed, and it shows a suggestion of a forward extending structure vaguely suggestive of the lobes of *Bathmoceras*. However, this structure appears to be a single one and not a series of segmental units, one pertaining to each segment of the siphuncle, and seems therefore to be allied to the ventral rods found in *Cyptendoceras* and allied genera in the Baltoceratidae. The supposed occurrence of this species, in the Lower Canadian Chepultapec dolomite, lies far below the known range of these rod-bearing Baltoceratidae, none of which is certainly known below the Cassinian, but both stratigraphically and morphologically this interpretation is less anomalous than when the species is referred to *Bathmoceras*.

Systematic Appendix

Like the man who put the clock together again and had some wheels left over, the above systematic treatment of the Ellesmeroceratida has a residue of forms which belong outside the above discussion, but require comment. This will probably always be true in an attempt to treat systematically a group in the taxonomic treatment of which one must either ignore some forms entirely or base descriptions on incomplete and inadequately preserved materials. Possibly others would recommend that more forms should have been grouped here which are treated under the genera discussed above.

The forms treated here are a heterogeneous lot. First, I have included notes on a few species assigned to some of the above genera which are certainly atypical; in some instances, their occurrence lies outside the stratigraphic ranges of the genera. This was, in the beginning, quite an assemblage; gratifyingly, it is now down to six species.

Second, there is a group of "genera dubia," genera which are ellesmeroceroids from all indications but not recognizable for one reason or another. Third, there is a group of ellesmeroceroid genera recognizable, but for the proper placement of which our present information is yet inadequate. Fourth, notice is included of some genera, either formerly placed in the order and since removed, as *Buttsoceras* and *Oxfordoceras*, or with which some of these forms were previously considered related, as *Cyrtendoceras*, some of the endogastric ellesmeroceratidae having been placed formerly (UF&M, 1943) in the Cyrtendoceratidae.

At the end are placed a few species which are not ellesmeroceroids, but which are here illustrated and described. Here is a *Lobosiphon*, significant as part of the fauna which seems of uncertain stratigraphic position, from the north end of the Ely Springs Range, and also the probable endoceroid which was previously described as *Boreoceras cloudi*.

A. Dubious Species

Ellesmeroceras ? amplum Kobayashi

Ellesmeroceras amplum Kobayashi, 1931, Japanese Jour. Geol., Geogr., vol. 8, no. 3, p. 162, pl. 17, fig. 1a-c.

Ellesmeroceras amplum Kobayashi, 1931, is atypical in large size, broad cross section, and range. Neither description nor figures show clear lateral lobes. The interpretation of the siphuncle wall is suspect. The species probably belongs to *Rioceras* but is so inadequately described and illustrated that restudy must precede any proper assignment.

The species is found in the Wolung limestone, late Canadian, of southern Manchuria.

Wolungoceras ? chiushuense Kobayashi

Wolungoceras ? chiushuense Kobayashi, 1933, Tokyo Imp. Univ., Fac. Sci., Jour., sec. 2, vol. 3, p. 275, pl. 3, fig. 4.

This species is a small, slender orthocone. The shape of the cross section of the shell, assumed to be essentially circular, is really inadequately demonstrated. The siphuncle is relatively large in proportion to the diameter of the shell, is submarginal, the nature of the siphuncle wall is inadequately known, but it is clear that the extant portions of the type show no trace of diaphragms which might be expected in such a long portion of a phragmocone.

The generic disposition of this species presents several problems which can only be solved by the acquisition and study of more and better material. Several matters are evident. First, the submarginal siphuncle is so widely at variance with the central siphuncle of typical *Wolungoceras* that the species can be placed in that genus only as a matter of temporary expediency. Second, this species is Lower Canadian in age, occurring in an association otherwise dominated almost completely by the family Ellesmeroceratidae (Flower, 1954). In view of the number of features inadequately known, and others which are definitely atypical, recognition of this as the one and only Lower Canadian member of the Baltoceratidae, requires a readjustment of concepts of relationships and relative ages of the families of cephalopods which the present evidence does not warrant. The species is equally suggestive of *Robsonoceras*, and, in absence of information as to the cross section and possible lateral lobes, could as easily be placed in *Ectenolites*. It is from the Wan-wan-kou limestone of southern Manchuria.

Robsonoceras ? meridionale

Robsonoceras meridionale Kobayashi, 1934, Tokyo Imp. Univ. Fac. Sci., Jour., sec. 2, vol. 3, pt. 8, p. 376, pl. 10, fig. 7; pl. 11, fig. 9-10; pl. 14, fig. 5.

Slender orthocone, very slightly compressed in section, ventral tubular siphuncle. Suture pattern not observed. Chikunsan bed, Makkol, southern Korea.

Placing this species is difficult. Probably it is closest to *Baltoceras*, though the camerae are short in relation to *B. burchardi*. They are, however, relatively long in relation to the alternate possibility, the Canadian genus *Rioceras*, and both proportion and age favor assignment to *Baltoceras*.

A compressed section is not typical of either *Baltoceras* or *Robsonoceras*.

Paradakeoceras? sp. (Poulsen)

Clarkeoceras sp. Poulsen, 1927, Medd. om. Grønland, bd. 70, p. 289-90, text fig. 4a-d.

This is a moderately small endogastric shell with a large ventral siphuncle, distinctive in the circular section. No genus is now described which would contain this species, but the closest is probably *Paradakeoceras*. The species is from the Gasconadian Cape Clay formation of western Greenland.

Rioceras? modestum (Poulsen)

Ellesmeroceras modestum Poulsen, 1927, Medd. om Grønland, bd. 70, p. 301, pl. 20, fig. 18, text fig. 5.

This is a tiny nondescript orthocone from the late Canadian Nunatami formation of Greenland. The circular section and rather close septa suggest *Rioceras*, but it is not certain that the siphuncle is marginal; assignment to *Wolungoceras* is an alternate possibility. It is from the Nunatami formation of western Greenland.

Protocycloceras (?) sp.

Cephalopoda, gen. and sp. indet. Poulsen, 1927 Medd. om Grønland, bd. 70, p. 295, pl. 19, fig. 9.

This is a fragment of an annulated orthocone of the aspect of *Protocycloceras*, but the interior is not preserved, from the Nunatami formation of western Greenland.

B. Dubious Genera

Genus SHANTUNGENDOCERAS Sun

Shantungendoceras Sun, 1937, Geol. Soc. China, Bull., vol. 16, p. 347.
——— Flower, 1951, Jour. Paleont., vol. 25, p. 115.
——— Flower, 1954, N. Mex. Inst. Min. and Tech., State Bur. Mines and Mineral Res., Bull. 40, p. 5.

Shantungendoceras was erected for a group of slender shells, straight and some slightly endogastric, from occurrences in North China, then regarded as Upper Cambrian. The form is clearly not an endoceroid, and the extant figures and description suggest that these shells are members of the Ellesmeroceratidae. Further, it now appears that the beds which yielded these forms are no longer considered Cambrian, but the equivalent of the Wanwanian, Lower Canadian (Endo and Resser, 1937). While precise generic determination is not possible from descriptions and illustrations, there are involved here straight forms of the aspect of *Ellesmeroceras* and *Ectenolites*, while the slender curved forms are probably best put in *Stemtonoceras*.

Genus VASSAROCERAS Ulrich, Foerste, Miller and Unklesbay

Genotype: *Orthoceras henrietta* Dwight

Vassaroceras Ulrich, Foerste, Miller, and Unklesbay, 1944, Geol. Soc. Amer., Special Papers, no. 58, p. 32.

This I regard as a genus of doubtful position and validity. It was erected for the reception of a single species from the Rochdale limestone of New York, and described as a slightly endogastric shell with strong annuli and a small tubular siphuncle. Restudy of some of the original material leads to the conclusion that *V. henrietta* is a small annulated shell, very slightly curved. The septa appear to be essentially transverse, the annuli tend to slope slightly forward on the convex side. The only sections so far described which show the siphuncle are transverse and slightly oblique to the longitudinal axis of the shell. The siphuncle is shown as close to one margin, but it is not evident from such specimens (UFM&U, 1944, pl. 4, fig. 1) whether the siphuncle lies close to the concave or to the convex side of the shell. Restudy of one of the best specimens (U.S. National Museum, no. 109438) is not altogether conclusive, but shows that the siphuncle is not close to the concave side. The form is presumably, then, exogastric and doubtfully distinct from *Rudolfoceras*.

Genus COCHLIOCERAS Eichwald

Genotype: *Cochlioceras avus* Eichwald

Cochlioceras Eichwald, 1860, Lethaea Geognostica, ou Palaeontologie de la Russie, p. 362.
——— Balashov, Z. G., 1955, Voprosy Paleontologiit 2, p. 55-60, 1 pl.

Balashov would substitute *Cochlioceras* for *Baltoceras*, considering them the same genus, and proposed the family Cochlioceratidae. *Cochlioceras*, based upon *C. avus* Eichwald, was described as a straight shell with one side strongly flattened. The illustration shows these features and shows, further, that sutures form lobes on the flattened side, with small triangular central areas which probably represent a partially exposed siphuncle. I have regarded the distinctive features of *Cochlioceras avus* as a rather odd preservation phenomenon: An internal mold of an orthoconic phragmocone was filled with matrix, and the materials fairly well solidified, after which abrasion, perhaps connected with a sinking of wave base, resulted in planing down of the uppermost side of the shell. This sort of preservation is not uncommon in orthocones of the genus *Orthonybyoceras* in the Corryville beds of the Maysville at Cincinnati.

Several points in Balashov's conclusions seem debatable. First, even granting that conclusions are correct at the specific level, it would seem much wiser to admit that *Cochlioceras* and its type species would never have been described except for features which are clearly inorganic, and it is debatable whether there is any point in trying to revive such a genus.

Second, is the species *C. avus* certainly identifiable with material which has not been similarly flattened by abrasion? This seems doubtful from the five specimens which Balashov has identified in terms of this species. The single plate accompanying his work shows in his figure 1 a small orthocone with a rather large ventral siphuncle and straight transverse sutures; figures 2 and 3 represent similar specimens and may represent the same species, but figure 4 shows an orthoconic shell with sutures forming ventral lobes as in *Cyptendoceras*, though *Murrayoceras* is also somewhat similar. However, the identity of either of these two specimens with *Cochlioceras avus* seems highly uncertain. It is best to admit that the type of *C. avus* is so altered by abrasion that the species cannot be identified with certainty.

Third, if Balashov is correct, is the restored *Cochlioceras avus* identical with *Baltoceras*? With such identification the writer would not agree; rather, it would seem that this species has the general aspect, not of *Baltoceras*, but of the species with shallower camerae which in the present work are placed in *Rioceras*. The possibility of using *Cochlioceras* for this generic group was rejected because it was felt that the identity of shells of the aspect of *Rioceras* with the type of *Cochlioceras avus* was simply not demonstrable; the form could as easily be one like Balashov's pl. 1, fig. 4, with a prominent ventral lobe, and typical instead of the genus *Cyptendoceras*. Inasmuch as Balashov has himself identified both of these forms with *Cochlioceras avus*, confusing two distinct generic groups, the claim that either is truly that species can hardly be credited.

It is further questionable whether species and genera based upon preservation phases are properly to be regarded as more than curiosities and taxonomic errors. Even when one has revisited the precise locality and horizon, and finds suites of specimens ranging from well preserved to such altered individuals as inspired such descriptions, the specific identity is usually still not demonstrable beyond any possible question. We have, curiously, two belemnite genera which have been based on rostra abraded to cigar-shaped objects, *Actinocamax* and *Atractites*, but inasmuch as many, in fact practically all, belemnites may be altered in this way, identifying the genotypes and the genera seems to involve claims of identity which cannot be substantiated. The same is true of *Cochlioceras* and a number of nautiloid genera and species; some, indeed, were named and seemed distinctive because they were overgrown with bryozoa or stromatoporids; Galloway and St. Jean have very sensibly used one such-named "*Orthoceras*" species, not for the cephalopod, but for the encrusting stromatoporid which gave the orthocone its supposed distinctive features.

Genus PROTOBALTOCERAS Troedsson

Genotype: *Protobaltoceras quruqense* Troedsson

Protobaltoceras Troedsson, 1937, Paleontographica Sinica, N.S., B, No. 2 (whole series, no. 106), p. 16.

Troedsson regarded this genus as containing slender shells, orthoconic or faintly cyrtoconic, probably circular in section, with a marginal or submarginal siphuncle of rather smaller size than in the Endoceratida, with straight, rather short septal necks. He recognized two species, *P. quruqense*, and *P. holmi*. Curvature, where developed, is endogastric. The illustrations of the two species are highly suggestive of *Ectenolites*. Almost certainly, the work of Ulrich and Foerste (1935) describing *Ectenolites* and *Ectenoceras* (under which name the species have been grouped previously) was not available to Troedsson when he wrote the description of this form. The genera are close, and I believe them to be identical. Troedsson's illustrations show the aspect of *Ectenolites*, including the lateral lobes of the sutures, and the one possible difference, the supposed circular section of *Protobaltoceras* in contrast to the compressed section of *Ectenolites*, is quite probably more apparent than real. The two known species are from beds of Lower Canadian age from western Quruq Tagh, eastern T'ien-Shan, Chinese Turkestan.

Genus CYPTENDOCERINA Ulrich, Foerste, Miller and Unklesbay

Genotype: *Orthoceras explorator* Billings

Cyptendocerina Ulrich, Foerste, Miller, and Unklesbay, 1944, Geol. Soc. Amer., Special Papers, no. 58, p. 117.

This genus was erected for a species similar to *Cyptendoceras* in slender form, slightly depressed section, sutures showing broad ventral lobes, but differing in that the siphuncle is smaller and somewhat removed from the venter.

The genotype and only species referred to the genus is *C. explorator* Billings, 1865, from the Canadian of Pistolet Bay, Newfoundland. Nothing is known of the details of the siphuncle wall. No rod is evident, but only a short bit of phragmocone is known. While on the one hand, one cannot be certain of the position of this genus, on the other, the features by which it was set apart from *Cyptendoceras* are probably quite minor, and until the genotype can be restudied from additional material, which might result in the discovery of further differences, there is little merit in recognizing the genus. Oddly, the gross features of the internal mold are duplicated by *Loxochoanella* Teichert and Glenister, but similar form is attained by quite a number of other genera, including *Murrayoceras* and some Michelinoceratida.

C. Ellesmeroceroid Genera of Uncertain Position

Genus SMITHVILLOCERAS Ulrich, Foerste, and Miller

Genotype: *Smithvilloceras thompsoni* UF&M

Smithvilloceras Ulrich, Foerste, and Miller, 1943, Geol. Soc. Amer., Special Papers, no. 49, p. 155.

This is a moderately expanding endogastric cyrtocone, subcircular in cross section, the exterior annulated and with transverse lirae and striae. Sutures straight and transverse. Siphuncle close to venter, small, its structure has not been ascertained.

Only the genotype, from the Smithville formation of Arkansas has been referred to this genus. Its taxonomic position is uncertain in the absence of information concerning the structure of the siphuncle.

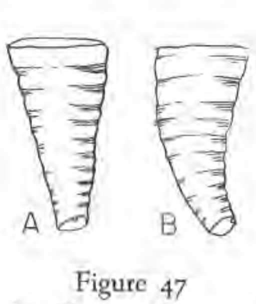

Figure 47
Smithvilloceras thompsoni
A. Ventral view. B. lateral view, venter at right. Both × 1.

One illustration shows a shell of compressed section and with lateral lobes, apparent on one side but not on the other. Neither point is mentioned in the description (UF&M, pl. 62, fig. 9-11). These features suggest that *Smithvilloceras* may be a survivor of the Ellesmeroceratidae into the Upper Canadian, in which family it was placed by Flower and Kummel. It is, however, equally possible that the genus may be related to *Endocycloceras*, from which it differs mainly in its smaller size. While enough is not known about this genus to make its taxonomic position at all certain, its similarity with *Endocycloceras* is close, far closer than its resemblance to any of the Ellesmeroceratidae. Therefore, it seems wiser in the present state of our ignorance to place this monotypic genus in the Protocycloceratidae rather than in the Ellesmeroceratidae.

Genus BRIDGEOCERAS Ulrich, Foerste, and Miller, 1943

Text Figures 48, 49

Genotype: *Bridgeoceras subannulatum* UF&M, 1943

Bridgeoceras Ulrich, Foerste, and Miller, 1943, Geol. Soc. Amer., Special Papers, no. 49, p. 59.
Dresseroceras Ulrich, Foerste, Miller, and Unklesbay, 1944, *ibid.*, no. 58, p. 132.

Two genera and species were recognized from material from boulders of the Levis conglomerate which seem closely similar. One, *Bridgeoceras subannulatum*, is a straight conical shell with annuli; the one known specimen is 60 mm long and 30 mm across at its adoral end; the section is very slightly compressed; sutures, transverse in the young, form faint, rather obscure, ventral lobes in the later stages. The marginal siphuncle is composed of concave segments.

Dresseroceras corrugatum is based upon a living chamber described as circular in section, 32 mm across at the base, 42 mm long, essentially straight, the profiles slightly convex owing to an adoral reduction in the rate of expansion. The shell

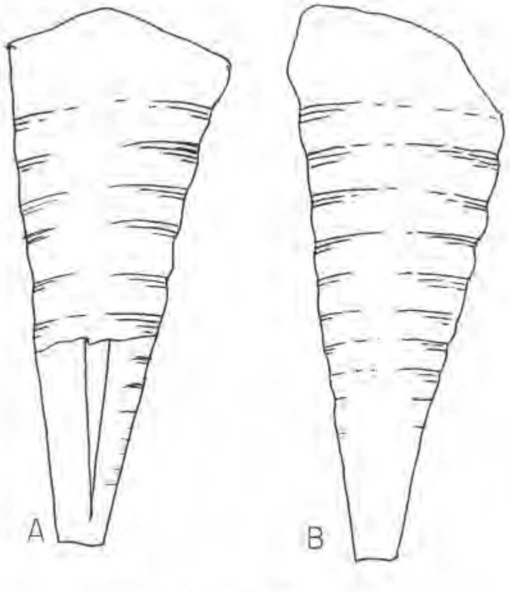

Figure 48

Bridgeoceras subannulatum

Holotype, A. ventral view, B. lateral view, venter at right. Both × 1.

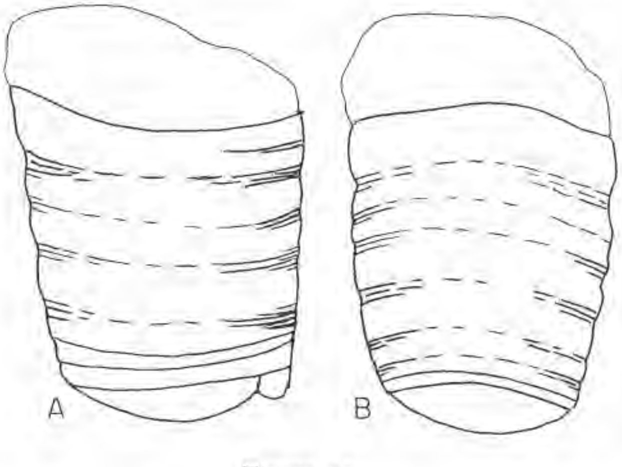

Figure 49

Bridgeoceras corrugatum

The holotype, a living chamber, A. lateral view, venter at right. B. dorsal view. Both × 1.

bears low annuli. The illustrations suggest most strongly a slightly compressed cross section and sutures with faint lateral lobes.

Allowing for possible slight distortion to explain minor differences in the suture pattern, it seems not impossible that *Dresseroceras corrugatum* could be a mature living chamber of *Bridgeoceras subannulatum;* this is not demonstrable as a certainty, but clearly, even if two species are involved, there is no good justification for placing them in separate genera.

The slight morphological information now available is insufficient to establish the position of *Bridgeoceras,* with *Dresseroceras* regarded as a synonym. Conceivably, straightening of the shell and broadening of the section could produce this shell by modifications of *Annoceras;* it could also be a conically expanding development within the Protocycloceratidae.

D. Genera Which Are Not Ellesmeroceratida

Genus CYRTENDOCERAS Remelé

This genus will be discussed more thoroughly in another work now in an advanced stage of completion, one dealing with the Endoceratida. *Cyrtendoceras* is a curved endogastric endoceroid, properly given a family by itself, but apparently derived from *Bisonoceras* of the late Middle Canadian, a genus quite closely related to true *Piloceras.* The assumption that compressed endogastric cyrtocones should be placed together in spite of wide variations in internal structure has found no support in the present work. UF&M (1943) placed most endogastric genera of the Ellesmeroceratidae in the Cyrtendoceratidae. *Cyrtendoceras* has holochoanitic siphuncle walls and contains endocones, though, curiously, only the anterior portions of endosiphuncles are known. The genus is certainly known only in the Orthoceras limestone of the Baltic, in beds which, at the most, embrace Whiterock and Chazy equivalents.

Genus BUTTSOCERAS Ulrich and Foerste

Genotype: *Orthoceras adamsi* Butts

Buttsoceras Ulrich and Foerste, 1933, Science, n. s., vol. 78, no. 202, p. 288.

——— Flower, 1962, N. Mex. Inst. Min. and Tech., State Bur. Mines and Mineral Res., Mem. 10, p. 3 ff. (contains intervening references).

Inasmuch as *Buttsoceras* was formerly assigned to the Ellesmeroceratida and placed in a family there, the Buttsocertidae, by itself (Flower, *in* Flower and Kummel, 1950), it may be noted here that new material has shown that the supposed free tube within the siphuncle is only the inner silicified surface of a lining, exposed by leaching, in the type material. *Buttsoceras* is therefore assigned to the family Troedssonellidae of the Michelinoceratida. *Oxfordoceras* would certainly never have been distinguished had it not been for the misinterpretation of the structure of *Buttsoceras,* and is probably a synonym of the genus.

Genus OXFORDOCERAS Ulrich, Foerste, Miller, and Unklesbay, 1944

Genotype: *Oxfordoceras billingsi* UFM&U, 1944

Oxfordoceras Ulrich, Foerste, Miller, and Unklesbay, 1944, Geol. Soc. Amer., Special Papers, no. 58, p. 70.

——— Flower *in* Flower and Kummel, 1950, Jour. Paleont., vol. 24, p. 608. (Assigned to the Baltoceratidae.)

——— Flower, 1962, N. Mex. Inst. Min. and Tech., State Bur. Mines and Mineral Res., Mem. 10, p. 8.

Oxfordoceras, previously assigned to the Baltoceratidae, proves to be a genus which, in the light of the reinterpretation of *Buttsoceras,* is in no known way distinguishable from the genus, and is to be regarded as its synonym. As noted (Flower, 1962), there is some question as to the precise stratigraphic and geographic origin of *B. billingsi,* but *B. atticus* (Billings) is from the Corey limestone of the Phillipsburg region of Quebec, which is clearly late Cassinian in age.

Genus GARRYOCERAS Foerste

Genotype: *Orthoceras semiplanatum* Whiteaves

Garryoceras Foerste, 1928, Univ. Michigan, Mus. of Paleontology. Contrib., vol. 3, p. 42.
——— Foerste, 1929, Denison Univ. Bull., Sci. Lab., Jour., vol. 24, p. 165.
——— Flower, *in* Flower and Kummel, 1950, Jour. Paleont., vol. 24, p. C10.

Only one species has been placed in this genus, *Orthoceras semiplanatum* Whiteaves. Foerste (1926, Denison Univ. Bull., Sci. Lab. Jour., vol. 21, p. 312) assigned the species to *Murrayoceras* but later (1928) erected for it the genus *Garryoceras*, regarded as a depressed slender shell, very faintly curved, with the dorsal concave side strongly flattened, the siphuncle close to the convex side, which is indicated as broadly round in cross section. The genus is of interest in relation to the Ellesmeroceratida inasmuch as Foerste at one time referred its genotype to *Murrayoceras*; the genus was investigated to ascertain whether is belonged, with *Murrayoceras*, to the Baltoceratidae. The type was lent from Ottawa through the kindness of Dr. Alice Wilson. The supposed tubular siphuncle is an adventitious structure. The shell is a very gently expanding exogastric cyrtocone, and though somewhat distorted, is very close in general aspect, not only to *Kindleoceras*, but more specifically, to *Kindleoceras cummingsi*; there can be no doubt but that *Garryoceras* Foerste, 1928, is a synonym of *Kindleoceras*, Foerste, 1924.

Genus OGYGOCERAS Ulrich, Foerste, Miller, and Unklesbay

Genotype: *Ogygoceras gracile* UFM&U

Ogygoceras Ulrich, Foerste, Miller, and Unklesbay, 1944, Geol. Soc. Amer., Special Papers no. 58, p. 69.

Only the genotype is known, a slender shell, circular in section, with a ventral tubular siphuncle, straight transverse sutures, showing sigmoid curvature apically, the early part being exogastric, the shell then becoming very faintly endogastric before becoming straight. The siphuncle is apparently empty; its wall structure is not known.

Several possible affinities can be suggested for this inadequately known genus. A similar sigmoid apex is found in the genus *Suecoceras* Holm, which has been generally accepted as an endoceroid; this may be wrong as no figured or described material shows any trace of an endosiphuncle. The exogastric curvature of the apex suggests such Bassleroceratidae as *Leptocyrtoceras*; indeed, one cannot but wonder whether the paratype, which seems oddly slender (UFM&U, 1944, pl. 15, fig. 3, 4), is a *Leptocyrtoceras*. An alternate possibility is that both this genus and *Suecoceras* might be Baltoceratidae with modification in curvature of the early stages.

Genus PARAENDOCERAS Ulrich, Foerste, Miller, and Unklesbay, 1944

Genotype: *Saffordoceras jeffersonense* Ulrich and Foerste

This genus was erected for straight, moderately rapidly expanding shells, smooth externally, section subcircular, siphuncle small, "apparently holocoanoidal," and close to the venter.

The name is a substitution for *Saffordoceras* of Ulrich and Foerste, 1935, as the name had been used previously (Foerste and Teichert, 1930) for an actinoceroid genus.

The genotype is an endoceroid, but some other species assigned to it are anomalous as endoceroids, have no known endosiphuncle, and may be Baltoceratidae. The described species (UFM&U, 1944) may be summarized as follows:

Paraendoceras jeffersonense, from the Roubidoux of Tennessee, shows evidence of an endoceroid endosiphuncle.

P. chadwickense, from the Cotter of Missouri, shows the siphuncle more removed from the venter; wall structure is unknown and there is no evidence of endocones. Taxonomic position is necessarily uncertain; it could belong to the Endoceratida or to the Baltoceratidae.

P. clinchburgense, from a Cotter horizon in Virginia, is a slender shell with a small tubular siphuncle, with no evidence of endocones. This is probably a member of the Baltoceratidae, and would fit rather nicely in *Rioceras*.

P. cullisoni, from the upper Jefferson City of Missouri, is another possible member of the Baltoceratidae; its siphuncle is narrowly separated from the venter. The type is a reasonably complete specimen, and absence of endocones is definite evidence that the form is not a true endoceroid.

P. dwighti, from the Rochdale formation of New York, I regard as inconclusive from the present evidence. The rather large size makes assignment to the Endoceratida possible; also I have found abundant Endoceratida in the Middle Canadian of New York, but only one possible member of the Baltoceratidae.

P. levisense, from the Levis conglomerate, is of uncertain position. The ventral lobation of the sutures and the size both suggest possible assignment to *Clitendoceras*, but endocones are not known.

P. rusti, from the St. Armand limestone of Quebec, is a rather rapidly expanding shell with a very small tubular siphuncle. The small siphuncle suggests the Baltoceratidae rather than any certain Endoceratida, but the conical expansion is unlike any member of the Baltoceratidae so far known.

E. Nonellesmeroceroid species

Lobosiphon sp.

Pl. 23, fig. 12, 13

The only specimen of this form is a weathered portion of phragmocone 35 mm long. One side shows the siphuncle and some camerae, the opposite side shows only matrix. The illustrated side shows the siphuncle well to the right of the center, and represents a weathered ventrolateral surface. The siphuncle expands from 14 to 16 mm in width; the cross section remaining suggests a slightly depressed condition. The weathered surface exposes part of an endosiphocone. A cross section at the base shows the endosiphocone with a round dorsal lobe, constricted near its center, and resembles the dorsal part of the siphuncle of *Lobosiphon*. The septa, seen only on the left side of the specimen as oriented in our figure, appear moderately inclined, nearly straight; camerae average 3 mm in length; eight occur in a length of 20 mm.

Discussion. The cross section of the endocones shows the general pattern of *Lobosiphon*, but the ventral expansion of the cone is not retained. The very straight septa, as seen in a weathered surface, are such as to suggest a similarity with associated *Cyptendoceras*, but upon closer examination, are insufficient to prove the development of a suture pattern similar to that of *Cyptendoceras*. The form is of interest in that it increases the range of *Lobosiphon* and shows part of the phragmocone, but it is considered inadequate as the type of a species.

Type and occurrence. The figured specimen, in the U.S. National Museum collection, is from locality 2175, from the north end of the Ely Springs range, Highland Peak quadrangle, Nevada, originally regarded as "lower Chazyan, above the *Receptaculites* horizon"; the writer considered the horizon as possibly late Canadian on the basis of the cephalopods. It seems not impossible that a considerable stratigraphic interval was included in this collection.

Clitendoceras (?) cloudi

Pl. 17, fig. 4-6, 8, 9, 14

Boreoceras cloudi Miller and Youngquist, 1947, Jour. Paleont., vol. 21, p. 12, pl. 6, fig. 6, 7.

The holotype is a shell 75 mm long, endogastric, slightly curved, gently expanding and subcircular in cross section. The dorsum has a radius of curvature of between 90 and 100 mm. The phragmocone, 26 mm long, contains fourteen camerae, is essentially circular in cross section, and increases from 22 to 28 mm in height. The siphuncle is large, tubular, and though the venter is poorly preserved so that the ventral wall of the shell cannot be made out with certainty, it is evident that the siphuncle is 7 mm in height with the camerae dorsad of it 18 mm high. Septal necks are gently curved, and probably only their very tips join the connecting ring. Nowhere in the specimen is the connecting ring preserved. The wall structure of the siphuncle is comparable to both that of the Ellesmeroceratidae and of the simpler Proterocameroceratidae. In the apical portion of the phragmocone internal structures are destroyed. In any event, the phragmocone does not extend far enough apicad from the living chamber that one could expect it to show either diaphragms or endocones, if these structures are present in the species. The living chamber, incompletely preserved ventrally, has a dorsal length of 65 mm, increasing in width from 28 to 32 mm. It bears rather obscure transverse markings which slope apicad from dorsum to venter and there are two rather pronounced constrictions on the lateral part of the living chamber such as are not uncommonly found on nautiloids approaching or attaining maturity.

A second specimen, labeled as *Boreoceras cloudi?* (pl. 17, fig. 14; Yale Peabody Museum, No. 17311) shows the dorsolateral portion only of a somewhat larger shell and one which appears to be slightly more rapidly expanding. Eleven camerae, their sutures faint, can be seen on the ventrolateral part of the shell, occupying a length of 13 mm. The remaining 54 mm of the shell is a living chamber. The cross section was circular or nearly so, the shell enlarging from 27 to 49 mm. The surface is rough, crystalline, and shows no clear growth lines, but as in the preceding form the aperture slopes apicad toward the venter. This specimen has none of the internal structure preserved.

Discussion. What is known of this species is really insufficient to establish its taxonomic position; it could belong either to the Ellesmeroceratida or to the Endoceratida. Certainly it is not a proper member of the genus *Boreoceras*, and the concept of the genus was colored by the apparent association of this with the compressed species which are here regarded as typical. What is needed for proper assignment of this species is material showing a more complete phragmocone, in the siphuncle of which one would hope to find endocones, if it is a member of the Proterocameroceratina, or diaphragms, if it is a member of the Ellesmeroceratida. As it is, the material shows only short adoral portions of phragmocones close to the living chamber in which neither structure can be expected.

The species is quite convincing as an endoceroid and is, in fact, very close in aspect to comparable portions of *Clitendoceras*, species of which are quite similar in cross section, slope and spacing of sutures, size and position of the siphuncle. Adoral parts of *Clitendoceras* show a somewhat greater prolongation of septal necks than is developed in this species, but observations on this matter have been limited to a very few sections in typical *Clitendoceras*. In that genus there is considerable diversity in the structure of the endosiphuncle, and some variation in the prolongation of septal necks in the adoral part of the phragmocone is quite possible.

As a member of the Ellesmeroceratidae this form is less convincing. It is relatively large for representatives of that order, and the few genera in which species are known approaching this one in size are quite different in having a strongly compressed cross section; such species are found in *Clarkeoceras* and *Caseoceras*.

In the Ellesmeroceratidae, cyrtocones which develop similar broad cross sections are few and are represented by relatively small species in the genera *Paradakeoceras* and *Woosteroceras*. *Beekmanoceras*, though round in cross section of the whorl, is a tiny gyroconic shell quite different from this species in aspect. Other forms with broad cross sections are the straight genera *Pachendoceras* and *Robsonoceras*, both of which are quite remote from the present species in proportions and aspect. While assignment of the species *cloudi* to the Ellesmeroceratidae is not impossible, as yet no closely similar forms are known which are certain members of the family. In younger and more specialized families of the Ellesmeroceratida, there are again no closely similar forms. The Protocycloceratidae contain dominantly straight annular shells; the Baltoceratidae contain smooth orthocones of subcircular cross section, mainly of small to moderate-sized species which *cloudi* does not resemble at all closely.

The association is of no help. From field observation, the bed from which this specimen came was considered as the same interval as that yielding (1) typical *Boreoceras*, which is a member of the Ellesmeroceratidae, a family dominantly Lower Canadian in age; (2) a group of species of Red River aspect and, plainly, of Red River age; (3) the genus *Suttonoceras*, which has an actinosiphonate siphuncle close to the concave side of the shell, a feature otherwise unknown in cephalopods older than Middle Silurian in age.

From morphology alone, *B. cloudi* would be assigned to *Clitendoceras*; such an assignment would suggest that an additional stratigraphic element, beds of Middle Canadian age, are involved in the short stratigraphic interval of Sutton Island. Without endocones, such an assignment is, of course, tentative, but the same criticism can be raised for some species currently and previously assigned to the genus.

Stratigraphic Appendix

Here are grouped some notes on matters relating to stratigraphic correlations and ranges of cephalopods, which seem to be better included as supplementary notes to the above discussion than as a part of the prefatory remarks. The matters included are largely rather specific in nature, without which some statements made in the earlier portion might seem ambiguous or even contrary to previously published work.

THE EL PASO SUCCESSION

The great hazard in evaluating the faunal succession of the El Paso limestone is the poor preservation of many of the fossils, a situation made the more extreme by the absence of such weathering as will cause the specimens to separate readily from the matrix; the absence of such weathering is certainly to be correlated with the dry climate, for such separation I have found elsewhere to be produced by weathering under moisture.* For this reason, even after some years of work, our knowledge of the faunal succession in the El Paso is sadly short of the forms really contained in the rocks.

Chopping has yielded fossils separating from the matrix at weathered edges of ledges, but such propitious weathering fails to continue more than one to two inches from the edges; such occurrences have yielded fragments of trilobite and gastropod faunas which are most promising, but further chopping has failed to bring to light any more identifiable specimens. Undoubtedly, with years of work these rare occurrences will be multiplied, but the present study could not wait for enough such occurrences.

We are thus dependent upon (1) rare, specialized occurrences where fossils can be chopped out, largely confined to the oolite, the highest calcarenites, and extremely local lenses found occasionally in other parts of the sections; (2) those fossils which can be removed by etching; and (3) those which can be studied from sections. Silicified trilobites have been found to be practically nonexistent. Amazingly, silicified brachiopods are generally poor, scattered, and fragmentary. The same is true of the gastropods. There remain three types of common large fossils evident, the cephalopods, the sponges, and the algae. Thus far, the algae, the stromatolites, have not yielded to any taxonomic treatment and are so wide-ranging and uniform that they fail to serve as good zone markers. Our knowledge of the sponges is yet inadequate for their ready use as zone markers in the El Paso group, though current studies may alter this situation. It is only the cephalopods which are large, conspicuous, and varied enough from one horizon to another to serve as useful zonal indices.

The Lower Canadian portion consists largely of thin-bedded limestones, with wavy bedding, in which solution along bedding planes was involved. The faunas here are small, consisting of the following:

Algae: "*Girvanella*" and an unnamed hollow tubular alga.

Brachiopoda: Rare, small *Finkelnburgia*-like shells and *Apheoorthis* cf. *melita*.

Gastropods: *Lytospira gyrocera* is the only form found which seems fairly widespread. *Ozarkina*, *Ophileta*, and *Sinuopea*-like forms have been found, none well preserved.

Cephalopoda: A very few poorly preserved Ellesmeroceratidae, including the genera *Ectenolites*, *Ellesmeroceras*, *Dakeoceras*, and *Clarkeoceras*.

Trilobites: *Symphysurina* is the only certainly determinable form found in the lower beds. The higher 25 feet have yielded fragments undeterminable but indicating additional forms. The higher beds in the anomalous section in the Big Hatchet Mountains have yielded *Kainella* and *Leiostegium*. These beds are wanting in eastern sections and should belong at the horizon of the second pebble bed of Cloud and Barnes (1946).

The first endoceroid zone, the base of the Middle Canadian, has yielded, largely from calcarenites in interstices in algal reefs, a host of straight endoceroid siphuncles, probably *Proendoceras*, the curved *Clitendoceras* (= *Kirkoceras*), and rare *Rioceras*. The endoceroids are the commonest and most conspicuous elements of the faunas. Here also occur *Aphetoceras*, a small unnamed piloceroid, *Diaphelasma pennsylvanicum*, and a host of gastropods largely known from internal molds which permit only approximate determination, but including apparent *Ozarkina*, *Ophileta*, and *Lytospira* (which give the horizon a Lower Canadian aspect), but with some more advanced forms, as yet undescribed.† The interval ranges 40 to 60 feet in thickness.

Trilobite fragments are common, but determinable forms have not been found. It is, however, evident that there are hystricurids and a pliomerid, probably *Protopliomerops*.

The first piloceroid zone (60 to 80 feet) has yielded little that is identifiable other than the cephalopods. Here, the siphuncles are larger; large straight forms, some rapidly expanding, and strongly curved forms give this fauna a very different aspect from that of the underlying zone. Here also are coiled cephalopods, including rather large *Campbelloceras*, an *Aphetoceras*, and the small straight *Rioceras nondescriptum*. Sponges become conspicuous elements in the beds for the first time; gastropods and trilobites occur, but we have no properly identifiable forms.

The oolite interval, which may range up to 40 feet in thickness but is commonly less, grading above and below into lighter calcilutites, consists of black oolitic limestones mixed with pink-weathering algal nodule layers. In places, the black calcarenites are packed with trilobite remains, mainly an apparent *Megalaspis*, and *Leiostegium*, apparently *L. maniton-*

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*The Fort Cassin beds at the Valcour shore separate readily along the surfaces of the fossils, but a few yards back, where the same beds are exposed but not subjected to such moisture, the rocks break through rather than around the fossils. The author has found the same phenomenon at Fort Ann, where the best fossils are obtained from pieces which have undergone prolonged weathering under moist soil, and again in the Rochdale limestone. There, obtaining fossils from rock surfaces was hopeless, but excellent material was obtained from pieces that had weathered under soil, some of which had been accumulated in stone piles and stone fences.

†The form that is apparently the basis of reports of *Rhaphistoma trochiscus* (Meek) is a new genus and species. It resembles *Liospira* of the Middle Ordovician.

ense. Flat-spired and high-spired gastropods are present and a few small tubular cephalopod shells (*Rudolfoceras?*). Beds transitional at the base and at the top have yielded *Diaphelasma*, some small cephalopods (*Basslerocerina, Shumardoceras, Rioceras*), and hystricurids.

Reefs above the oolite have yielded very few fossils but the large flat-spired gastropod *Bridgites* (formerly cited as "*Orospira*" sp., though editors seem to have removed the quotation marks on occasion). It is found also in basal beds transitional with the oolite. The reef is mainly algal, with a good admixture of sponges. Lithology is unfavorable for the extraction of most fossils, but some distinctive cephalopods occur here, in particular *Dartonoceras* and an *Endocycloceras*. It is commonly 20 to 25 feet thick.

Beds above the *Bridgites* reefs vary somewhat in aspect, and only in New Mexico in the Florida and in the San Andres mountains is there clear development of the algal reef beds with some considerable scattering of sand marking the base of the Jefferson City. At El Paso, this horizon is more prominent and is separated from the underlying oolite—the *Bridgites* reef is wanting—by a conspicuous sandstone.

The Jeffersonian of New Mexico has proved puzzling and difficult to interpret; lithically, there is more regional variation here among the various sections than was found in the underlying beds.

An obvious correlation, by position, would be the *Bridgites* reefs of the New Mexico section with the *Mcqueenoceras* reef of the El Paso section. Suspicion that all was not well came with the realization that in the Cooks Range and in the Black Range, *Leiostegium* was found in thin beds well above the *Bridgites* reef; it seemed unlikely that this genus, previously generally believed to be Lower Canadian, could range into the Jeffersonian, even though its position in the Demingian had to be accepted (barring splitting of the genus, and even then it appears that *L. manitouense* is Demingian). With the reduction of the dolomite of the *Mcqueenoceras* horizon to a limestone and failure of the siphuncles to be silicified, they fail to stand out, and this horizon becomes obscure, being one limestone among many others. Even the sand, abundant in the El Paso section and retained in the Hembrillo Canyon section, though only as a minor constituent, is not at all evident in the Florida Mountains section, where the horizon is readily recognizable faunally, or in the Cooks Range, where it is most obscure. However, in the Florida Mountains, the *Mcqueenoceras* occurs 20 feet above the *Bridgites* reef, but in the Cooks Range it occurs about 100 feet above that horizon, the beds between being thin-bedded calcilutites, some barren, others with hordes of tiny gastropods, obviously several genera, but so preserved that they defy adequate extraction and thus also proper determination. Such layers are reminiscent of similar layers in the Lowville of northwestern New York.

At El Paso, alternating limestones and dolomites in rather thin beds occur above the *Mcqueenoceras* reef, followed by a great thickness of massive, reefy limestones with abundant sponges and piloceroids. There are trilobites and gastropods evident, but remains found are not determinable. *Ceratopea* (probably *C. keithi* and *C. tennesseensis*) is present. Above are massive limestones with piloceroids, followed by thin beds with practically no recognizable faunal yield, though numerous scraps are present. A second, thinner (15 to 20 feet) reef occurs, with a meager fauna (again the identifiable things are maddeningly few, but Cotter age is suspected from the cephalopods) followed by massive and then thin beds. A third reef with more advanced fauna (*Curtoceras* is present) is somewhat different, but the identifiable forms from here are even fewer and the scraps more inadequate. The author suspected this of being possibly Powell, by position, but there is little to justify this conclusion, and other considerations cause one to wonder whether the Powell is other than a facies of the Cassinian. There is better evidence of a Powell fauna considerably higher. The reef grades up into dolomites; sand appears in the dolomite; in the middle, a striking discordance in bedding and grain size supplies a logical break between the Jeffersonian and the Cassinian. A few fossils from the lower dolomites indicate their affinity with the underlying limestones.

The upper dolomites of this interval in the section at El Paso belonging in the Cassinian are largely barren, but two 8- to 12-inch layers of black dolomite near the top of this interval contain silicified fossils, including several cephalopods and *Ceratopea*, apparently both *C. hami* and *C. ankylosa*. There follow 200 feet of dominantly thin-bedded limestones, with a few key horizons. The basal limestones contain *Diparalasma*. The ribbon limestones are largely barren, but occasional lenses may be filled with gastropods and, more rarely, cephalopods. Above the middle, a calcarenite contains silicified *Hesperonomiella* of considerable size. It is largely above this interval that the lenses with coiled cephalopods and occasional graptolites have been found. The higher beds particularly are characterized by abundant, large, asaphid trilobite fragments and a small *Pseudocybele*. I would disagree with Berry (1962) that this is *P. nasuta*.

The upper 35 feet (division C of Cloud and Barnes) at El Paso consist of dirty calcarenites alternating with yellow, silty, calcareous shales.

Only at one other section, that of the Florida Mountains, have equivalents of the Cassinian been recognized. Elsewhere in New Mexico they have been removed by erosion. The uppermost beds are dominantly dark calcarenites which have yielded a better preserved and more abundant fauna than the beds in the Franklin Mountains. Here *Buttsoceras* has been found. Beds below fail to resemble the Cassinian of B2b, bedding being thicker, more like those of the lower Jeffersonian, and the faunas yielded from the calcarenites are extremely meager. Their base is indicated by several layers of very black limestone, possibly the equivalent of the black beds high in the dolomite, but there is no underlying dolomite and no sand is apparent at the base.

In New Mexico, few sections extend far above the second piloceroid zone, and above that horizon these sections show a great thickness of beds with only a sparse and fragmentary fauna, without, for the most part, distinctive horizons. This is true of the Cooks Range, where, however, piloceroids become moderately abundant again in the upper layers which contain an abundance of red-weathering chert. The Florida Mountains show, in what is regarded as the upper part of the Jeffersonian, neither an abundance of such red chert nor any distinctive fossil horizons other than one persistent massive bed which has yielded only sponges. The second piloceroid zone of the Hatchet Mountains is not distinctive, and, indeed, the whole of the section above the *Bridgites* reef is relatively barren, though in walking the beds, one could recognize fauna of the second piloceroid zone.

The Cassinian in New Mexico has been recognized only in the Florida Mountains; its absence in the Cooks Range, 30 miles to the north, is surprising. The discordance of the Florida section with the Cassinian at El Paso has already been noted.

Nomenclature

The currently popular concept that stratigraphic intervals must be defined by character of the rock alone is, of course, utter nonsense. In spite of many assertions to the contrary, the lithic differences may in many instances be intangibles, almost defying definition. A striking example is the shales of the Hudson Valley. Ruedemann very wisely depended upon the faunal differences for distinction of his formations in the shales of that region. What seems to be ignored is the fact that Ruedemann mapped these beds rather extensively on the basis of lithology, which reflects another aspect of the situation: Lithic differences may be so subtle as almost to defy succinct verbal definition. Those who have worked in a formation extensively enough to obtain the faunas, which are sometimes extremely sparse, have achieved an intimate acquaintance with it and can identify it in the absence of fossils with far greater authority than someone who has come into the area and, with limited experience, has decided to attempt differentiation by lithology alone. It may be pointed out also that fossils are part of the content of the strata and that to lay down rules excluding them in making stratigraphic divisions is to accept part of the evidence and reject the rest, a course perhaps permissible in a profession, but one completely inadmissible by those who would regard geology as a sience.

Kelley and Silver (1952) divided the El Paso into the Sierrite and Bat Cave formations. Their work was done in a region in which the El Paso is eroded rather deeply; in Mud Springs Mountain, the second piloceroid zone is not reached and in Cable Canyon the top of the El Paso extends only a little way beyond that interval. Where sections are more complete, the two intervals are nowhere nearly equal. In defining it as consisting of thin beds of limestone with undulate bedding, the Sierrite is approximately fixed so as to embrace the Lower Canadian interval. However, lithology alone fails to supply a good top for this section. In some sections the first endoceroid zone is preceded by as much as 35 feet of calcarenite and the zone itself is marked by conspicuous stromatolites. Other sections, however, fail to show the stromatolites at this horizon in any abundance, and the calcarenites below may be wanting or inconspicuous. In such sections, one is inclined to place the top of the Sierrite higher, and it is certainly such sections which result in the citation of endoceroid siphuncles from this member (Kelley and Silver, 1952). The Endoceratida are completely unknown in the Lower Canadian.*

Several factors combine to make one wonder whether there is much point in giving geographic names to the divisions of the El Paso. First, mapping is done on such a scale in New Mexico that divisions are impracticable. Ironically, Kelley and Silver (1952), who maintained that formations must be mappable units, proposed the Sierrite and Bat Cave formations but failed to map them in the same work.

Second, the present fashion of delimiting formations on lithology alone has succeeded in separating "formations" from any reality in temporal consideration of stratigraphy or from the consideration of geological history, but it is a practice the writer has no intention of observing. Third, it is doubtful whether the distinctions of formations would be a matter of any general interest. However, the El Paso extends through the entire Canadian, with the addition of early Lower Canadian beds included in the underlying Bliss sandstone, and in the Ozark uplift there are recognized nine separate formations, and the succession of strata and faunas are capable of continent-wide recognition. One can hardly leave the El Paso group divided only into the rather approximate lithic units of Sierrite and Bat Cave formations, as previously proposed by Kelley and Silver. It therefore seems appropriate to propose the following divisions:

The term *Sierrite limestone* is here employed for the thin-bedded Lower Canadian limestones.

Big Hatchet formation is employed for a thickness of massive dolomites with interbeds of shale and overlying limestones or dolomites with round chert nodules containing *Leiostegium* and *Kainella*, regarded as younger than the Sierrite limestone, and well developed only in the Big Hatchet Mountains.

The first endoceroid zone is distinguished as the *Cooks formation* from the defunct town of Cooks, 12 miles north of Deming, which is as reasonably close to the type section in the northern end of the Cooks Range as a named place can be found. Though the town is defunct, the limestones are still there.

The first piloceroid zone is given the name *Victorio formation* from exposures in the Victorio Mountains, where the beds are exceptionally thick and well exposed. Mere facts and names should be no deterrent for defining the type of this interval in the Cooks Range, however.

The oolite is given the name *José formation*, from the José mining district in the Cooks Range; the district itself lies on the Montoya and Fusselman, largely in the latter, but is again a named place reasonably near the oolite type section in the northern end of the Cooks Range.

The *Bridgites* reef above the oolite is named the *Mud Springs Mountain formation*, being exceptionally well exposed and developed in Mud Springs Mountain (called *mountains* on the map, which is absurd) near Hot Springs, New Mexico.

Overlying, largely barren, thin-bedded limestones are named the *Snake Hills formation*, being exceptionally well exposed in those hills southwest of Deming.

The Demingian consists of the beds from the Cooks formation through the Snake Hills formation.

The Jeffersonian, being variable in lithology and in succession is considered as a formation by itself, the *McKelligon formation*, named from McKelligon Canyon at the southern end of the Franklin Mountains at the northeast edge of El Paso.

For the present, members in the McKelligon Canyon formation are only incompletely designated, largely because of a lack of suitable place names. Outcropping just above the Pistol Range along the Scenic Drive is the reef with the *Mcqueenoceras*, and this horizon is named the *Pistol Range member*.

Higher horizons in New Mexico appear too variable to merit member names; besides, we have been hard put to it to find enough unused place names as it is.

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*Their faunal lists are sadly approximate. They cite Bryozoa which, in truth, are sponges; their cup corals are piloceroid siphuncles.

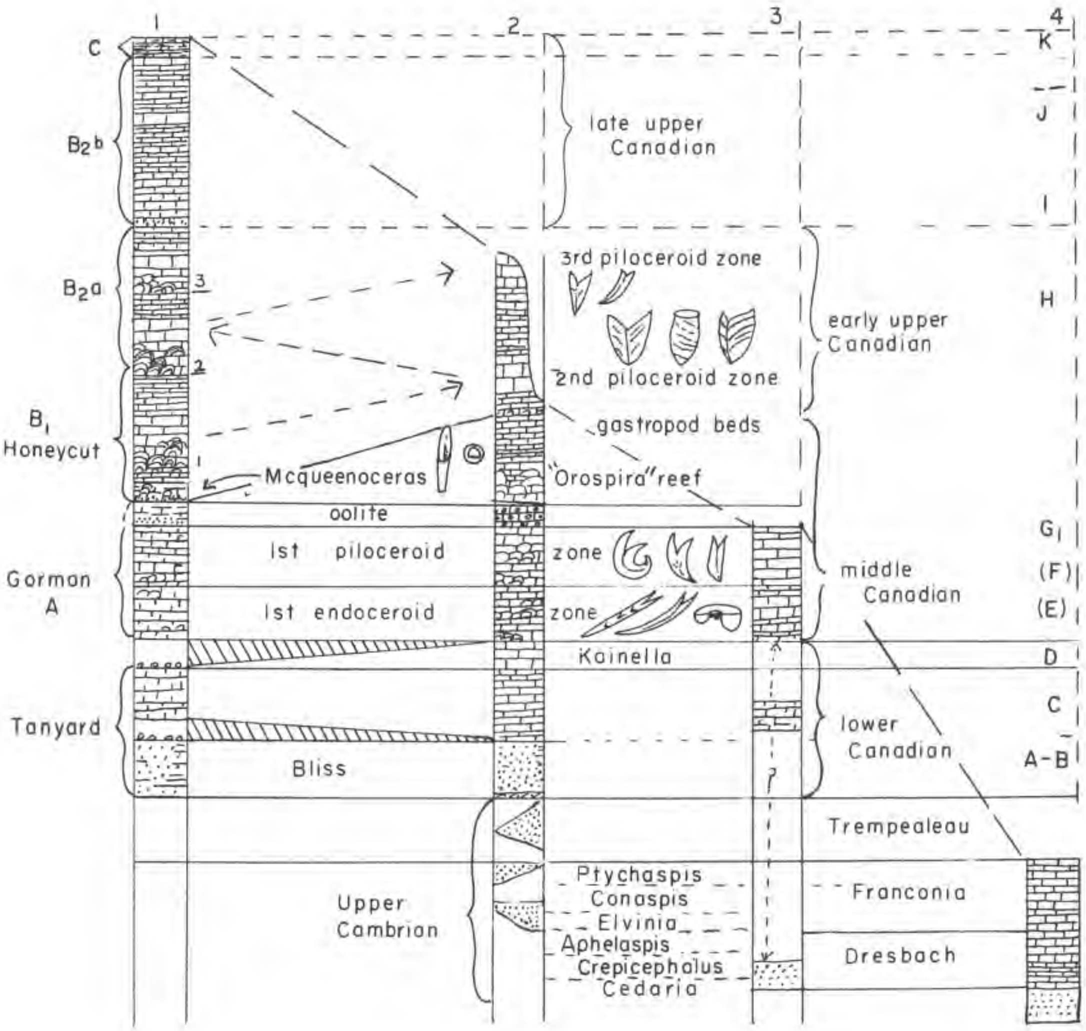

Figure 50

GENERALIZED SECTION OF BLISS AND EL PASO GROUPS IN NEW MEXICO

1. Column at El Paso, southern Franklin Mountains; the lettered divisions indicated are those of Cloud and Barnes (1946).
2. Column in the Cooks Range. Cambrian portion based upon White Signal and Lone Mountain, just south of Silver City.
3. Section at Dos Cabezos, Arizona.
4. Apparent correlation with the lettered zones recognized in the Garden City–Swan Peak and Pogonip successions in Utah, for the Canadian, with apparent limestone succession (generalized) of the later Cambrian from southern Arizona.

The Cassinian is recognized as containing two formations; the *Scenic Drive formation* consists of basal sandy dolomite, sand-free dolomite, and 200 feet of thin-bedded limestones at El Paso, essentially B2b of Cloud and Barnes (1946).

The beds designated as C by Cloud and Barnes, 35 feet thick, are developed as dark calcarenites in the Florida Mountains (Spanish pronunciation of *Floreeda* is used) and are named the *Florida formation*.

More detailed stratigraphy with more extensive discussion of the individual sections, with description of additional faunal elements, will be presented at a later time.

CEPHALOPODS OF THE LEVIS CONGLOMERATE BOULDERS

It has long been known that the boulders of the Levis conglomerate represent an assortment of horizons in the Cambrian and continue into the Canadian. While various Cambrian horizons have been recognized and the faunas distinguished, the previous monographs of the Canadian cephalopods treated all the cephalopods as "Ozarkian", that is, our present Lower Canadian. This conclusion is strongly at variance with the types of cephalopods, a matter which was recognized both by the writer and the late Dr. Josiah Bridge, a matter on which we had considerable and extremely harmonius correspondence.

Lithology of the cephalopods seems fairly uniform, a light to medium gray calcilutite, but such similarity of beds of different horizons is by no means unique. Experience with Canadian limestones in the Hudson Valley shows that beds of materially different age which may be distinct in western, presumably shoreward exposures, come to resemble each other closely in more easterly exposures which were laid down farther from the shore, in this instance, the Adirondacks, possibly extended north and south as the Adirondack axis. The westerly sections at Fort Ann show the Smith Basin limestone a very light gray calcilutite, while the Middle Canadian Fort Ann limestones are black and locally quite dolomitic. However, in the northern part of the quadrangle a thrust exposes a more easterly sequence of the same section. There the Smith Basin limestone is a darker calcilutite, essentially free from chert, and the Fort Ann limestones are a lighter gray and largely free from dolomite. The two formations are approaching each other closely though not perfectly in lithology. The Rochdale limestone of the southern Hudson Valley is the equivalent of the Smith Basin limestone, and from all indications, was laid down farther seaward; it approaches even more perfectly in lithology the Fort Ann limestone as it becomes darker eastward. Thus, the Lower and Middle Canadian are potential sources of fossiliferous pebbles which it would be difficult, and perhaps impossible, to separate certainly on the basis of lithology.

Faunally, the cephalopods of the Levis boulders may be grouped as follows:

I. Ellesmeroceratidae—forms of definitely Lower Canadian aspect and affinities:

Eremoceras syphax
Levisoceras mercurius
L. belli
Quebecoceras quebecense (a monotypic genus, but one close to *Stemtonoceras* and *Dakeoceras*).

II. Simple Bassleroceratidae—such forms are particularly common in the Middle Canadian, but genera usually extend higher. These forms, in their size and affinities, suggest Demingian rather than Jeffersonian or Cassinian:

Bassleroceras alethes
Diaphoroceras belli
D. collinsi (described as *Lawrensoceras*)
Dyscritoceras dictys
D. metullus

III. Forms of definitely Cassinian aspect—only one is certainly included here, *Onychoceras surgens* Barrande.

IV. Protocycloceratidae—members of this family range from Middle Canadian to the close of the Upper Canadian; they are particularly prevalent in the Cassinian, but genera and species groups fail to show clear indication of restricted ranges within this broad interval. The family begins in the Lower Canadian, where *Walcottoceras* is one of the characteristic and common genera. Two species of *Rudolfoceras* are known also from the Smith Basin limestone:

Rudolfoceras kindlei
R. levisense
R. subarcuatum
Protocycloceras levisense
Endocycloceras wilsonae

V. Orthoconic types of generalized aspect, with ventral siphuncles—these forms, known from fragmentary specimens, are most difficult to assign. Without demonstrable endocones, assignment to the Endoceratidae cannot be made certainly, but such an assignment seems probable for a number of these forms. The alternate possibility, assignment to the Baltoceratidae, is possible for some forms, but not for "*Clarkeoceras*" *lawrensense*, which shows elongation of necks unknown in that family but similar to the condition found in *Clitendoceras*. For the species formerly assigned to endoceroid genera, neither endocones nor details of the siphuncle walls are known, and some of these could as easily be Baltoceratidae.

The problem of the species assigned to "*Endoceras*" has been noted elsewhere (Flower, 1955):

Clitendoceras (?) *lawrensense* (formerly *Clarkeoceras*)
Clitendoceras ? *levisense* (formerly *Clarkeoceras*)
Endoceras ? *lawrensense*
E. ? *logani*
E. ? *richardsoni*
Paraendoceras ? *levisense*

VI. Two anomalous, straight, annulated shells remain, differing from the Protocycloceratidae in their fairly rapid conical expansion—these were described as *Bridgeoceras subannulatum* and *Dresseroceras corrugatum*. Differences are slight; the slight contraction of the aperture of *Dresseroceras* might be a feature only developed at full maturity. The two species are best considered members of a single genus, *Bridgeoceras* having priority. Affinities seem highly questionable, as siphuncles are inadequately known. These forms have, however, no close relatives in any known Lower Canadian faunas, and their broad cross sections suggest a considerably higher stratigraphic position.

It is thus evident that a good number of the cephalopods of the Levis conglomerate suggest an origin in beds ranging in age from Demingian to Cassinian. How many such formations may have contributed it is impossible to say, but a logical origin would be in erosion of some such sequence as is found at Phillipsburg, Quebec. At the least, it would appear that constituents of Gasconadian, Demingian, and Cassinian ages are involved, and these three units are represented farther south throughout the length of the Champlain Valley.

CEPHALOPODS AT THE CANADIAN-ORDOVICIAN BOUNDARY

See Text Figure 3, p. 23

As previously represented (Flower, 1954), the Canadian–Ordovician boundary appears as a horizon at which profound changes took place in the cephalopods, marked by the general extinction of most Canadian stocks and the representation of a few others by only scattered specialized survivors while their place was taken by new stocks. Indeed, it appears to mark the inception of the orders Michelinoceratida, Actinoceratida, Oncoceratida, Ascoceratida, Barrandeoceratida, the inception of the Endoceratidae and extinction of the Piloceratidae of the Canadian, survival of some modified and, in some instances, bizarrely specialized members of the Proterocameroceratina, with only the Baltoceratidae of the Ellesmeroceratida and the Trocholitidae of the Tarphycertida, and possibly *Bathmoceras*, surviving without major morphological changes, and more specialized modified stocks consisting of the Cyrtocerinidae and the Shideleroceratidae.

Interestingly, there are changes in faunas of somewhat comparable magnitude only at the close of the Lower Canadian and again at the Devonian–Mississippian contact. Admittedly, the change there may appear greater than it is because our knowledge of later Devonian cephalopods is very poor.* Interestingly, the orders and many of the families known in the Chazyan can be traced up through the Ordovician and into the Silurian, and in a few instances, even farther. Radically new types appearing prior to the Mississippian are confined to the Rutoceratida and the probably derived early Nautilida (Centroceratidae) with the addition of the first Ammonoidea, the possibly distinct Clymeniids, and, from de Koninck's single record, the first of the Coleoidea, all in the Devonian.

What can be the significance of such a profound change in cephalopod faunas at the close of the Canadian? Obviously, either there was some general change, possibly climatic such as was involved with the extinction of the dinosaurs and ammonites at the close of the Mesozoic, or else our known record is marked at this point by a profound break, so that there is a considerable "lost interval" here without a known record of the marine invertebrate faunas. In either event, one might hope that with further investigation, fuller knowledge of the faunas would reduce the magnitude of the break in the faunas. Studies of the cephalopods have reduced this break slightly, but not so much as one might hope. The picture still remains one of dominant Canadian groups which send relatively few survivors into the Ordovician, some of which are highly modified, and beginnings of some Ordovician groups that have been found in the Canadian, but which are few as to species. In only one instance, *Buttsoceras* of the Michelinoceratida, are they abundant enough to be significant factors to be taken into account in evaluating the Canadian faunas in general. That there are regions in which there are serious breaks between Canadian and Ordovician deposition is a matter which will find, if it has not already found, general acceptance; the Canadian surfaces in New Mexico, central Texas, and the Ozark uplift show clear evidence of beveling by erosion, which has removed later Canadian beds and further, obviously acting upon surfaces which were gently warped and thus unevenly elevated, has removed the upper beds to depths which vary appreciably from place to place. Such emergence and erosion is, of course, hard to date precisely, but the earlier time intervals of the Ordovician, the Whiterock, and the succeeding Chazy or Marmour, are represented by sediments which are relatively restricted geographically. The erosion may well lie in this interval or might possibly lie in the Chazy–Black River hiatus. Whiterock sediments are known (1) in the Utah–Nevada region, (2) in Oklahoma, and (3) in Newfoundland; the writer would consider the Day Point beds—considered a part of the Chazy since the days of Brainerd and Seely, though originally excluded by Emmons—a possible fourth example of beds of this age interval. In the Utah–Nevada region there is no evidence of a serious break in deposition between the latest Canadian and the earliest Whiterock; indeed, there is evidence that below the Whiterock there are beds of latest Canadian age, equivalent to the highest El Paso and the Odenville, for *Buttsoceras* of that horizon occurs in the Garden City, and in the Pogonip of the Ibex area, brachiopods and gastropods, close to those found in this horizon in the El Paso, have been found by the writer above beds (both intervals are in zone K) close to the lower Cassinian El Paso faunally and lithically. Zone L of the Garden City sections have yielded two genera of bizarre and specialized endoceroids, *Williamsoceras* and *Rossoceras,* which are certainly unlike anything known in underlying Canadian beds. *Williamsoceras* belongs to the Allotrioceratidae, otherwise known from two Chazyan genera; it probably originated in *Coreanoceras* of the Canadian. *Rossoceras* is known from higher zones, M and N in Nevada, and is possibly allied to what Balashov (1960) called the Interjectoceratina of the Endoceratida on the basis of less complete material comprising other genera from the Ordovician of Siberia. The same zone (L) in the Pogonip is relatively sparsely provided with fossils, and few cephalopods are known to the writer; there are Endoceratida and a member of the Michelinoceratida, both anomalous in terms of what is known from the underlying Canadian. One *Rossoceras* was seen but not collected in this interval at Ibex, Utah. For Oklahoma, the evidence is less clear; the top of the Canadian presents a lithic contrast, and some faunal evidence, largely the brachiopods, suggests possible Odenville equivalence (Cloud and Barnes, 1946). For Newfoundland, the information on the beds below the Table Head is less adequate; certainly the St. George beds have yielded coiled cephalopods of Cassinian aspect, but there are also forms (largely the *Aphetoceras* and *Pycnoceras*) which are dominant in the Jeffersonian. *Deltoceras* from these beds turns up in zone J in Nevada, and the present records, at least, fail to demonstrate clearly faunas marking the closing phase of Canadian deposition.

Probably the closing phase of the Canadian is present in the Garden City and Pogonip successions, is preserved at least locally in the El Paso succession, and may be represented by the latest Arbuckle, the Black Rock of Arkansas (present, it may be noted, only on the south side of the present Ozark uplift), in the Odenville of Alabama, in the Providence Island of Lake Champlain, and probably in the Corey and Basswood Creek of the Phillipsburg section. Of these regions, only those in Utah, Nevada, and Oklahoma coincide with those showing certain Whiterock beds above this latest Canadian, to which may possibly be added the Day Point beds of the Champlain Valley; interestingly, the Mystic conglomerate of Phillipsburg contains pebbles with both Canadian and Chazyan faunal elements.

One would expect that unless there is a major time interval unrepresented by fossiliferous marine sediments, which, as shown above, we have reason to doubt, future work would tend to reduce the contrast between the Canadian and Ordovician faunas. For the cephalopods, work has reduced the contrast to some degree, but the reduction is still slight. In the Ellesmeroceratida only one family, the Baltoceratidae, passes the Canadian–Ordovician boundary. Records are possibly faulty which suggest that one genus, *Rhabdiferoceras,* may be common to the late Canadian and the Whiterock. Other Ordovician members of the Baltoceratidae, *Baltoceras, Bactroceras, Murrayoceras,* and *Cartersoceras,* are post-Canadian developments. Other Ordovician modified survivors of the Ellesmeroceratida comprise the Cyrtocerinidae, known only from *Cyrtocerina,* and the Shideleroceratidae, known only from *Shideleroceras.*

For the Tarphyceratida, two families, the Bassleroceratidae and Tarphyceratidae, disappear at the close of the Canadian,

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*Lineages of coiled nautiloids are involved. In North America only one coiled genus, *Carlloceras* is known above the *Manticoceras* faunas, and as yet one described and one manuscript species are all that are known of *Carlloceras.*

and only Trocholitidae pass the boundaries extending not only through the Ordovician but, as *Graftonoceras*, persisting until the close of the Middle Silurian. Some evidence suggests that the genus *Litoceras* is common to the Cassinian and the Whiterock, but perplexity surrounds the precise age and range of some species, including the genotype, one of a number of coiled cephalopods described, each practically in a short sentence and not illustrated, from Newfoundland. There *Litoceras* is regarded as coming from the Canadian St. George beds. Large coiled shells which appear to be *Litoceras* occur in the Cassinian part of the El Paso, but thus far none has been found where they could be collected; they have all been seen in large boulders or on flat surfaces. There can be no question, however, but that *Litoceras* is one of the characteristic forms of the sponge beds of the Whiterock in Nevada. In Europe, the Lituitidae is an exclusively Ordovician stock.

The Barrandeoceratida is a stock ranging from Ordovician to Devonian. Separation from the Tarphyceratidae of the Tarphyceratida involves some practical problems, owing to the fact that the crucial difference found in the connecting rings is not shown in poorly preserved material. While adequate material for the study of the rings is unavailable for some species and even genera, thus far the Canadian forms have all shown the thick rings of the Tarphyceratida and the Ordovician genera have shown the thin homogeneous rings of the Barrandeoceratida. It seems probable that the Barrandeoceratida arose through the Plectoceratidae from such Tarphyceratida as *Campbelloceras* (probably *Cycloplectoceras* is based upon early growth stages of this genus) leading to *Plectoceras* of the Ordovician. Except for the nature of the connecting rings, the two genera are extremely close.

The Oncoceratida of the Ordovician arose probably through the family Graciloceratidae, small, slender, exogastric cyrtocones with ventral tubular siphuncles showing only thin rings, from the Bassleroceratidae of the Canadian, which are similar, though generally somewhat larger and more abundant cyrtocones, but with the thick layered ring of the older cephalopod stocks. Yet nothing like a transition has been found, and no forms on the two sides of the boundary are similar enough to cause any confusion in identification.

The contrast in the Endoceratida at the Canadian–Ordovician boundary is less obvious, perhaps because some morphological features of species and genera close to the boundary remain inadequately known. Certainly no Piloceratidae are known to survive the close of the Canadian, and no Endoceratidae are known below that boundary. Oddly, there are some Proterocameroceratina which pass from Canadian into the Ordovician (Flower, 1957); some of these forms pose problems as to their proper taxonomic disposal, but most of the Ordovician forms are families distinct from anything known in the Canadian. In the Whiterock of Utah and Nevada, the Endoceratida are represented by three genera, *Williamsoceras*, certainly assignable to the Ordovician Allotrioceratidae, and two genera as yet impossible to place with certainty. One, *Rossoceras*, certainly allied to the Interjectoceratina, is thus far known elsewhere only in Siberia, though *Endoceras gladius* of the Baltic may belong, and the other, *Trinitoceras*, is a genus yet known only from material too incomplete to make its position certain.[*] The Table Head of Newfoundland has yielded "*Orthoceras insulare*" of Barrande, a large slender endoceroid (its inadequately known ectosiphuncle suggests assignment to the Proterocameroceratina, but more material is needed before a conclusive decision can be made), and some small, slender endoceroid siphuncles, strongly flattened ventrally, the ectosiphuncles not yet adequately known; one of them is suggestive in gross features of the inadequately known late Canadian genus *Oderoceras*. For the remainder of the world, the stratigraphic picture is less clear, but *Dideroceras* of the Baltic and of central China is clearly post-Canadian, and there are no associated forms known which are certainly either Proterocameroceratina or Endoceratidae with shorter (holochoanitic rather than macrochoanitic) necks. These beds may be of Whiterock age. In north China and Manchuria, some Endoceratida close to the boundary are inadequately known and cannot yet be evaluated. It should be noted that the Maruyama bed with a piloceroid and with *Polydesmia*, the first of the actinoceroids, is here accepted as Wolungian, late Canadian.

A gap still separates the Discosorida, definitely known only in beds as old as the Chazyan (one fragment from possible Whiterock beds of California may belong to this group; it is similar to *Ruedemannoceras* of the Chazyan), and their ancestors in the Plectronoceratina are not known above the Wanwanian, the Lower Canadian of north China, Manchuria, and Korea.

Recognition of the Maruyama beds as late Canadian places *Polydesmia* and its subgenus *Maruyamacerina* in the closing phase of the Canadian, with the Wutinoceratidae marking the next stage in evolution, with the reduction of the dendritic canals to a reticular pattern, being a group thus far known exclusively in the Whiterock of eastern Asia, Utah and Nevada, Newfoundland, and the Aseri (Platyurus) horizon in the Baltic, strata regarded as of Whiterock age.

Formerly it was believed that the Michelinoceratida was an order which appeared after the close of the Canadian; there are American Whiterock forms, though they are not yet adequately known; all so far found certainly have tubular siphuncles. Further investigation brought to light the fact that *Buttsoceras*, a genus particularly characteristic of the closing phase of Canadian deposition in North America and with which *Oxfordoceras* is possibly synonomous, belongs to the Troedssonellidae of the Michelinoceratida; further, that true *Michelinoceras* is found in beds not only of the same age but also in a horizon materially lower in the Cassinian (Flower, 1962A). Thus, the beginning of the Michelinoceratida in the Canadian is definitely established, though there are only two families, two genera, and only six known species involved. The great expansion of the order is post-Canadian, and we may tentatively attribute the beginning of the Clinoceratidae to the Whiterock (Aseri limestone of Sweden), but such derived stocks as the Proteoceratidae and Allumettoceratidae are unknown prior to the Chazyan, where also the derived Hebetoceratinae of the Ascoceratida make their first appearance.

Such vexations as remain involve matters of interpretation and correlation. *Bathmoceras*, the writer had regarded as Late Canadian, though the species generally occur in sandy environments removed from the normal and more easily correlated faunas. However, if this is so, Sweet (1958) has certainly described from Norway a species from the *Orthoceras* shale, apparently as young as the Chazyan, which has the essential

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[*] These last two are manuscript names, but the works describing them are finished and await publication.

structure of the genus; it could be made a separate genus, as it is definitely curved exogastrically, but it is proof that the essential lineage, in which only one genus has been recognized, extends this high in the column.

The present conclusions rest, of necessity, on the findings made and recorded up to the present; such results are certainly incomplete, and there is no doubt that they will be altered with future finds. They are worth noting, however, inasmuch as they are based upon evidence far more complete than was available before for the cephalopods—involving some Canadian and Whiterock forms which the writer has at present in manuscript and some others—collections brought together but not in manuscript in the sense of completed, written descriptions and prepared illustrations—and thus contribute to the knowledge of the faunal changes marked by the Canadian–Ordovician contact.

THE FORELAND SEQUENCE OF THE FORT ANN REGION, NEW YORK

This section is briefly described here since some of the ellesmeroceroids described are from formations in it which have not been properly published, and the region is also one which contributes to the solution of some broader problems of Canadian stratigraphy. The writer came upon the Fort Ann section quite by chance when taking a detour to the Champlain Valley, and made initial collections, largely from the Smith Basin and Fort Ann limestones, in the summer of 1941. Immediate pursuit of the problem was impossible for some years, but while at the New York State Museum, he made further examination of the section, collected several significant faunas, and mapped a good part of the Fort Ann quadrangle. Because of various limitations of funds, laboratory and publication facilities, as well as numerous interruptions, the mapping of the entire belt of the foreland beds was not quite completed, but investigations were extended into the correlations with other regions. In 1951 the writer moved to New Mexico, from where continuation of this work was impossible; all but a part of the earlier collections was left behind.

In view of promises of "special consideration" to be given this work, it was planned that a summary of the section would be submitted to the American Journal of Science and information supplied for the guidebook for the field trip to be held in conjunction with the meeting of the Geological Society of America at Boston. The submitted paper lay for the better part of a month unacknowledged; there followed some hurried letters referring vaguely to changes to be made in it, but the changes were made known to the author only when proof was received, and it was then indicated that restorations would not be made. In view of the promise of special consideration, this seemed an anomalously high-handed procedure, and I could not possibly allow publication on these terms. The stratigraphic names then used were, however, employed by Rodgers (1952) in the guidebook, to which was added a pasted note that the paper describing them had been withdrawn; an odd way of summarizing the cavalier treatment it had received. Oddly, some years earlier, a summary of the section was presented in abstract of a paper presented before the Geological Society at the meeting in Ottawa (1947). That, however, was the year that the Geological Society decided to refuse to publish new names in abstracts, so at the demand of the secretary or editor, the names were deleted and an essentially meaningless abstract resulted. It was in the same volume that another abstract was devoted to the proposal of the Bolarian by G. M. Kay. The Society has never vouchsafed an explanation for this anomaly. Still more oddly, the Geological Society found it convenient to publish these names in its 1952 guidebook, though in view of the misediting and consequent withdrawal of the paper, the author had protested against this procedure.

The location of the region is shown in Figure 51. It lies in the upper Hudson Valley, southeast of the Adirondacks. Two sequences of strata are involved, the foreland series and the Taconic overthrust series. Only the former is of immediate concern to the present work. Within the quadrangle (fig. 52) are masses of Precambrian granite with some metamorphosed sediments, a portion of the Adirondack complex.

Lying on the Precambrian and dipping gently to the southeast is a series of Paleozoic rocks beginning with the Potsdam and continuing to the Snake Hill shale; in the northern half of the area a thrust causes repetition of the section. To the east, not indicated, is the westward present limit of the Taconic sequence; to the south it is separated from the limestones by a broad, largely covered area underlain by the Snake Hill shale, there considerably distorted and with marked cleavage developed. To the northeast, however, the Cambrian lies in contact with the limestones, and in the Mettawee River black shales of the Schodack formation lie on top of the Providence Island formation. The foreland sequence is generally well exposed in fields, largely pastures, but several broad east-west-trending valleys represent faults, with some displacement, and are broadly covered. This brief summary will suffice for the general regional picture.

Because of careful and prolonged collecting, the faunas yielded a large suite of fossils. The collections made by the writer are largely in the New York State Museum, from which institution he was informed that if study of these or other collection was needed it would have to be done there. Consequently, the forms here described and based upon parts of the initial collections are far from representing even the complete cephalopod fauna.

The region is one in which controversy has reigned over the proper position of the Cambrian–Ordovician boundary. In the early days a column was recognized consisting of Potsdam sandstone, Calciferous, Chazyan, and then Mohawkian. Brainerd and Seely (1890) grouped the Calciferous into division A through E, not because they could not remember what came after E but because they ran out of Calciferous and into Chazyan. The name *Theresa* was proposed for lower sandy dolomites. Cleaner dolomites supposed to be Cambrian were given the name *Little Falls dolomite*, and the name *Beekmantown* was given to those supposed to be Ordovician. This worked nicely except that there was little agreement as to where the Cambro–Ordovician boundary belonged. One difficulty was that everyone assumed that the lettered divisions A through E of Brainerd and Seely could be widely correlated; yet a closer look at them would make one wonder why this should be so. They are not, after all, very fundamental, particularly in a region where lateral gradation from dolomite to limestone is clearly evident. A is dolomite, B is limestone, C is dolomite with a sandstone base, D is mainly limestone

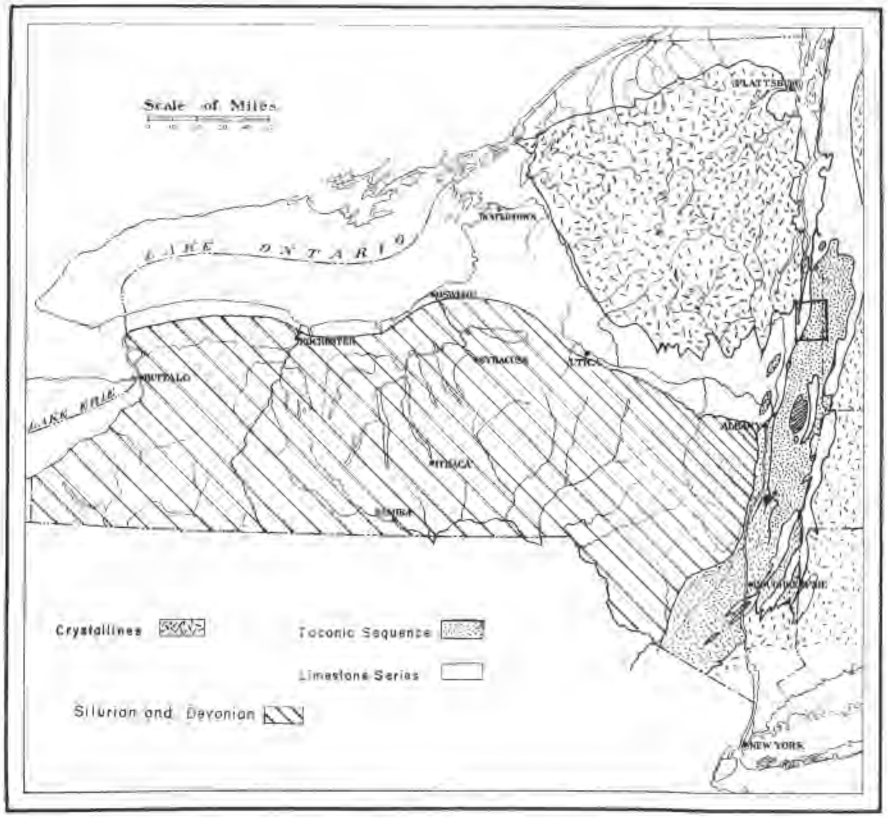

Figure 51
Location of the Fort Ann Region.

with dolomite flanking a sandstone in the middle,* E is mainly dolomite. As it turns out, the sections at Fort Ann and at East Shoreham are not very similar; each has units peculiar to itself.

Rodgers (1937) mapped the Whitehall quadrangle, recognizing a section there interpretable in terms of the divisions of Brainerd and Seely. He named there the supposed equivalent of division B the *Whitehall formation* and concluded it was of Gasconade age on the basis of fossils which had been determined by Ulrich, not from Whitehall but from the section at East Shoreham, Vermont. Some years later Wheeler (1942), working in the Whitehall and Fort Ann regions, found fossils in the Whitehall limestone at its type locality, which proved to be Trempealeauan and in general equivalent with the Hoyt limestone at Saratoga, New York. Wheeler also accepted equivalence of the sections in this region with that at East Shoreham. He proposed a good number of new formation names but failed to designate type localities, defining them only in terms of the units in the section of Brainerd and Seely. They cannot be recognized with certainty, and the author has treated these names as though they were unoccupied. The oddest of the lot is the "Fort Ann limestone," defined as Brainerd and Seely's C1. C1 is, according to Brainerd and Seely, not a limestone but a sandstone.

The present summary has reduced or omitted a number of matters of purely local interest, as precise directions to places where certain phenomena are exceptionally well shown, and discussion of some long used, and misused, formational names dealing with the Canadian in general in the New York region. The present work describes a number of Ellesmeroceratidae from the Smith Basin limestone; Tarphyceratida of the Fort Ann limestone are included in a work now near completion dealing with the Tarphyceratida as a whole, and Endoceratida are included in another work, largely devoted to descriptions of representatives of that order from the El Paso group.

SUMMARY OF THE FORELAND SECTION

Potsdam Sandstone

The Potsdam sandstone of the Fort Ann region is estimated to be 300 feet in thickness; there is no one place on the quadrangle where the entire section is exposed. The contact between the Potsdam and the Precambrian appears as such a straight line on the map as to suggest a fault contact, but several exposures show the contact to be normal, with the Potsdam lying upon an essentially peneplained Precambrian surface. The basal beds here are not markedly arkosic, though such a condition has been found in the vicinity of Ticonderoga. At Fort Ann, the basal three to four feet contain quartz pebbles, large and irregular, in a matrix which is only slightly arkosic.

Over the greater part of its thickness, the Potsdam is a sandstone or a sedimentary quartzite, the latter condition prevailing. Surfaces with ripple marks are common, and cross bedding may attain an amplitude of three feet. The greater part of the thickness of the formation is barren of fossils. At rather widely spaced intervals there are, in varying combina-

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*Why this division was limited to the boundaries given remains a mystery, but oddly, the validity of the unit has not been questioned previously. Here, it is rejected, as a unit of disparate periods of sedimentation.

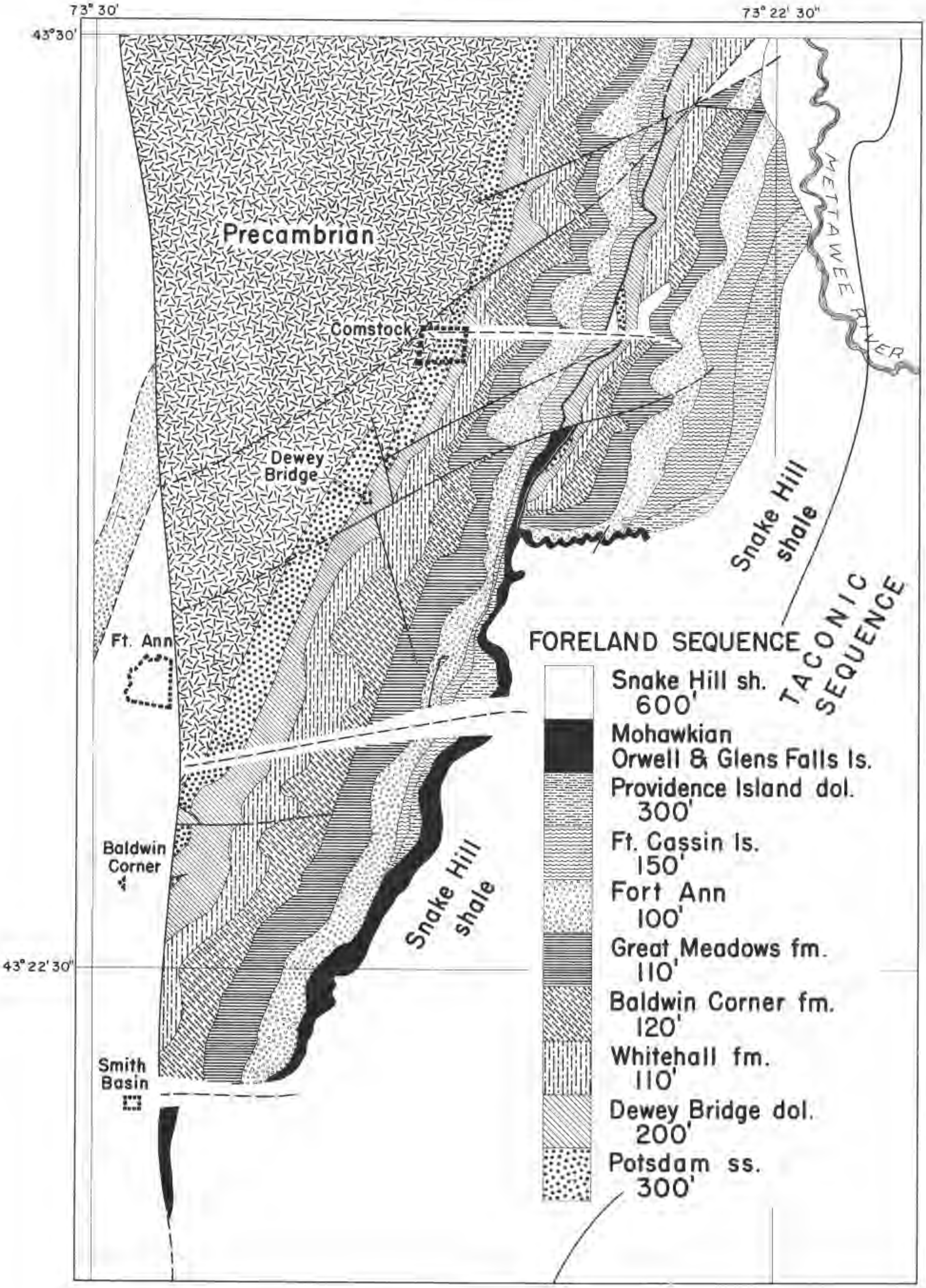

Figure 52
Map of part of the Fort Ann quadrangle.

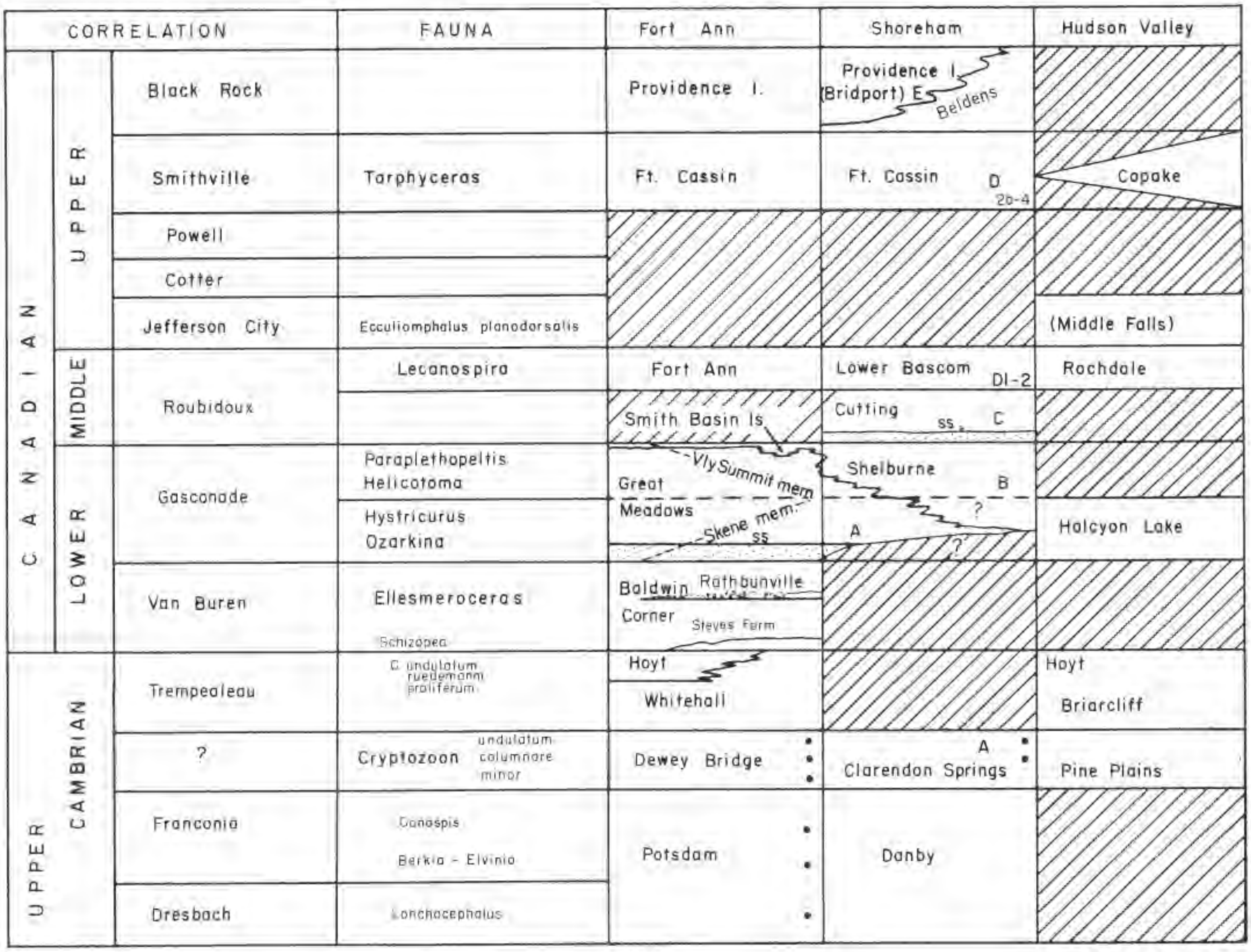

Figure 53

Correlation of Cambrian and Canadian units of the Fort Ann region with those of adjacent areas, primarily in the Champlain and Hulean Valleys.

tions, (1) thin-bedded, slightly calcareous sandstones, (2) beds, also slightly calcareous but massive, containing greenish clay pebbles which weather easily, giving the edges of such layers a pitted appearance, and (3) occasional calcareous sandstones with abundant evidence of reworking by worms. Fossils are confined to lithologies of these sorts and to a few quite narrow zones. While the faunas are diagnostic as to age, the Potsdam presents no evidence whatsoever as to how the barren beds between the fossiliferous layers should be treated. Fifteen to twenty feet above the base of the Potsdam is a fine, even-bedded calcareous sandstone with a spare fauna. Here the nondiagnostic *Lingulepis acuminata* is the commonest fossil, but there have also been found *Hyolithes, Lonchocephalus minutus, Komaspidella seelyi,* and fragments of a possible *Crepicephalus* and forms of the *Coosia–Maryvillia* persuasion. The trilobites are erratic and subject to peculiar local concentration. Having made one promising collection, I returned to the same general region and horizon the next day with such complete lack of success that I ended by taking the pieces rejected on the collecting of the previous day.

Fifty feet of barren sandstone follow, with next two to three feet of vermicular sandstone which has yielded only *Lingulepis.* A third fossil zone occurs 70 feet higher; here is found the Ironton fauna with *Camaraspis cushingi* (Ruedemann) *Elvinia matheri* (Walcott), and *Berkia saratogensis* Resser. A *Hyolithes,* larger than that found in the *Crepicephalus* beds below, is not uncommon.

A layer 80 feet above the *Elvinia* horizon has yielded fragmentary trilobites which appear to be *Conaspis whitehallensis;* with them was found *Paleacmea typica* Hall, which is rather surprising, as the type came from Ausable Chasm where no faunas above the *Crepicephalus* horizon have been identified.

It would appear that the Potsdam represents the deposition of sandstones which were dominantly nonmarine or lacustrine, with short-lived marine invasions in which faunas penetrated this area. As one passes to the north, the base of the Potsdam descends, while at the same time the top increases, by change of the dominantly dolomitic Dewey Bridge dolomite to a more purely sandy facies. The typical "red Potsdam" of the type area certainly lies appreciably below the *Crepicephalus* zone, and the top includes beds with *Ptychaspis striata* and a still higher horizon with *Prosaukia*. Depositon is not, however, smiple and uniform. At Chateaugay and in the Saranac River the *Ptychaspis striata* beds are surprisingly close to the *Crepicephalus* horizon, and it is evident that the intervening thickness is far smaller than that between the *Crepicephalus* beds and the *Elvinia* beds at Fort Ann. To the north there are significant interruptions in the sedimentation which, from our present evidence, embraced the time involved in the *Elvinia* and the *Conaspis* zones elsewhere. The break, among so many bedding planes and disconformities of no great time significance, is hard to detect. Contrary to the opinions of many contemporary stratigraphers, whistles do not blow and red lights do not flash when a geologist approaches a significant break in a section.

It seems that in the absence of evidence indicating where, between the narrow faunal zones, depositional boundaries could be drawn, there would be little point and less success in any attempt to subdivide the Potsdam of the Fort Ann region in terms of units to be given geographic names.

Dewey Bridge Dolomite

Above the Potsdam, which is dominantly a sandstone with sparse, widely spaced beds of calcareous material, are 180 to 200 feet of beds which are dominantly dolomite, within which are sparse, relatively thin beds of sandstone, usually less than four feet in thickness. This formation in the Fort Ann area should be a delight to those who would define formations on lithology alone, for it is without diagnostic fossils indicative of age. It is evident, however, that the *Conaspis* fauna lies only a little below its gradational base and that the overlying Whitehall formation is Trempealeauan, so it is evident that it occupies the later half of the Franconian, the *Ptychaspis–Prosaukia* beds, which are subdivisible into several horizons, but while it is significant to note that an appreciable time span and several faunal horizons of generally continental significance are involved in this interval, the details are not relevant to the immediate local problem. Calcareous algae form three persistent horizons, and the author has found them developed in every section. A horizon 100 feet above the base is characterized by *Cryptozoan* with small heads, rarely more than six inches across; this the author has called *C. minor* in his notes for some years. Near the top and capping the only shaly zone in the section is a columnar alga, which he has called *Cryptozoan columnare*. Oddly, in the lower two and one half feet, these columns are three to four inches across; but they continue in a succeeding ten-foot bed where they are six to eight inches in diameter. Six to ten feet of barren dolomite separate this distinctive horizon from an eight-foot bed of *Cryptozoan undulatum*, a massive reefy bed in which rather small heads merge and their identity is hard to demonstrate. The top of the unit is a four-foot massive sandstone ledge, largely a sedimentary quartzite, reminiscent lithically of the Potsdam. It contains a characteristic burrow which extends vertically for a half inch to an inch, then turns abruptly and extends horizontally for a somewhat greater length, usually two to three inches. The unit, grading below into the more dominantly sandy Potsdam is about 180 feet thick. The type section is well exposed just east of Dewey Bridge. Several abandoned quarries in the Fort Ann quadrangle expose the upper beds exceptionally well.

Whitehall Formation

The Whitehall formation is a unit of Trempealeauan age 110 feet thick, composed dominantly of clean, light-colored dolomite in contrast to the darker, fetid dolomite of the Dewey Bridge formation. The middle layers commonly contain vugs with quartz crystals, "Little Falls diamonds." The upper part contains persistent locally massive bands of cherts, black to bluish, with occasional white spots and blotches. Locally, as much as the upper 40 feet of the formation may be limestone, and limestone and dolomite alternate quite unpredictably in the upper part, strikingly displayed when the beds are traced laterally for any distance. In the limestones or their dolomite equivalents are found the three bands of *Cryptozoan* similar in thickness and position to those found at Saratoga in the Hoyt limestone which is dark, commonly calcarenite, and oolitic, while in the Whitehall the beds are commonly light and calcilutites dominate. The algal zones consist of, first *C. proliferum*, then, masses of the small heads of *C. ruedemanni*, with a reef of *C. undulatum* at the top. Trilobites are present, but commonly the calcilutite does not yield good specimens. The fauna is more comprehensive than that at Saratoga, containing *Matthevia* in local concentrations, and gastropods, similar to what Ulrich called *Dirachopea*, with the trilobite *Stenopilus* and the brachiopod *Finkelnburgia*.

Rodgers (1937) defined the Whitehall formation, indicating the type section at Skene Mountain, but his age assignment depended upon fossils obtained from division B at East Shoreham, Vermont, which he assumed to be equivalent. Wheeler (1942) found Trempealeauan fossils in the type Whitehall at Skene Mountain, where Rodgers had not bothered to look.

Baldwin Corner Formation

This formation consists largely of clean, light-colored dolomites with two persistent limestone horizons. The first, at the base, is a light gray limestone, a fine-grained calcilutite, the *Steves Farm limestone member* (named from the Steves Farm, two and one half miles northeast of East Granville) which is never more than 12 feet thick and usually less. It has yielded a number of gastropods, mostly rather poorly preserved. The commonest form has the proportions of a *Sinuopea*. Locally, and best developed on the Steves Farm outcrops, there are operculae of this gastropod preserved in numbers, silicified, weathering out of the rock in relief, and black in color. There follow 40 feet of barren dolomite which is usually capped by a layer of dolomitic breccia four feet thick. This breccia fills cavities and depressions made by the solution of a second limestone, the *Rathbunville School limestone*, which is never more than four to six feet thick and may be wanting, with only the breccia present, over large areas. This limestone has evidently been largely removed by erosion, for it is confined to isolated exposures commonly distant and of small extent. It has yielded straight ellesmeroceroid cephalopods, closely septate, and unfortunately of uncertain position because all specimens so far found show reduction by solution, and styliolitic edges; unfortunately, no specimen has been found retaining the siphuncle. These shells have the aspect of *Ellesmeroceras*, *Eremoceras*, and *Ectenolites* and may be Ellesmeroceratidae; without evidence of the siphuncles, however, one cannot be certain that they are not Plectronoceratidae allied to the Asiatic genera *Multicameroceras*, *Sinoeremoceras*, and *Wan-*

wanoceras. Above this horizon, there follow 70 feet more of dolomite, indistinguishable from that below. This part is particularly apt to carry vugs with quartz crystals, a second occurrence of "Little Falls diamonds." The highest twelve feet, which have been observed only in an abandoned quarry about half a mile northeast of Smith Basin, are largely a dolomitic shale with fucoidal markings on the surface, very reminiscent of fucoidal beds in the Tribes Hill limestone. Elsewhere, exposures of this part of the section are poor, and it is not plain whether there is, at this locality, a high horizon which was eroded in most other places, whether this is a local facies of the higher beds, or whether it is simply not evident from lack of suitable exposures, though this last seems unlikely, as one would expect bits of the fucoidal shaly layers to be evident even on considerably covered slopes.

The formation, well exposed at Baldwin Corner and the hills between there and Smith Basin, takes its name from the former place. It has a thickness of about 120 feet.

Great Meadows Formation

This is a unit of Gasconade age showing a persistent and characteristic lithological sequence. Twelve feet of coarse, cross-bedded sandstone at the base (formerly confused with the base of the Cutting formation, which is much finer and more evenly bedded) pass through a few feet of sandy, wormy dolomite into a sequence of 40 feet of dominantly dark, vermicular dolomite with occasional fossil shadows, containing a few lenses of good limestone which have yielded faunas with *Ozarkina* and a *Hystricurus* with a particularly high glabella as especially characteristic. This part, well exposed in quarries on the east of Skene Mountain at Whitehall, is the *Skene member*. The *Vly Summit* member follows[*] with two feet of even-bedded, slightly dolomitic siltstone, followed by 40 feet of dolomite, free from vermicular markings but containing irregular chert masses. At the top is a persistent light gray limestone, weathering a gleaming white in the fields, the Smith Basin limestone. Though the name is taken from the Great Meadows Prison at Comstock, the entire type section is that exposed just east of Smith Basin, where pastures to the north of the road display the entire section with remarkable completeness. Occasional limestone lenses in the Vly Summit dolomite member show that the Smith Basin limestone is only one such persistent limestone which happens largely to have escaped such alteration. The faunas here contain *Prohelicotoma uniangulata* and a *Paraplethopeltis,* which will be described upon another occasion. It has yielded the ellesmeroceroids here described as *Eremoceras multicameratum, E. magnum, E. perseptatum, E. (?) expansum, Ellesmeroceras angulatum, E. progressum, E. imbricatum, E. indomitum, Ectenolites simplex, E. curviseptatus, E. sinuatus, E. penecillin, Paradakeoceras planiventrum, P. minor, Annoceras costatum, A. (?) perobliquum, Buehleroceras infundibulum, B. arcuatum, B. sinuatum, Conocerina reducta, Clarkeoceras ruedemanni, C. rhomboidale, C. trapezoidale, Keraiaceras costatum, Rudolfoceras antiquum,* and *R. praenuntium.* In addition, *Walcottoceras* cf. *obliquum* is common, and there are evident fragments of *Levisoceras.* Probably our present material does not exhaust the list of cephalopods. Gastropods include *Prohelicotoma, Archinacella, Proplina, Sinuopea,* the trilobites *Paraplethopeltis,* a form allied to the Cambrian *Stenopilus,* and a *Remopleuridella.* Brachiopods are sparse, but there is a *Finkelnburgia.* Small colonies of an apparent *Lichenaria* are quite common though obscure, irregular, and rather loosely growing, with never many individuals in a colony. Essentially the same fauna occurs in the Vly Summit cherts in the dolomites below, and apparently the siltstone at the base of the Vly Summit member also marks a significant faunal change.

The top of the Smith Basin limestone shows in places a network of bands of dolomite enclosing polygonal patches of pure limestone. Such patches, up to two feet across, are bounded by bands one to three inches wide which in turn are a network of finer, yellow-weathering dolomite bands with limestone between. Some such "tadpole nests" are seen extending from patches of breccia. Obviously, they represent dolomitization in permeable areas in this otherwise dense, fine-grained limestone.

Locally, the Smith Basin may show algal nodules three to four inches across. At one place, such nodules are partially accentuated by weathering around their edges. On fresh surface they commonly show a pinkish cast not shared by the rest of the limestone. The Smith Basin limestone surface shows old solution features, solution-widened joint cracks, and irregular to rounded potholes filled with a sedimentary breccia; sometimes the limestone is removed over several hundred square feet, with only the breccia evident, but this condition is exceptional. This same type of erosion surface extends not only over the Fort Ann and Whitehall areas but is again evident at the top of the Shelburne Marble of the East Shoreham region and is there below the Cutting formation, which has no equivalent at Fort Ann.

The Fort Ann Formation

The Fort Ann formation is defined as the unit of Middle Canadian age, here consisting of 40 feet of dominantly dark, somewhat vermicular, highly fossiliferous limestones with minor beds of dolomite in the base, followed by 60 to 75 feet of dolomite containing only rare, silicified traces of fossils. The fauna is highly characteristic. The lower limestones contain abundant *Bassleroceras, Clitendoceras,* and *Proendoceras,* the species of which are in manuscript elsewhere. There is a large, thick-shelled, flat gastropod of the genus *Leseurilla,* rare *Hystricurus* (cf. *conicus* Billings), *Sinuopea,* rare *Seelyoceras* (possibly a synonym of *Campbelloceras*), and *Aphetoceras.* Small brachiopods of the genus *Syntrophopsis* are common, but almost universally poorly preserved. The upper six feet of the lower limestone member consists of a ledge of relatively pure limestone with coiled cephalopods; proper study was not possible (specimens in the New York State Museum which I found and collected were not made available), but these forms, from which I called this the *Eurystomites* limestone in my early notes, are almost certainly *Campbelloceras,* and the first *Lecanospira* found in the section appears here, being wanting below. Higher dolomites have yielded only sparse silicified crusts of internal molds representing *Lecanospira.* Apparently the same endoceroids and *Bassleroceras* of the lower beds continue to the top of the

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[*] Vly Summit, misnamed Fly Summit, is some way off, but there is a dearth of conveniently located place names; the type section is along the road leading east from Smith Basin. The Board of Geographic Names seems to have overlooked the old Dutch word Vly or Vlie and has changed it to Fly. Such ignorance should be neither encouraged nor followed. It merely bleaches our geography of the color history might otherwise supply.

formation, but remains are rare and too poor for close specific analysis.

The uppermost dolomites are nondescript and usually barren. It should be noted that deceptively similar are dolomites in a few localities of Theodosia age with *Eccyliopterus planidorsalis*. Such dolomites appear to be isolated erosion remnants, and though they are separated by a break from the beds below, representing the deposition of the Rich Fountain formation, dolomitization has resulted in such present uniformity of lithology that the beds are not readily distinguishable. At Middle Falls, New York, this interval contains good limestone, from which Ruedemann obtained this gastropod.

Fort Cassin Formation

The Fort Cassin formation follows; interestingly, the most southwesterly sections show none of this unit, and as one proceeds northeast the beds are incompletely exposed when they first appear; absence of the basal sands and dolomites in the more southerly outcrops strongly suggest onlap conditions from northeast to southwest. The best exposures, northeast of East Granville, show the entire sequence, very much as described by Brainerd and Seeley from East Shoreham, Vermont. The sandstones, fine-grained and fairly evenly bedded, are characteristic and useful in mapping; followed by, first, massive dolomites, then thin, even-bedded alternating dolomite and limestone, the lowest interval of which has yielded fossils; they are sparse, but those found are typical of the higher faunas above. There follow again massive dolomites with a few two- to three-foot beds of pure light gray limestone —there are gastropods there which decline to come out—then dark, thin, even beds of limestone with a few thin dolomites, largely filled with *Isoteloides whitfieldi*, grading up through thicker beds, a few of which contain abundant pebble conglomerates, to the massive reefy calcilutites which contain the Fort Cassin fauna in its fullest extent. As one passes upward, dolomites intervene between the reefy limestones; dolomites increase until the limestones are isolated lenses in dolomite, and finally disappear altogether. Thus, the contact between the lower, dominantly limestone, beds of the Fort Cassin to the dolomites of the Providence Island beds is lithically gradational.

Providence Island Dolomite

At Fort Ann, the Providence Island beds are dominantly dolomites, barren and nondescript, the estimated measurement of thickness of Brainerd and Seely at 300 feet at East Shoreham, Vermont, is reasonable for this region also. The writer had for some time considered the Providence Island as merely an upper dolomitic phase of the Fort Cassin, the apparent absence of fossils resulting from secondary dolomitization. However, the known listed fauna contains some anomalous things seemingly similar to those of the latest Canadian in other regions, as the Black Rock of Arkansas and the Odenville of Alabama. The very top beds at Fort Ann contain a few thin limestone layers with some poorly preserved fossils. One is choked with a small gastropod, and it is evidently such material as this which yielded at Glens Falls (where much the same section is found, though more faulted and more covered) Hall's type of *Maclurea sordida*. *Maclurea*, more properly *Maclurites*, is a genus in which species are nondescript and generalized and supply a poor basis for correlation, but it is noteworthy that similar forms, as far as one can tell, characterize the Odenville of Alabama and are found in equivalents of the Odenville in the highest El Paso from Beach Mountain, Texas, to the Florida Mountains of New Mexico. Farther north and east, the highest El Paso has been removed by erosion, but the writer has found similar forms again in the top of zone L of the Pogonip, which contains a brachiopod association similar to that of the highest El Paso limestone.

Mohawkian

Lying on the Canadian at Fort Ann, and evidently upon an eroded surface which is as low as the Fort Ann limestone to the southwest and the apparent highest Providence Island to the northeast, are Mohawkian limestones; at the base are the massive, light-weathering Orwell limestone and above, the thinner-bedded, dark, Glens Falls limestone. Thrusting, evidently the Taconic thrusting, resulted in displacement of these beds and of the Snake Hill shales above; outcrops in places show oddly sinuate patterns on a relatively small scale, which are conspicuous from the air. Flowage has destroyed fossils in the Orwell in many places, but the quarry south of Smith Basin shows several layers of thick operculae, evidently of the large *Maclurites* or *Maclurina*, which one could mistake on casual examination for the operculae in the Steves Farm limestone.

CORRELATION

Without going into elaborate detail, it is evident that the section at East Shoreham, Vermont, which everyone since Brainerd and Seely has taken as a standard, is divided thus: A is dolomite, B is limestone, C is dolomite with a basal sandstone, D is mainly limestone, though with some dolomite and a sand in the middle, E is dolomite. It should take no great perspicacity to see that this sequence is not based upon very fundamental features, and it is rather odd that all subsequent workers expected the divisions A through E to be valid formational units and a suitable basis for widespread correlation. They are not. Division A consists of two parts, lower dolomites with traces of the Dewey Bridge *Cryptozoan* horizons and, in places at least, the sandstone which caps that formation at Fort Ann. The top of this part represents a hiatus occupied at Fort Ann by the Whitehall and Baldwin Corner formations; the upper dolomites are a part of the Great Meadows formation, the basal sand of which is gone here. Possibly only the Vly Summit member is represented. The Shelburne marble is an immensely thickened Smith Basin limestone of the Great Meadows and contains many species common to the Smith Basin limestone of Fort Ann. The fauna is Gasconade. The overlying division D contains a lower unit of the Fort Ann formation, the sandstone at the middle marking the base of the Fort Cassin interval. There are places here where remnants of the Theodosia beds with *E. planidorsalis* are retained. Rodgers reputedly found one such collection not far southwest of Shoreham, Vermont.

The mapping done by Cady (1945) involved the uncritical acceptance of the divisions A through E of Brainerd and Seely, for which new formation names were substituted, and mapping was done on that basis insofar as the Canadian was concerned. Such "formations" have so little relevance to the geological history in terms of intervals of deposition and nondeposition or erosion as to be meaningless. Division A contains a break comprising the Trempealeauan and the earliest Lower Canadian. B was defined as a limestone, but areas of dolomitization were blithely ignored even in the mapping. Advocates of the theory that mapping units should be based on lithology will find this an occasion for censure. While C was separated from lower D, with which it is gradational, D has in itself no real unity, including Demingian and Cassinian with possible scattered remnants of one short depositional interval in the Jeffersonian retained here and there between.

The Cutting formation, division C of Brainerd and Seely, represents dolomites coming in below and at the base of the Fort Ann formation, with eventually a basal sandstone at the bottom; it is gradational at its top with the Fort Ann formation and represents the lowest Middle Canadian of the region. Below it the top of the Shelburne marble shows the solution features noted in the Smith Basin limestone.

In the southern Hudson Valley we are dealing with a quite similar sequence, but poor exposure and inadequate work have obscured this fact in most places. To this situation there is one happy exception. Dr. Eleanora B. Knopf (1946) has studied the section in the Millbrook quadrangle with immense care and most gratifying results. Her Pine Plains formation is largely barren; only Cryptozoans are known, which supply a poor basis for correlation, but it is plainly in the Upper Cambrian, and may represent the Potsdam or the Dewey Bridge at Fort Ann or, possibly, even be equivalent to both these units. The Briarcliff formation—cleaner, lighter dolomite—has yielded a Trempealeauan fauna and is equivalent to the Hoyt and the Whitehall formations. The overlying Halcyon Lake formation has yielded a small Gasconade fauna indicating affinities with the Great Meadows; possibly only the lower Skene member is represented, for only vermicular dolomite was found, and at one locality there is a basal cross-bedded sandstone reminiscent of that at the base of the Great Meadows formation at Smith Basin. The Rochdale limestone contains the *Lecanospira* and some of the cephalopods of our Fort Ann formation, but the large *Leseurilla* of the lower beds has not been found. Possibly its beds, of relatively pure limestone, are equivalent only to the upper part of the Fort Ann formation, but such precise equivalence, of course, is not certain. The upper dolomites of this unit are largely barren and nondescript. The Copake limestone formation has as a basal unit a sandstone remarkably similar to that at the base of the Fort Cassin, and succeeding dolomites contained sandy casts of the common Fort Cassin *Eccyliopterus*. Upper beds are, in general, partially dolomitized and have not yielded good faunas, but at several localities better limestones with Fort Cassin trilobites and brachiopods have been found. Thickness suggests that the Canadian does not have equivalents here preserved of the Providence Island dolomites.

At Saratoga, there is some Potsdam which has not yet yielded known faunas, succeeded by sandy dolomites of the Galway formation to which the name *Theresa* has formerly been applied. The Hoyt limestone has been recognized above, and the disposition as Hoyt or Theresa of some intervening dolomitic beds has been vague and interpretations have varied. It is evident, however, that what appears to be similar dolomites includes Ironton beds with *Elvinia* and *Camaraspis* common and amazingly abundant and well preserved, but shortly above are dolomites of the Trempealeauan with *Plethometopus*, and these beds belong with the Hoyt. Higher up occur typical dark oolitic Hoyt limestones with the general assortment of known Hoyt trilobites and the few odd gastropods. The highest beds contain only *Plethopeltis*. The writer had thought, from the previous Cambrian correlation chart, that this was the highest zone of the Trempealeauan, the *Plethopeltis* zone. This is possibly true, but as the result of more critical work, it is now generally considered that there is no reliable continent-wide faunal succession evident for Trempealeauan time, and the succession in the type area of Wisconsin and Minnesota involves considerable facies control. Overlying dolomites, formerly called "Little Falls," have been differentiated by Fischer and Hanson as the Ritchie limestone, Gailor dolomite, and Mosherville sandstone. They are evidently Canadian in age. The Ritchie limestone has yielded only a few poor gastropods, not good enough to substantiate identity with those of the Steves Farm limestone of the Baldwin Corner formation, but suggestive of them. The Gailor dolomite has yielded *Prohelicotoma uniangulata*, *Lytospira*, and *Ectenolites*. Equivalence with the higher Great Meadows in suggested, and Gasconade equivalence in a broader sense is beyond question.

The Bald Mountain limestone of Cushing and Ruedemann (1914) has been found to represent some equivalents of the Fort Ann section. At Louse Hill,* both the higher Smith Basin limestone of the Great Meadows and the overlying Fort Ann limestone are present; the former has yielded diagnostic ellesmeroceroids, and Mrs. Robert Schultz succeeded in collecting *Lecanospira* and *Bassleroceras* of the Middle Canadian Fort Ann formation there. The quarry at Bald Mountain exposes largely, and probably only, the Orwell limestone, here showing flowage, which has destroyed most of the fossils, as well as advanced cleavage. There is also some of the Glens Falls (Shoreham) limestone; here cleavage produces the false effect of a conglomerate, and it is such material, seen also in the Fort Ann region in places, which produces what Ruedemann identified, not unnaturally, as the Rysedorf conglomerate. Unlike the Rysedorf conglomerate, it contains no evidence of pebbles of older faunas.

This should supply some clarification of the Canadian of eastern New York. Continuation of the work into the Champlain Valley was not completed, but it is evident that there is Lower Canadian there, Middle Canadian beds with *Lecanospira*, the Fort Cassin, and the Providence Island. Just beyond the Canadian border, at Phillipsburg, Quebec, a thrust brings up a somewhat more easterly sequence, one with more limestone instead of dolomite and with a more complete section, as one might expect from a series laid down farther from the old Adirondack shore. It is futile to comment on correlation in detail, as the faunas are yet incompletely known (some species rest only upon Billing's brief and essentially unrecognizable descriptions) and the distribution in the several formations recognized is at present only incompletely recorded. It is evident, however, that the base of the Middle Canadian is marked by the Hastings Creek formation which yields the first endoceroids; possibly the Naylor Ledge is also Middle Canadian, but above the St. Armand, it is certainly Cassinian;

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*This appears in the text altered, surprisingly, to Louise Hill by editors in the New York State Education Department who thought Louse Hill was not quite nice. The hill derives its name from the fact that soldiers in the American Revolution wintered there (Ruedemann, 1937, personal communication). The tradition still existed among local residents when Ruedemann did his field work there.

it seems possible that, as in the New York eastern sections, the Jeffersonian is incompletely represented and may possibly be absent.

The difficulties presented by the Champlain and Hudson valleys could have been resolved much earlier had they been approached on the basis of the study of the faunas instead of the sophistry of "How do you know that the succession is the same in your area as in mine?" The number of would-be stratigraphers among us today who have not quite caught up with William Smith (1719-1839) yet is truly astounding. The necessary moral to be drawn may be further emphasized by the following lines addressed to a geology major who had failed to take any instruction in paleontology:

ADVICE RENDERED WHILE THERE IS YET TIME

To
One who by his craft expects
To make his fortune, and rejects
The guiding aid of clams and such:
You'll never add to your pile much.

So
Heed the warning ere the days
Are gone when you can mend your ways
By studying fossils kept in trays;
They'll help you through the crooked maze
Of geosynclines and of domes

Scorn not
To know the names of worms
Long dead, for he who once them learns
Is lifted high among his peers
(Into the very rank of seers)
For who knows when the little dears
May tell you where to strike a lode
By striae on the internode
That tell you that their deep abode
Marked in this cabalistic code
Is where you ought to dig.

By one who prefers to be anonymous
Because he holds popular acclaim to be superfluous.

ADDENDUM

Some note should be taken of the Russian treatise the nautiloid volume (1962) of which was received only when the present work was in proof. It contains some further contributions to the Ellesmeroceratida, of which the following are the most important:

Multicameroceras siberiense Balashov—expansion of the Plectronoceratidae into Siberia in early Gasconade time.

Bathmoceras linnarsoni (their pl. 5, fig. 8)—This form is certainly not a *Bathmoceras,* for it shows siphonal elements extending apicad, not orad.

Pictetoceras eichwaldi (Verneuil)—New figures show this genus to be an ellesmeroceroid and a member of the Cyclostomiceratidae.

Albertoceras chunense Balashov—This is not an *Albertoceras;* it has a long bactritiform phragmocone like *Ectenolites,* but fails to show lateral lobes, in which it is more like *Robsonoceras.*

The Ellesmeroceratida in that work is divided into the "Bathmocerataceae," with essentially the scope of our present Ellesmeroceratida, and the "Basslerocerataceae," with the scope of the Bassleroceratida of Flower and Kummel, 1950. Apparently the suppression and division of the Bassleroceratida by Flower in Flower and Teichert, 1957, was overlooked. In the light of the inclusion of nonsuccessful short-lived exogastric lineages, as the Balkoceratidae and the genus *Cyrtobaltoceras,* some justification could be found for a similar inclusion of the Bassleroceratidae, but definitions are simplified by its retention in the Tarphyceratida. Inclusion of the Graciloceratidae, however, seems impossible.

The general classification in that work is to be deplored, in reference to the Ectocochlia and Endocochlia. In the Endocochlia are recognized the Nautiloidea, Endoceroidea, Actinoceroidea, Bactritoidea, and Ammonoidea as equivalent groups. The elevation of the Endoceratida and Actinoceratida in this way is the more anomalous in the light of included genera which belong elsewhere and those placed elsewhere that belong. Oddly, the most isolated lineage phyletically is the Discosorida, which is included in the Nautiloidea.

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PLATES 1-32

WITH EXPLANATIONS

PLATE 1

Palaeoceras undulatum Flower, n. sp.

P. 32

Figures

1. Vertical section from lower part of Figs. 4-7, × 11.6; venter and siphuncle on right, showing long necks scarcely inclined from steep septa on the center, short dorsal necks; rings largely destroyed. No. 300. Holotype.

2. Further enlargement of siphuncle showing vestiges of bulbs in sixth and eighth segments on dorsal sides, essentially contiguous necks on venter where rings are not evident; × 20.

3. Small portion from base, apicad of tip of Fig. 4-7, and of Fig. 1, in vertical section, siphuncle and venter on right, showing slightly shorter necks on the ventral side. Anterior two camerae filled with calcite; the earlier one shows a suggestion of the siphuncular bulb; in the last segment, calcite extends slightly into the siphuncle.

4. Ventral view, × 3, showing lateral constrictions of the internal mold.

5. Ventral view, × 1½, unwhitened, showing traces of septa.

6. Lateral view, × 1½, unwhitened, showing traces of septa.

7. Lateral view, × 1½, whitened, constrictions and sutures not evident.

8. Vertical section of paratype, × 9.2, siphuncle on left, No. 301.

9. Adoral part of siphuncle, × 19, from same section, showing expansion of matrix of siphuncle into camerae. In segments 2 to 4, the real siphuncular bulb is outlined, but material of the ring is not clearly distinct; in the sixth segment calcite of the siphuncle extends abnormally into the camerae, but its rounded form suggests stretching of the ring; × 19.

10. Apical part of section from the same specimen showing traces of bulb on dorsal side, to the right, in segments 1, 2, 6, and 7. The eighth segment overlaps with the basal segment of Fig. 9; × 19.

Both specimens are from the upper Trempealeauan San Saba limestone, Threadgill Creek, Gillespie County, Texas, in collection of the writer.


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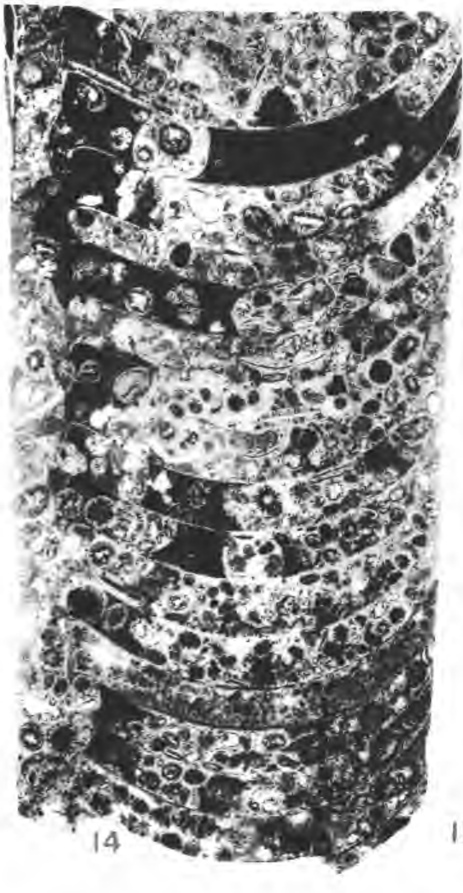
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PLATE 2

Figure		Page
1-3.	*Balkoceras gracile* .... 1. Lateral view, venter on left, × 1½ of a specimen with a nearly complete living chamber; 2. enlargement × 3 of the same, unwhitened, showing course of sutures; 3. same, whitened, showing growth lines impressed on internal mold and sutures obscure because of their faint relief. Paratype, No. 310.	34
4-7, 16.	*Palaeoceras mutabile* Flower .... 4, 5. Lateral view × 3, of a paratype; 4. unwhitened, showing relatively clear sutures; 5. whitened, showing faint adoral constriction of shell. 6, 7. Ventral view, natural color and whitened. 16. Septal view; × 6. Hypotype, No. 305.	31
8-10.	*Palaeoceras undulatum* Flower, n. sp. .... 8, 9. Dorsal view × 3, natural color and whitened. 10. Venter, natural color, showing narrow saddles. Paratype, No. 302.	32
11-15, 17, 18.	*Palaeoceras mutabile* Flower .... 11. Lateral view, × 1½; 12-13, venter, natural color and whitened; × 3. 14. Thinsection from adoral part, × 10, venter on left. 15. Thinsection, apical part, venter on right; × 9. 17. Enlargement of siphuncle from Fig. 15, ×20, showing rings faintly defined, but outlining segments extremely expanded on dorsal side. 18. Enlargement of siphuncle from Fig. 14, × 20; rings largely destroyed, but indicated faintly by matrix of siphuncle expanding in second and third segments; straight, thick, apparent ring in segment 9 is adventitious. Adoral rings missing on dorsum, steep septa on ventral side shown adorally. Hypotype, No. 306.	31

All are from a single bed in the upper San Saba limestone, late Trempealeauan, from Threadgill Creek, Gillespie County, Texas.

PLATE 3

Figure		Page
1-9.	*Palaeoceras mutabile* . . . . 1. Ventral. 2. lateral, venter on left. 3. dorsal view, natural color, showing septa, × 3; 4. venter. 5. side, venter on left. 6. dorsum, whitened. 7. ventral view, venter ground down to siphuncle, × 3½. 8. septum from base, apicad of portion shown in previous figures × 3. 9. enlargement of part of Fig. 7, × 9, showing siphuncle, largely replaced with marcasite, apex showing a trace of the bulbs, × 10. Hypotype, No. 304.	31
10-15.	*Balkoceras gracile* . . . . 10. Lateral, venter on left, × 3. 11. dorsal view, × 3. 12. venter, ground exposing siphuncle, × 3. 13. lateral, unwhitened. 14. dorsum, unwhitened. 15. venter, enlargement of Fig. 12, × 9, showing details of siphuncle segments, with necks lengthening progressively, and showing small bulbs in the apical region. Holotype, No. 311.	34

Both from the upper San Saba limestone, Threadgill Creek, Gillespie County, Texas.


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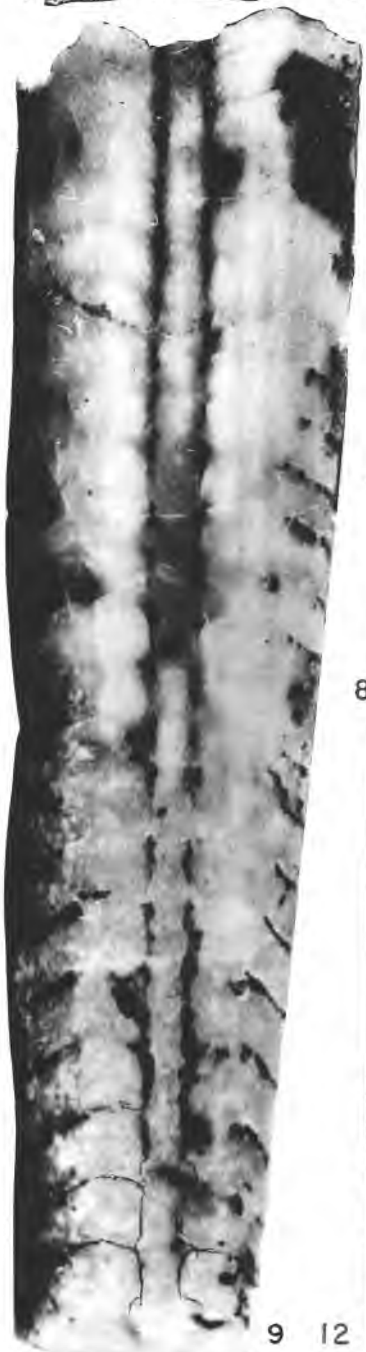
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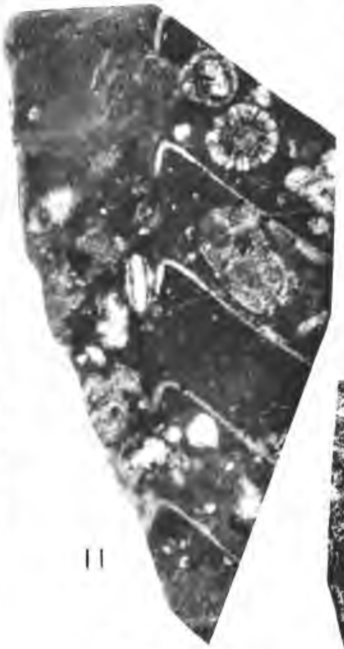
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PLATE 4

Figure		Page
1-4, 10.	*Balkoceras gracile* Flower, n. sp. . . . . Paratype, No. 309, showing considerable length of phragmocone and base of living chamber. 1, 2. Lateral views. 3.-4. Opposite side. 3. whitened, showing septa and faint longitudinal markings; 4. natural color. 10. Same view as 1, unwhitened. 1, × 3; 2, × 1½; venter on left. Dark spots in lower third are oolites in the camerae and not color markings.	34
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All from high in the Trempealeauan San Saba limestone, Threadgill Creek, Gillespie County, Texas.

PLATE 5

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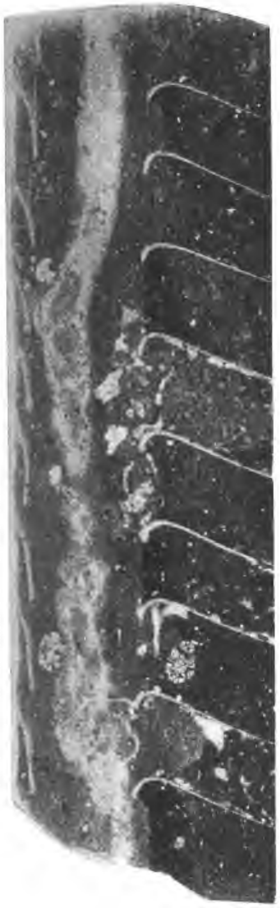

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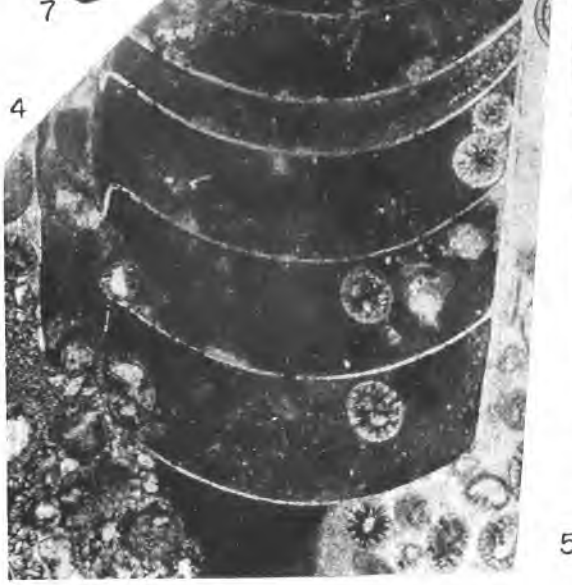

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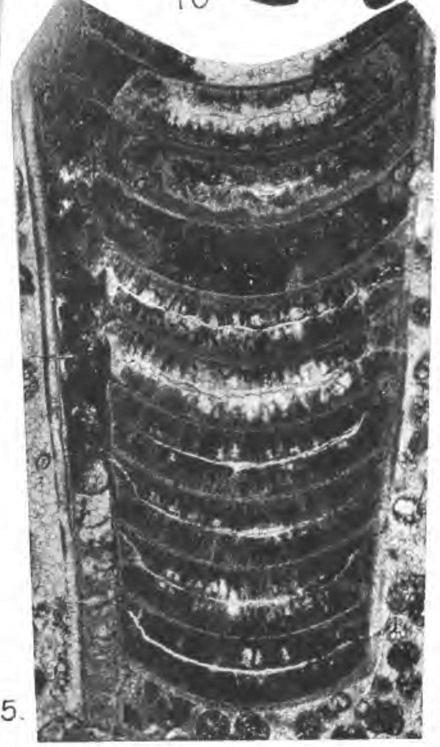

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PLATE 6

Figures		Page
1-2.	*Eremoceras multicameratum* Flower, n. sp. 1. Lateral view of holotype, × 1; 2. basal portion, × 1½, removed and ground from the opposite side, showing rapidly expanding initial part of conch, with more slender siphuncle. *See also* Pl. 10, fig. 14 and Pl. 28, fig. 7, for further enlargement. No. 167.	50
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All specimens in the collection of the writer, from the Smith Basin limestone, from the section just east of Smith Basin, Fort Ann quadrangle, New York.

PLATE 7

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1-6.	*Ectenolites extensus* Flower, n. sp. 1. Ventral view and 2. lateral view with convex venter on left, of holotype (188a). 3. Ventral view and 4. lateral view, venter here concave and on the left, of a paratype, showing normal slight endogastric curvature of the genus. 5. Septum, a paratype, showing cross section and size and position of siphuncle. 6. Lateral view of a portion of a phragmocone exposing part of the siphuncle. All × 2, from the Chepultapec limestone, near Roanoke, Virginia. No. 188, collection of the writer.	55
7.	*Ectenolites sinuatus* Flower, n. sp. Holotype, lateral view, venter on left, × 1. No. 182.	56
8.	*Ectenolites curviseptatus* Flower, n. sp. Holotype, lateral view, venter on right. No. 180.	55
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10-12.	*Ectenolites penecilin* Flower, n. sp. Holotype, No. 181. 10. Entire specimen, × 1. 11. Anterior part of same, × 2, with apical part of phragmocone sectioned. 12. Further enlargement of section of phragmocone, about × 4, with venter and siphuncle on right.	55
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Except where otherwise indicated (figs. 1-6 and 24-26), specimens are from the Smith Basin limestone, from the section east of Smith Basin, New York. All except Figs. 24-26 are in the collection of the writer.


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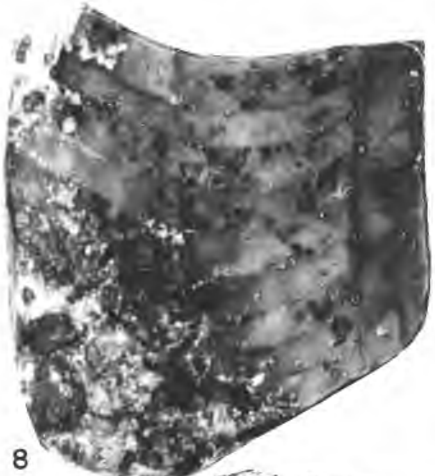
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PLATE 8

Figures *Page*

1-7. *Paradakeoceras planiventrum* Flower, n. sp. 64
1. Two paratypes, one a poorly preserved lateral surface, the other, seen in ventrolateral view, showing the siphuncle, the apical end of which is closed by a diaphragm. 2. Enlargement of the second specimen shown in Fig. 1, showing the smooth curved surface of the diaphragm, about × 2. 3. Another view of the same, tilted to show the second specimen in lateral view. 4. Same specimen, dorsolateral view showing the exfoliated siphuncle in the apical part. No. 186. 5-7. Three views of the holotype, × 1, No. 185, 5. dorsal view, 6. lateral view, dorsum on left, 7. ventral view.

8, 13, 14. *Dakeoceras harrisi* Flower, n. sp. 62
8. Vertical section through phragmocone, about × 6, venter on right. 13. lateral view of entire specimen, × 1. 14. septum, venter at left, × 1. Collection of the writer, Tribes Hill limestone, Fort Hunter, New York. No. 203.

9-11. *Caseoceras obseum* Flower, n. sp. 72
9. Paratype, No. 206, naturally weathered vertical section, venter on right; × 1; 10. holotype, No. 205, × 1, a natural section not quite attaining a siphuncle, with a *Dakeoceras harrisi* in natural section in the living chamber, 11. enlargement, × 1.5, of phragmocone of the same specimen, which has here been ground down to the level of the siphuncle.

12. *Keraiaceras (?) percostatum* Flower, n. sp. 77
Holotype, an incomplete phragmocone, viewed from the dorsal side, × 1. No. 202.

15-16. *Paradakeoceras minor* Flower, n. sp. 64
Holotype, × 1; 15. dorsal view, 16. lateral view, dorsum on left. No. 187.

Except where otherwise indicated, specimens are from the Smith Basin limestone, just east of Smith Basin, New York.

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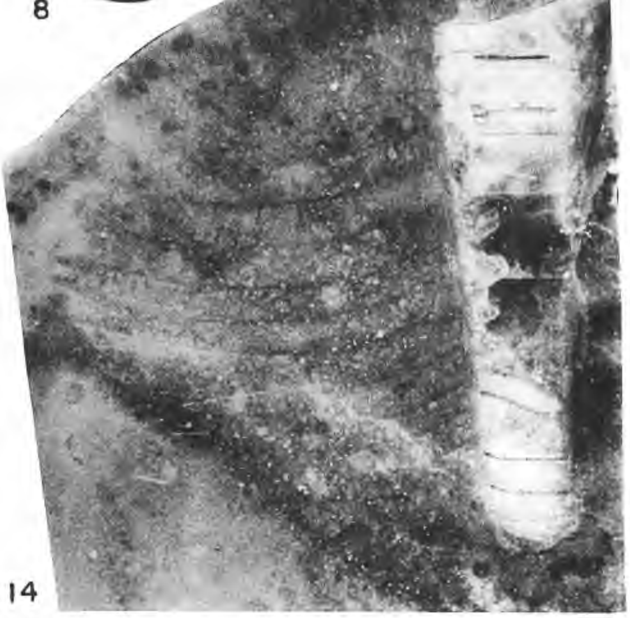

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PLATE 10

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1. *Eremoceras magnum* Flower, n. sp. 51
Thin sagittal section, venter on left. Apically the section passes close to the wall of the siphuncle, intersecting the thick rings and producing a false resemblance to diaphragms; about × 3, No. 189. *See also* Pl. 25, fig. 1.

2. *Clarkeoceras ruedemanni* Flower, n. sp. 69
Lateral view of phragmocone with base of living chamber, venter on right, the holotype, × 1, No. 199.

3-4. *Buehleroceras arcuatum* Flower, n. sp. 83
Two views of holotype, × 1; 3. ventral view, showing growth lines and deep sinus of aperture, 4. lateral view, venter on right. No. 194.

5-6. *Buehleroceras infundibulum* Flower, n. sp. 83
Paratype, × 1. 5. ventral view, with lower left incomplete, but showing arcuate lateral profile of anterior part of mature living chamber, 6. lateral view, venter on left. No. 193.

7-8. *Conocerina reducta* Flower, n. sp. 71
Holotype, 7. apical view, showing compressed cross section, venter below. 8. lateral view, venter on left, showing curvature and rate of expansion. No. 196, × 1.

9. *Buehleroceras infundibulum* Flower, n. sp. 83
Holotype, × 1, a living chamber, in lateral view, venter on right. No. 191.

10, 13. *Clarkeoceras trapezoidale* Flower, n. sp. 69
Holotype, × 1, 10. lateral view, with venter on right, 13. dorsal view. No. 201.

11-12. *Buehleroceras infundibulum* Flower, n. sp. 83
Paratype, an essentially complete living chamber, 11. lateral view, with supposed dorsum on left, 12. dorsal view, showing sinuate lateral profile and base of dorsal project of aperture. No. 192.

14. *Eremoceras multicameratum* Flower, n. sp. 50
Vertical section through apical part of the shell; siphuncle and venter on the right, × 7; same specimen as Pl. 6, fig. 2. Siphuncle interior retouched. *See also* Pl. 5, fig. 1, 2, and Pl. 28, fig. 7.

All material is from the Smith Basin limestone, from sections east of Smith Basin and Comstock, New York.

PLATE 11

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1-2.	*Barnesoceras lentiexpansum* Flower, n. sp. Opposite lateral views of a paratype, No. 252, showing a naturally weathered section in Fig. 1, not attaining center of siphuncle, and in Fig. 2, the surface of an internal mold, slightly more deeply weathered anteriorly. In the living chamber is *Ellesmeroceras* sp. (see p. 48).	80
3.	*Barnesoceras lentiexpansum* Flower, n. sp. A paratype, on which a vertical section was ground on a naturally weathered surface and passes through siphuncle close to its farther lateral wall. The thick rings, as seen in this section, simulate diaphragms. The shell is incomplete adorally, the surface of the specimen intersecting the far side of the shell before the aperture. No. 251.	80
4.	*Levisoceras contractum* Flower, n. sp. Holotype, No. 245, seen in a nearly vertical section which passes obliquely apicad, thus showing an exaggerated rate of expansion for the phragmocone.	66
5.	*Clarkeoceras ? sp.* A part of a living chamber, lateral view, venter on right, showing original color markings. No. 198. Smith Basin limestone, section east of Comstock, New York.	70
6-9.	*Barnesoceras lentiexpansum* Flower, n. sp. Views of holotype, No. 250. Fig. 6 is a lateral view, venter on right, showing much of the shell surface. 7. ventral view shows sinuous ventrolateral outline indicative of maturity, slightly reduced. 8. lateral view, venter on left, anterior part a rough internal mold, apical part sectioned vertically, showing full height of the siphuncle. 9. cross section at a level below middle of specimen, venter on left, at break anterior to sectioned part of Fig. 8.	80
10.	*Llanoceras gracile* Flower, n. sp. Holotype, No. 262. A shell seen in a naturally weathered section, essentially vertical, showing siphuncle at base of living chamber and midlength of phragmocone; elsewhere weathered beyond the sagittal plane.	58

All specimens about × 1; in the collection of the writer, all except Fig. 5, from 272 to 275 feet above the base of the Threadgill member of the Tanyard formation, from Threadgill Creek, Gillespie County, Texas. No. 262.


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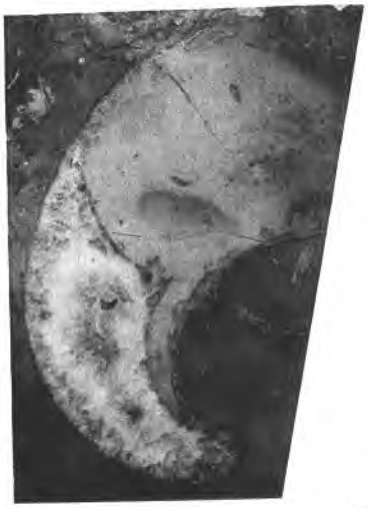
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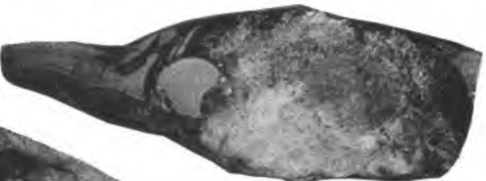
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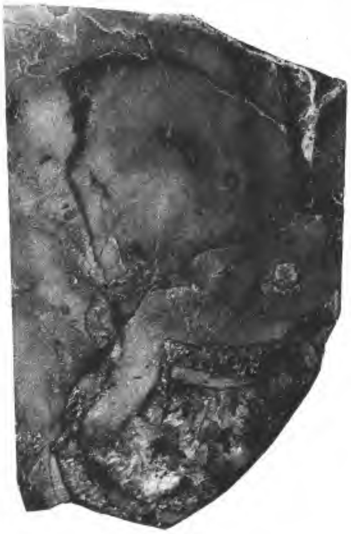
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PLATE 12

Figures		Page
1-2.	*Barnesoceras* cf. *lentiexpansum* Flower, n. sp. An immature specimen attributed to the species, showing earliest observed growth stage, a shell which, by itself, would be referred to *Levisoceras;* No. 259. Fig. 1 shows the specimen as a naturally weathered section, with a vertical cut made to show the shell cross section. Fig. 2 shows the larger part of the specimen ground to expose the siphuncle, though apically the natural section passes below the median plane and the siphuncle is lost there. No. 254.	81
3-4.	*Barnesoceras expansum* Flower, n. sp. A paratype, anterior part naturally weathered, apical part ground down to expose the siphuncle, × 1 in Fig. 3; apical part × 2, showing siphuncle wall in more details in Fig. 4. No. 255.	78
5.	*Buehleroceras sinuatum* Flower, n. sp. Lateral view of holotype, No. 195, with venter on right. Smith Basin limestone, section east of Smith Basin, New York. No. 195.	83
6-7.	*Annoceras perobliquum* Flower, n. sp. Holotype × 2, No. 200; 6. lateral view, venter on right; 7. ventral view. Smith Basin limestone, section east of Smith Basin, New York. *See also* Pl. 6, fig. 11.	57
8.	*Barnesoceras expansum* Flower, n. sp. A young individual showing early rapidly expanding phase of the shell, resembling *Levisoceras.* Paratype, No. 256, sectioned, with venter on left, showing a diaphragm in the siphuncle. No. 256.	78
9.	*Barnesoceras expansum* Flower, n. sp. Holotype, No. 253, a mature shell in essentially vertical section, slightly eccentric adorally and therefore exaggerating adoral contraction of the shell. No. 253.	78
10.	*Clarkeoceras* sp., aff. *luthei* UF&M A natural section essentially vertical, retaining much of the siphuncle on the venter, to the left. No. 261.	70
11-12.	*Barnesoceras conosiphonatum* Flower, n. sp. Holotype, No. 257, showing in 12. a lateral view, venter on left, apical part sectioned showing rapid initial expansion of the siphuncle; 11. is a view of the adoral end of the apical part of 12. taken prior to cutting the section. Venter on left. No. 257.	79

All specimens in the collection of the writer, × 1, except where otherwise indicated from 272 to 276 feet above the base of the Threadgill member of the Tanyard formation, from Threadgill Creek, Gillesipe County, Texas.

PLATE 13

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1-3. *Barnesoceras percurvatum* Flower, n. sp. 81
Holotype, No. 246, a specimen with dorsolateral part of the living chamber lost. 1. ventral view of anterior part of shell showing ventrolateral sinuosity, 2. lateral view, unwhitened, with basal sectioned part attached, 3. enlargement × 2.2 of siphuncle showing diaphragm in more detail.

4-6. *Barnesoceras ? transversum* Flower, n. sp. 82
Holotype, No. 260. Fig. 4 shows a natural weathered section, cut in the middle, from which the cross section shown in Fig. 5 is taken. The apical half was then cut exposing siphuncle in the section shown × 2.5, in Fig. 6.

7-8. *Woosteroceras spirale* Flower, n. sp. 76
Holotype, No. 207, Fig. 7 showing lateral view of the specimen, Fig. 8 a dorsal view, both photographed unwhitened.

9, 10, 14. *Woosteroceras flexiseptatum* Flower, n. sp. 76
9. Two natural sections believed to represent a single individual, Nos. 209-10, lateral view, venter on right. 10. Holotype, a naturally weathered essentially vertical section. 14. Same specimen as that shown in the basal part of Fig. 9, ground down to the siphuncle.

11. *Muriceras gracile* Flower, n. sp. 90
Holotype, × 2½, a specimen seen in a sagittal section, venter at left. Sinuosity of the living chamber indicates maturity. At the base diaphragms are developed in the siphuncle. *See also* Pl. 29, fig. 9.

12-13. *Woosteroceras percurvatum* Flower, n. sp. 76
Holotype, 12. Specimen ground to level of siphuncle in adoral camerae, × 2.5. 13. Natural section, specimen as originally found, × 1, with apical part of section passing below the middle.

15-17. *Barnesoceras expansum* Flower, n. sp. 78
15. An essentially vertical section ground from a natural surface, part of which is retained adorally. Paratype, No. 258. 16. Enlargement of siphuncle showing thick rings crossing siphuncle, here seen in a nearly tangential section. 17. Same section ground close to center of siphuncle, showing nature of siphuncle wall.

All specimens from 272 to 276 feet above the base of the Threadgill member of the Tanyard formation, from Threadgill Creek, Gillespie County, Texas, and in the collection of the writer.


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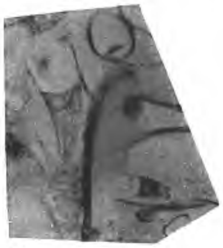
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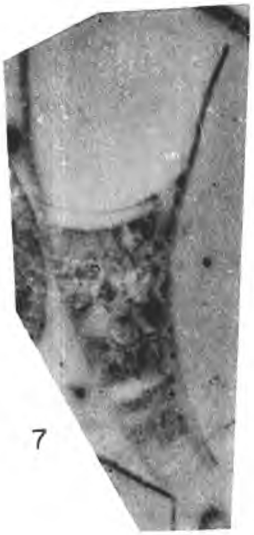
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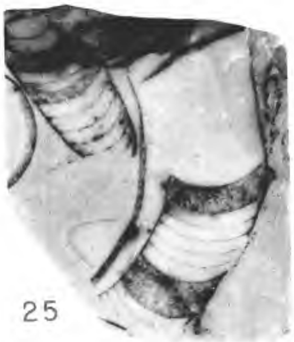
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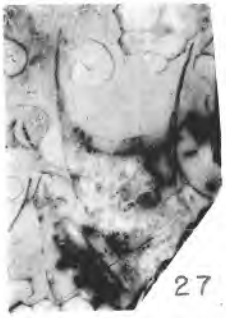
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PLATE 14

Figures Page

1-7. *Muriceras murus* Flower, n. sp. 89

1. A section showing in the center a paratype in a nearly vertical longitudinal section, with oblique sections of two other shells, × 2. 2. Same specimen, ground slightly further, showing the siphuncle in the anterior part of the phragmocone. 3. same section, × 5, showing further details of siphuncle and obscurity of the apical end, here obscurely separated from the surrounding matrix. No. 221. 4-5. Holotype, a nearly vertical longitudinal section, by which the siphuncle is exposed in the apical part of the phragmocone, × 2.5 and × 5. No. 219. 6-7. A second paratype, No. 235, shown in Fig. 6, × 2.5, and in Fig. 7, × 9. The siphuncle is exposed throughout the length of the specimen, though obscured by calcite in the middle part of the phragmocone.

8, 18. *Muriceras curviseptatum* Flower, n. sp. 90, 94

8. Paratype, No. 214, a nearly vertical section, the anterior part naturally weathered, and showing a false contraction of the aperture, the siphuncle exposed in the anterior end of the phragmocone only, × 2.4. 18. Holotype, No. 213, a larger shell shown in vertical section, venter on right and exposing the siphuncle throughout. The adoral apparent contraction of the shell is caused by the surface of the section, here naturally weathered, passing below the median plane of the shell. Beneath the type is a chance-oriented section of an unidentified apical end of an ellesmeroceroid, while another is shown in the middle lower right.

9-12, 21. *Muriceras hebetum* Flower, n. sp. 91

9. A section of a series of specimens, No. 224, × 3. In the lower center the holotype is exposed in a vertical longitudinal section, the siphuncle being exposed throughout most of the length of the phragmocone on the venter, to the right. The natural apex of the shell is retained, but the siphuncle cannot be seen in the apical fifth of the specimen. To its right is a chance-oriented section, though an essentially longitudinal one, of a second specimen referred tentatively to the species, and a very oblique section, specifically unidentifiable, is seen at the upper left. 10. A specimen, No. 223, referred tentatively to the species, here shown in a longitudinal section which is well off-center; the apparent contraction of the living chamber is due to a lateral contraction appearing here as a vertical contraction as in *Oncoceras*. 11. A second specimen referred tentatively to the species seen in a section oblique to the longitudinal axis of the shell, the direction of the section being responsible for the rapid initial expansion and the adoral contraction. The section intersects the siphuncle at the middle of the phragmocone. 12. A third specimen tentatively assigned to the species, seen in a section which is essentially vertical, but which attains the median plane apically, where the siphuncle can be seen, but becomes progressively eccentric as traced orad, the plane of the section intersecting the lateral side of the living chamber and not quite attaining the aperture. 21. A vertical longitudinal section of a paratype, No. 215, × 2.2. Calcite fills the camerae and all the siphuncle except the extreme anterior portion. Venter on left.

13. *Conocerina* cf. *brevis* Ulrich and Foerste 71

A small specimen seen in a naturally weathered section, the surface irregular, and retaining the siphuncle only at the anterior end of the phragmocone on the venter, at the right. No. 242, × 1.8.

14. *Muriceras* cf. *hebetum* Flower, n. sp. 94

A section showing the apical end of an ellesmeroceroid, showing a contrast between the blunt apex and the later part. Chance-oriented section, essentially longitudinal, but not retaining the siphuncle. No. 238, × 2.5.

15. *Muriceras micromurus* Flower, n. sp. 89

Holotype, a shell seen in a slightly eccentric sagittal section, No. 218, × 3.

16. *Muriceras murus* Flower, n. sp. 89

A section, No. 231, × 3.5, showing two chance-oriented sections through the shells of this species. The upper section is horizontal, attaining the maximum shell width only at the aperture, the variation in expansion resulting from the section intersecting the apical part nearly centrally, while adorally the shell curves toward the plane of the section so that its maximum width is shown at the aperture. The lower section is essentially longitudinal, but not central, as it fails to show the siphuncle.

17. *Muriceras moderatum* Flower, n. sp. 91

Vertical section of a syntype, No. 217, × 2.5.

19-20. "*Ruthenoceras*" sp. 93

Two successive sections of a chance-oriented specimen, No. 231, about × 5. The upper figure (19) shows a cyrtoconic shell with a living chamber, though the section gives no true concept of the rate of expansion. In Fig. 20, the section is ground further, exposing the siphuncle at the very base but passing obliquely orad and intersecting the shell margin in the anterior calcite-filled part of the phragmocone. This section is of particular interest in that it is very close to the chance-oriented section which is the basis of the description of *Ruthenoceras elongatum*.

22. *M.* cf. *hebetum* and *M.* cf. *murus* 89, 91

A section showing, on right, an essential horizontal section through *M.* cf. *hebetum*, in the upper center a horizontal section probably through a part close to the apex of the same species, and on the right an eccentric but essentially longitudinal section through a form comparable to *M. murus*, but more strongly curved. No. 234, × 3.

23. *Muriceras moderatum* Flower, n. sp. 91

Syntype, showing a vertical section, No. 211, × 1.

24. *Muriceras anomalum* Flower, n. sp. 89

Holotype, No. 220, × 7, a shell seen in a sagittal section, the siphuncle exposed throughout the length of the phragmocone, though obscured by calcite, as are all the camerae, in the middle. The living chamber shows the sinuous outline indicative of maturity.

25-28. *Burenoceras muricoides* Flower, n. sp. 86

25. A section showing a sagittal section through the greater part of the holotype, intersected by a natural break at the anterior end, showing the siphuncle complete on the venter, at the right. Included in the upper left is a chance-oriented section, not quite longitudinal, of a compressed orthocone, probably an *Ectenolites*. No. 225, × 2.2. 26. A paratype, No. 229, × 2.5, the anterior part a sagittal section, but with the apical part eccentric. 27. Another paratype, No. 237, × 2.5, seen in an essentially sagittal section. 28. A third paratype, No. 226, × 3, seen in a sagittal section in which the siphuncle is clearly preserved throughout the length of the phragmocone.

29. *Burenoceras cornucopia* Flower, n. sp. 86

A sagittal section through the holotype, No. 241, × 3, exposing the siphuncle, at right, throughout the length of the phragmocone, and showing sinuosity of the dorsum near the aperture, indicative of maturity.

All specimens in the collection of the writer, from 272 to 276 feet above the base of the Threadgill member of the Tanyard formation, from Threadgill Creek, Gillespie County, Texas.

PLATE 15

Figures		Page
1.	*Microbaltoceras* ? sp. A natural section, × 4, of a phragmocone, the section missing the siphuncle but apparently essentially parallel to the shell axis, its rotation from the vertical plane uncertain, but probably close to the horizontal. No. 243.	107
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Except where otherwise stated, specimens are in the collection of the writer. Figures 1-7 from the Tanyard formation, Tanyard Creek, Gillespie County, Texas.


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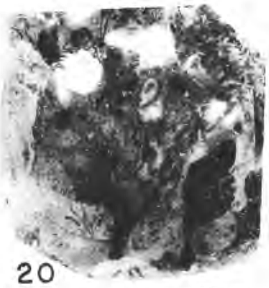
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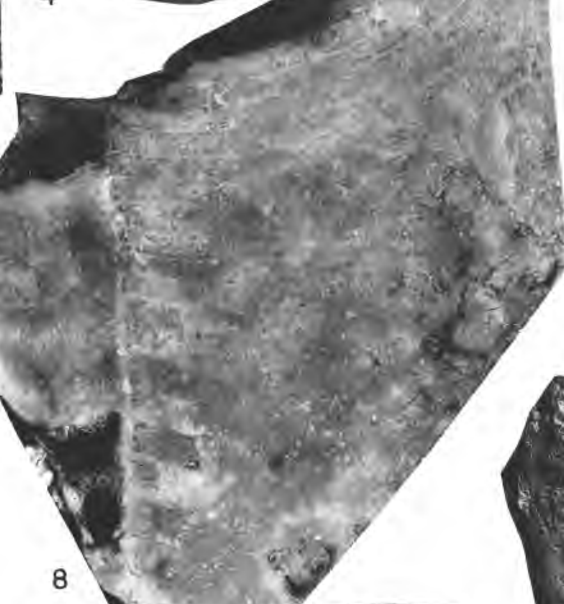
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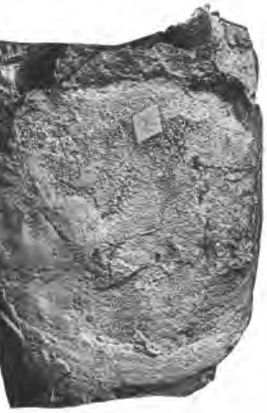
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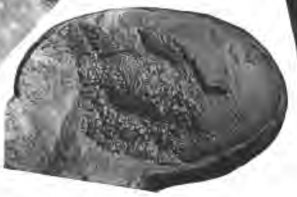
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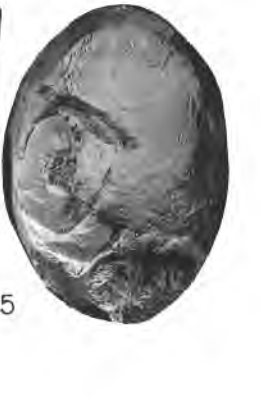
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PLATE 16

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6-8.	*Boreoceras ovale* Flower, n. sp. .... 6. lateral view of holotype, × 1, showing surface of the basal portion with sutures. 7. the same specimen, with the apical portion sectioned, showing the conically expanding siphuncle in the apical portion; both × 1. 8. enlargement, × 3, of the apical sectioned portion; the base of the matrix in the anterior part of the siphuncle is bounded by a diaphragm, with possibly another near the base. Septa are incomplete dorsally, but short necks of siphuncle wall are apparent anteriorly. Yale Peabody Museum, No. 17310. From the Canadian of Fossil Point, Read Island.	75
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12-15.	*Boreoceras brevicameratum* Miller and Youngquist .... Four views of a paratype, retaining a living chamber and a few adoral camerae. 12. dorsal view; 13. lateral view, dorsum on left; 14. ventral view; 15. septal view, venter below. Yale Peabody Museum No. 17312(a). From the Canadian of Sutton Island.	74

PLATE 17

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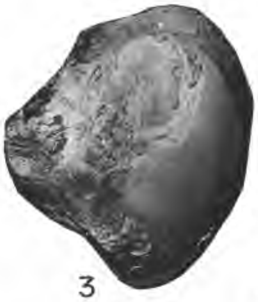
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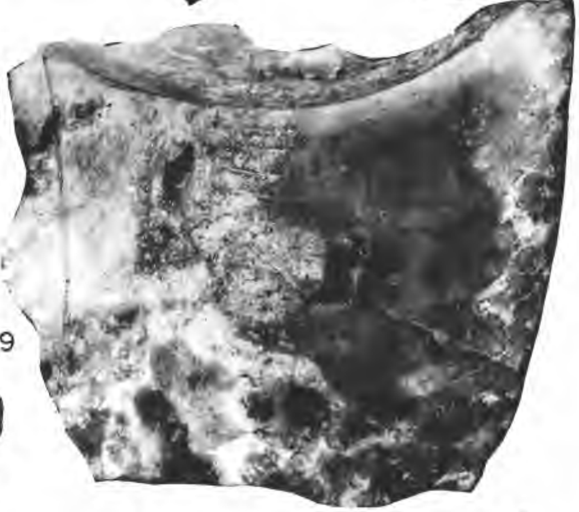
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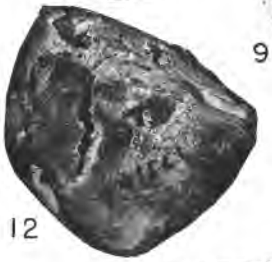
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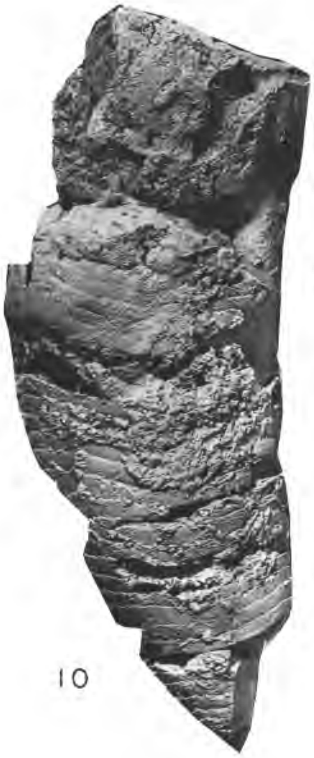
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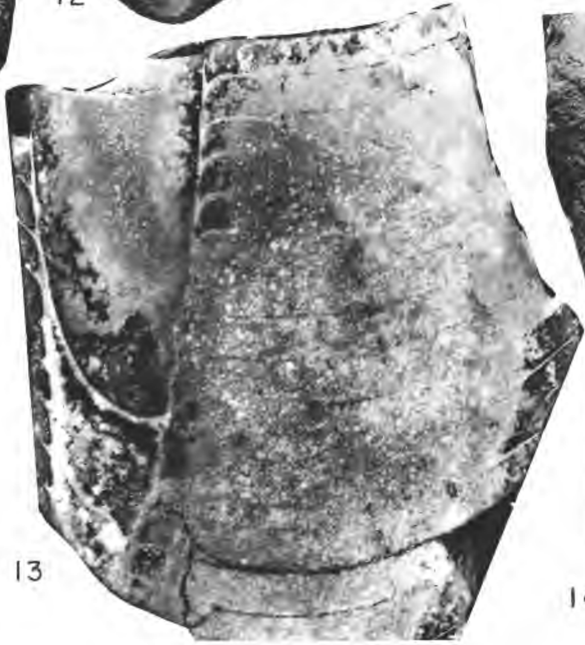
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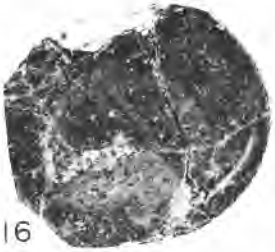
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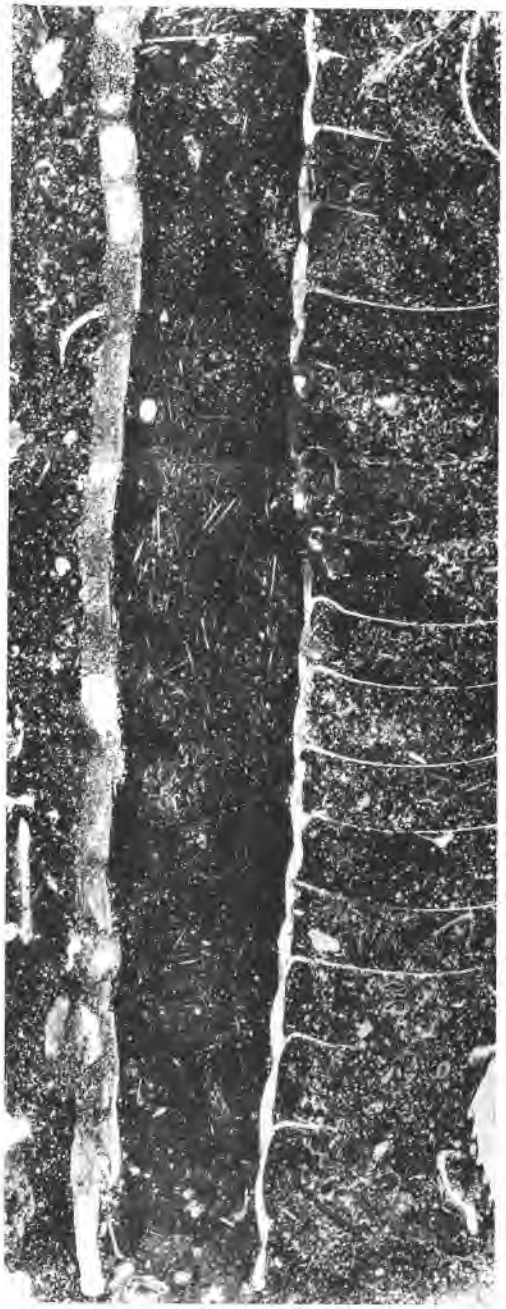
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PLATE 18

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1-3. *Rioceras nondescriptum* Flower, n. sp. 102
1. Lateral view, venter on left, No. 859, showing camerae and base of living chamber. 2. ventral view, × 1, prior to sectioning of basal part, showing a relatively mature portion, No. 857. 3. ventral view, No. 858, showing an earlier growth stage. All × 1. First piloceroid zone of the El Paso, Cooks Range, New Mexico. Syntypes.

4-5. *Rioceras fusiforme* Flower, n. sp. 103
4. ventral view and 5. lateral view, venter on left, of the holotype, × 1, No. 862. The right anterior of Fig. 5 is incomplete. First piloceroid zone of the El Paso, from the Cooks Range, New Mexico.

6-9. *Cyrtobaltoceras gracile* Flower, n. sp. 109
Three views of the holotype, No. 341. 6. ventral view showing siphuncle and traces of the ventral lobes. 7. lateral view, venter on left, showing obliquity of sutures and curvature. 8. dorsal view, the right side weathered, showing partial sutures pattern. 9. apical view, venter at left, showing relationship of siphuncle and conch cross sections, all × 2. From the Fort Cassin beds, Valcour, New York.

10. *Rioceras nondescriptum* Flower, n. sp. 102
Vertical section through phragmocone, × 2, venter on right, basal part ground to center; adoral part weathered beyond center, No. 856, from the first piloceroid zone of the El Paso, from Mud Springs Mountain, near Hot Springs, New Mexico. Syntype.

11-14. *Rioceras lobatum* Flower, n. sp. 104
Holotype, No. 863, × 2; 11. ventral view. 12. lateral view, venter on left, × 2; 13. septal view, venter below, × 2; 14. ventral view, × 1, showing actual size.

15. *Endorioceras rarum* Flower, n. sp. 106
Section of the holotype, × 1, venter on right. No. 888. First piloceroid zone, Cooks Range, New Mexico.

16-21. *Rioceras nondescriptum* Flower, n. sp. 102
16. Cross section, × 2, taken at midlength of specimen shown in Fig. 2, No. 857. 17. Septal view, × 2, at an earlier growth stage, same specimen as Fig. 1, No. 859. 18. Opaque section, × 2, 19-20. Opposite sides from vertical section, × 2, from lower part of Fig. 2; 19. is nearly tangential, below, to a lateral wall of the siphuncle, × 2. 21. Thinsection of siphuncle from same specimen as Fig. 18, × 5, reversed. No. 857. First piloceroid zone of the El Paso limestone, Cooks Range, New Mexico.

PLATE 19

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7-13.	*Rioceras depressum* Flower, n. sp. 7-12, holotype: 7. dorsal view, × 2; 8. lateral view, venter on right, × 2. 9. venter, prior to grinding to expose siphuncle, × 2; 10. venter, × 2, ground to expose the siphuncle. Irregular tranverse checking is the result of weathering. 11. septal view, × 2, venter and siphuncle below. 12. ventral view, whitened, × 1.5. NMBM No. 882. 13. a paratype, × 2, ventral view, a fragment showing a slightly earlier growth stage, NMBM No. 883. Both types from the first endoceroid zone of the El Paso, from Rhodes Canyon, San Andres Range, New Mexico.	103
14.	*Rioceras expansum* Flower, n. sp. Ventral view, × 2, showing small siphuncle and rapid expansion, same occurrence as the preceding form. NMBM No. 884, holotype.	103
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19-20.	*Murrayoceras* cf. *multicameratum* (Emmons) 19. A nearly horizontal longitudinal thinsection, × 2, showing siphuncle wall, cameral deposits, and calcitic rod within the siphuncle. The right side, as shown by the greater proximity of the rod to the siphuncle wall and the thicker cameral deposits, is closer to the venter than the left. 20. Enlargement of a portion of the siphuncle from the same section, × 5, showing short necks, rings thin and altered, independence of the rod from the true siphuncle wall. Lowville beds, Margaret's quarry, Ottawa, Ontario. Collection of the writer; No. 353.	121
22.	*Cyptendoceras ? floridaense* Flower, n. sp. Holotype, No. 886, × 2, a specimen weathered from the ventral side, showing the adoral termination of the ventral rod within the siphuncle. From the Cassinian portion of the El Paso limestone, Capitol Peak section, northwest side of the Florida Mountains, New Mexico.	116

If not otherwise indicated, specimens are in the collection of the writer.


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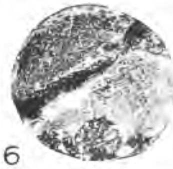
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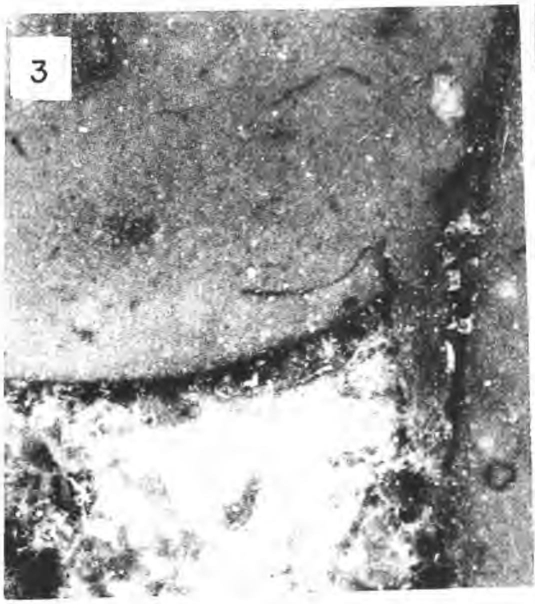
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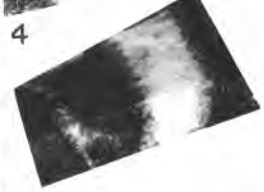
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PLATE 20

Figures Page

1-3. *Clelandoceras (?) rarum* Flower, n. sp. 97
1. and 2. opposite surfaces of a cut showing two parallel, nearly vertical sections, × 2. Fig. 1 is eccentric, and probably the plane of the section is slightly more eccentric adorally, exaggerating the contraction of the aperture. In Fig. 2 the plane of the section cuts the siphuncle segments in the adoral end of the phargmocone only, showing the plane of the section to be slightly eccentric apically and tilted slightly vertically from the plane of symmetry of the shell. The anterior part of the phragmocone is shown, × 10, in Fig. 3, showing the slight convexity of the siphuncle segments, vestigial necks, and thick rings. The two sides are numbered 812 and 813; the reverse of 812 shows a type of *Centrotarphyceras longicameratum*. From B2b of Cloud and Barnes, Cassinian, El Paso group, from McKelligon Canyon, southern Franklin Mountains at El Paso, Texas.

4-7, 12-14. *Rhabdiferoceras annuliferum* Flower, n. sp. 119
4. and 5. are parallel longitudinal sections, × 2, from opposite sides of the same piece, the plane of the section oblique, essentially as shown in Fig. 7. Fig. 4 shows part of the rod in the siphuncle; the rod is missed in the plane of Fig. 5. Fig. 4 is from the lower surface of Fig. 7; Fig. 5 is from the upper surface. 6. Cross section apicad of the portion shown in the preceding figures; obliquity of the plane is responsible for the apparent compression of the cross section. The siphuncle is largely filled by the rod, leaving only a narrow dorsal crescentic space filled with matrix. 7. Apical view, × 2, of piece of which the two sides, showing longitudinal sections, are illustrated in Figs. 4 and 5; oriented with the venter beneath. 12. Portion of thinsection made from the surface of Fig. 4, showing traces of septa, most parts of which are lost in calcite of the phragmocone, necks and thick rings. About × 15. 13. Entire thinsection reversed from Fig. 4. 14. Another portion of the siphuncle; matrix and cavity of siphuncle on the left, calcite-filled phragmocone on the right, showing relatively clear necks and traces of the original thickness of the connecting rings, about × 10. Holotype; USNM No. 139851, from USNM locality 2175, north end of the Ely Springs Range, Nevada, in the Pogonip, "about *Receptaculites*."

8-10. *Muriceras (?) obscurum* Flower, n. sp. 93
Holotype, × 2; 8. ventral view, 9. lateral view, venter on left, 10. septal view, showing venter and siphuncle at the left. No. 855, from the first piloceroid zone of the El Paso, Cooks Range, New Mexico.

11. *Rioceras (?)* sp. 105
An apparent *Rioceras*, a deeply weathered surface of a specimen, showing the siphuncle near the left side, filled with matrix; the camerate portion is filled with yellow dolomite. From the same locality and horizon as U.S. National Museum No. 139850, and Pl. 20, fig. 4-6, 12-14.

15-19. *Rhabdiferoceras* sp. 119
A specimen with calcite filling the phragmocone, with most septa destroyed; Fig. 15 shows the specimen, × 1, as viewed from its weathered dorsal side. Fig. 16 is an adoral cross section, × 2, showing the cross section near the anterior end of the rod; Fig. 17 is a similar section farther apicad, with the rod proportionately large. Fig. 18 shows a vertical section of most of the length of the specimen, × 2; adorally, the cavity of the siphuncle thins to a narrow point on the dorsal side of the siphuncle. In the apical third a short interval shows the outline of slightly expanded siphuncle segments. An apical cross section, × 2, is shown in Fig. 19, showing the siphuncle filled with calcite, the ventral part of the shell wall and septa wanting. No. 885, from B2b of Cloud and Barnes, from the Cassinian part of the El Paso, McKelligon Canyon, southern Franklin Mountains, El Paso, Texas.

If not otherwise indicated, numbered specimens are in the collection of the writer.

PLATE 21

Figures *Page*

1-14. *Rioceras dartoni* Flower, n. sp. 104
1-4. Holotype, NMBM No. 866, × 1.5; 1. lateral view, venter on right; 2. ventral view; 3. adoral view, venter below; 4. apical view. 5-8. paratype, No. 867, × 1.5; 5. lateral view, venter on right; 6. ventral view; 7-8. anterior and apical views venter, below. 9-12. paratype, No. 868, × 1.5; 9. lateral view, venter on right; 10. ventral view; 11. adoral and 12. apical views, venter below. 13-14. paratype, × 1.5, No. 869; 13. ventral view; 14. lateral view, venter at left.

15-23. *Rioceras wellsi* Flower, n. sp. 104
15, 16, 20. Paratype, a rlatively large portion of phragmocone, slightly abraded apically, × 2, No. 877. 15. ventral view; 16. lateral view, venter at right; 20. adoral view, venter below. 17-19. a paratype, No. 877, slightly worn and the siphuncle enlarged by weathering, × 2. 17. ventral view; 18. dorsal view; 19. adoral view, venter below. 21-23. holotype, × 2, No. 876. 21. ventral view; 22. dorsal view, 23. adoral view.

24-32. *Cyptendoceras richardsoni* Flower, n. sp. 116
24. ventral view of holotype, × 2, No. 870; 25. same, × 1; 26. same, × 1, lateral view, venter at left; 27. adoral view of an incomplete specimen, paratype, No. 873, but one representing a late growth stage; 28. adoral view of paratype No. 871; 29. Same specimen, ventral view, × 1; 30. same specimen, lateral view, venter at left, × 1; 31-32. dorsal view (31) and lateral view, venter at left (32), of a specimen showing an early portion of the phragmocone weathered from the dorsum and exposing much of the siphuncle. *See also* Pl. 19, fig. 16-18, 21.

33-35. *Rioceras tubulare* Flower, n. sp. 104
Three views of the holotype, No. 881, × 2. 33. view of base of the figured portion, showing cross section and siphuncle proportions. 34. lateral view of weathered side, venter on right, × 2; outline restored anteriorly, including silicified parts of a few anterior camerae on the upper right. 35. ventral view, anterior outline partially restored. The midventral region and siphuncle lie just to the left of the center.

All specimens in the collection of the writer, from the upper part of the dolomites, bed 8 of Cloud and Barnes, in the lower part of their unit B2b, Cassinian, from the southern Franklin Mountains at El Paso, Texas.


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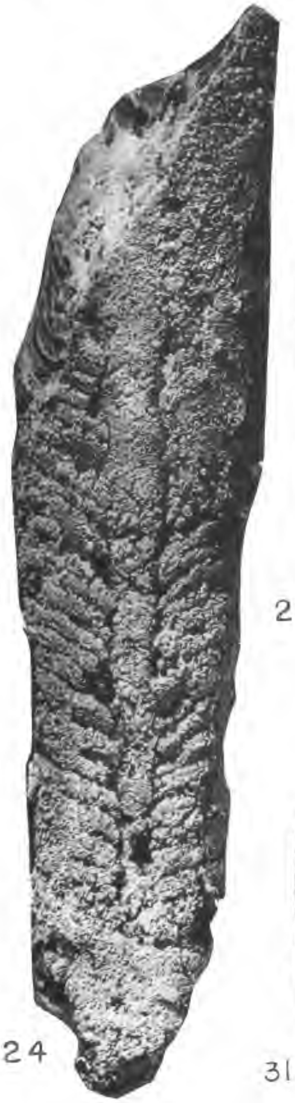
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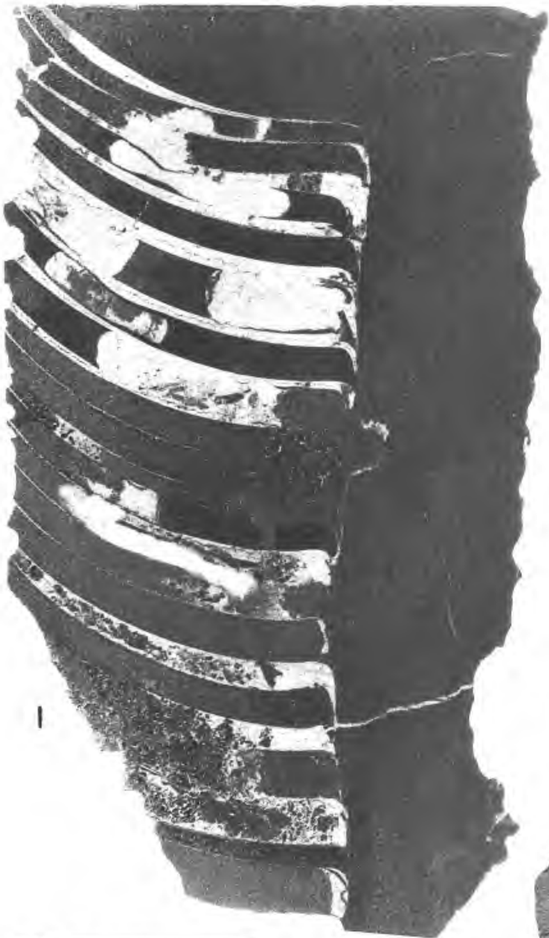
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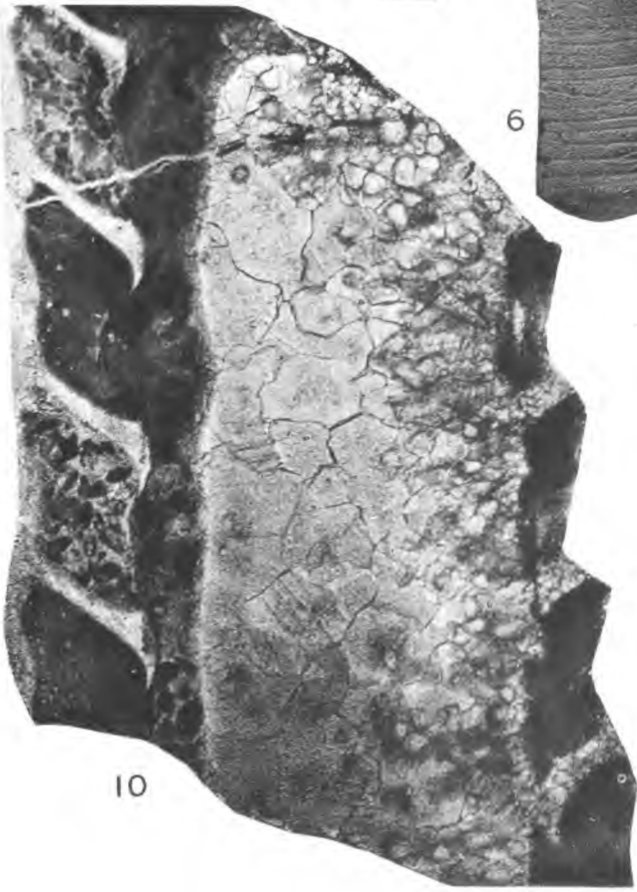
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PLATE 22

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1, 3-9. *Cyptendoceras rhythmicum* Flower, n. sp. 117

1. Thinsection of a paratype USNM No. 139839, × 3.5; sagittal section, venter on right (section reversed). 3. Holotype, ventral view, × 1, USNM No. 139838, showing ventral lobes and portion of siphuncle. 4, 5. Two portions of the siphuncle wall, × 16, taken from the section shown in Fig. 1; Fig. 4, from the apical portion, shows the terminations of two septal necks clearly, but in Fig. 5 replacement gives a false holochoanitic aspect in some segments, but shows evidence of the moderately thick rings. 6. Paratype, × 1, dorsal view, USNM No. 139841. 7. Paratype, × 1, viewed from the worn ventral side, exposing the siphuncle. The median structure in the siphuncle is apparently adventitious, USNM No. 139842. 8. Apical view, × 1, of Fig. 7, venter below. 9. Paratype, × 1, dorsal view, USNM No. 139842, showing a portion of phragmocone with closely spaced septa at the base of the living chamber. *See also* Pl. 23, fig. 1-4.

From the Pogonip limestone "above the *Receptaculites*," north end of the Ely Springs Range, Highland Peak quadrangle, Nevada.

2, 10, 11. *Cyptendoceras ruedemanni* Ulrich and Foerste 115

Three photographs from two thinsections of a hypotype, × 5. Fig. 2 and 11 are from opposite sides of a nearly horizontal section taken slightly dorsad of the center of the siphuncle, showing septa strongly inclined as they approach the siphuncle, short necks, rings relatively thin, outlining concave segments, the rings thickened at their tips. Fig. 10 is a nearly horizontal section from the ventral side of the same cut, cutting the siphuncle well ventrad of the center, below the point of greatest width of the siphuncle. On both sides, septa and septal necks are somewhat obscured by the addition of cameral deposits, mainly if not completely episeptal, the distinction between deposits and septa obscured by partial recrystallization. The right side is slightly more ventral than the left. Calcite within the siphuncle apparently represents a ventral rod, but the anterior end is broken. From the collection of the writer; No. 293. From the Fort Cassin beds, at Valcour, New York.

PLATE 23

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1-4.	*Cyptendoceras rhythmicum* Flower, n. sp. .... 1-2. Ventral and apical views of a living chamber, complete ventrally, weathered dorsally, paratype, USNM No. 139843. 3. a weathered specimen, ventral view, showing the siphuncle exposed near the base of the living chamber, paratype USNM No. 139844. 4. dorsal view of the specimen shown on Pl. 22, fig. 7 and 8, showing rhythmic variation of septal spacing, paratype, USNM No. 139842. All × 1. *See also* Pl. 22 .	117
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18-20.	*Cyptendoceras ruedemanni* (Ulrich and Foerste) .... 18. Dorsolateral view of the phragmocone of the holotype, × 2, normal to the obliquely broken surface of the siphuncle, and showing an oblique section through the ventral rod. 19. the entire specimen, × 1, viewed at the same angle. 20. the same, × 1, from an essentially dorsal view. USNM No. 92638, from the Fort Cassin beds at Fort Cassin, Vermont.	115


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PLATE 25

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1.	*Eremoceras magnum* Flower, n. sp. . . . . Enlargement × 18 of portion of dorsal wall of thinsection (*see* pl. 10, fig. 1) showing thin, steeply inclined dark bands in shell wall separated by lighter broader bands of light calcite, and the buttress-like mural parts of the septa.	51
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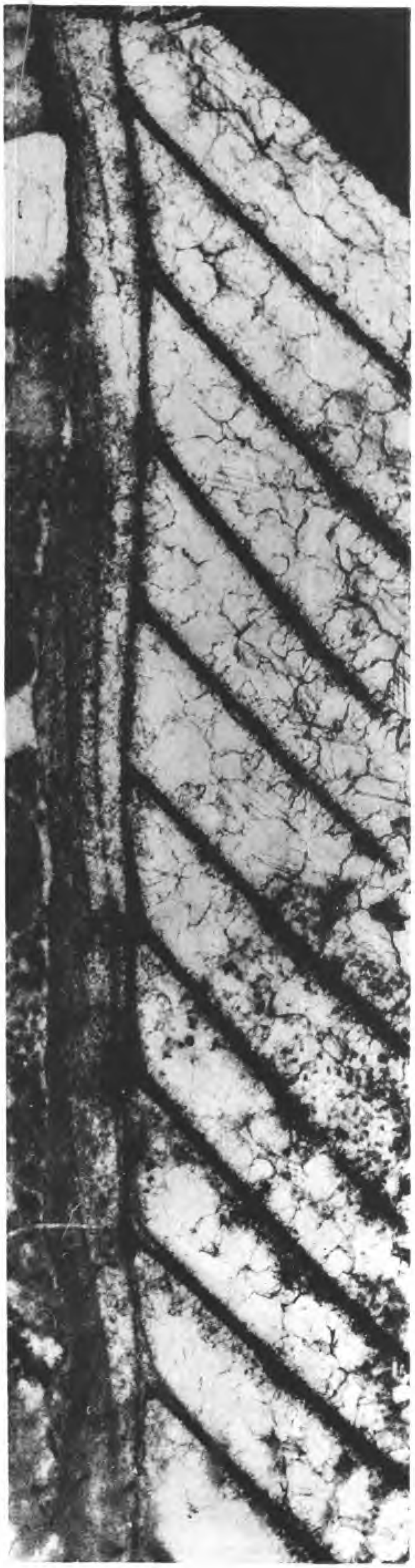
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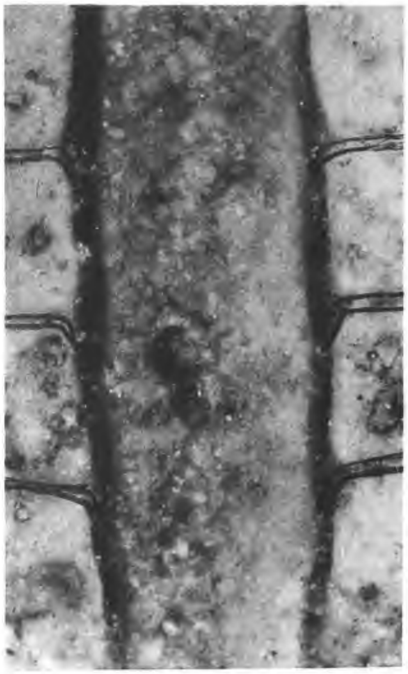
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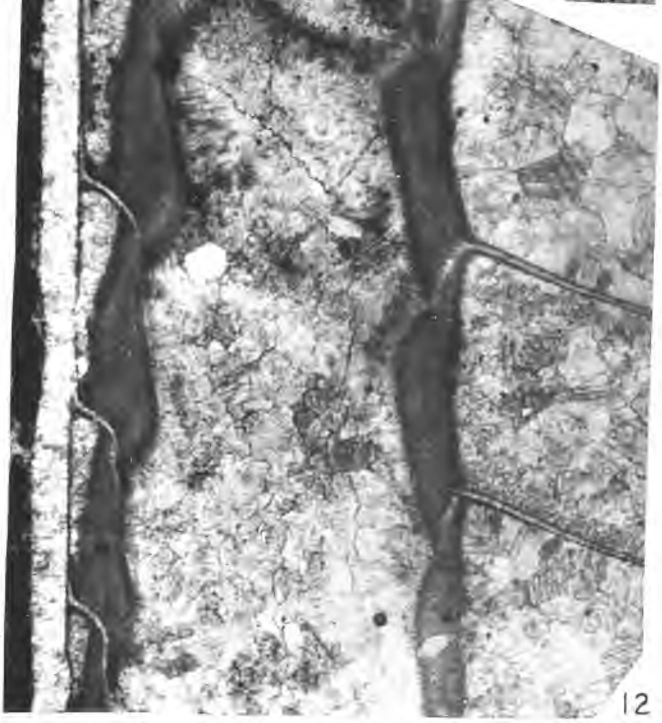
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PLATE 26

Figures *Page*

1. *Ellesmeroceras* sp. 48
Lateral view, × 2, No. 320, showing surface weathered to siphuncle adorally. Sierrite limestone, El Paso group, Mud Springs Mountain, New Mexico.

2, 7. *Dakeoceras* sp. 63
Two specimens weathered essentially to middle, and in nearly sagittal sections. From the Sierrite limestone of the El Paso group, Mud Springs Mountain, New Mexico. No. 319.

3, 4. *Cartersoceras shideleri* Flower, n. sp. 122
Holotype, ground to the level of the siphuncle on an original weathered surface, from the ventral side; section passes dorsad of the siphuncle apically. 3. × 1, showing general size and proportions. 4. × 2, showing details of siphuncle outline, ventral rod, thinning adorally, and cameral deposit. No. 390. Carters limestone, near Mt. Olivet, Tennessee.

5. *Cartersoceras* cf. *shideleri* 122
An earlier portion of a phragmocone ground adorally, close to *shideleri*, possibly identical but showing slightly different spacing of septa. Same horizon and locality. No. 392.

6. *Metabaltoceras minutum* Flower 109
Holotype, lateral, × 2, venter on right. Opposite side not preserved. No. 318, from just above the oolite, El Paso group, Mud Springs Mountain, New Mexico.

8-11. *Cartersoceras shideleri* 122
Paratype, a horizontal thinsection, Fig. 8, × 3, at level of the siphuncle. Dark bands on either side of siphuncle represent matrix in camerae, otherwise largely filled by cameral deposits, but with recrystallization obscuring identity of septa; cameral deposits and possible inorganic calcite. In the siphuncle, the ventral rod is advanced, filling the entire siphuncle at the level of the section, and recrystallized; reversed. 9. Enlargement, about × 20, of part of siphuncle wall, upper right of Fig. 8, showing septal necks and dark lamellar connecting rings. 10. Another portion, × 20, from third and fourth segments from upper left of Fig. 8, showing rings thicker, with more marked curvature and differentiation of the apical end of the ring around the spetal neck. 11. Anterior upper left of Fig. 8, anterior to Fig. 10, showing extreme thickening of lamellar ring with fuller differentiation within it, and greater curvature of apical ends or rings around the necks; more marked on the siphonal than on the cameral side, and suggesting growth of ring from outer to inner side, × 20. No. 391. Same locality and horizon as Figs. 3-5.

12. *Ellesmeroceras* sp. 48
Anterior end of vertical thinsection shown at lower enlargement in Pl. 27, fig. 4, here about × 24; it shows here in greater detail the unusual thickness of rings, their layering, and the development of their ends, not only enclosing septal necks but extending onto the free parts of the septa; the section shows also the texture of two anterior diaphragms; the upper one is clear, but the lower is only faintly differentiated from the matrix. Lower Canadian, York District, Seward Peninsula of Alaska; specimen in the U.S. National Museum.

PLATE 27

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1-6.	*Bactroceras avus* Holm 1. Ventral view of a phragmocone, × 1.5, viewed from the venter, and with the siphuncle exposed at midlength. 2. Section, showing the siphuncle, venter at right, from the apical end of the same specimen, × 2.5. 3. Further enlargement of siphuncle, × 5. 4. Vertical section, × 2.5. 5. Cross section, showing relative size of shell and siphuncle, and intersecting a septum. 6. A later growth, × 1, showing the rugose surface. Red Lituites limestone, 1-3. from Oeland, 4-6. from Vestergotland (after Holm, 1898).	112
7.	*Bactroceras angustisiphonatum* (Rüdiger) Vertical section, × 3. Gray Lituites limestone, erratic block, Mencklenburg (after Holm, 1898).	112
8.	*Ellesmeroceras* sp. Thinsection showing siphuncle containing several diaphragms; *see also* Pl. 26, fig. 12, for further enlargement of the anterior portion. From Lower Canadian strata, York District, Seward Peninsula, Alaska. × 15.	48
9.	*Murrayoceras multicameratum* (Emmons) Vertical section, × 2, venter on left, showing the anterior limit of a ventral rod in the siphuncle. From the Lowville of Ottawa, Ontario. Collection of the writer; No. 395.	121
10-24.	*Muriceras* sp. A series of specimens, all × 2, from the Chepultapec of Virginia. 10-12. are two lateral views and a ventral view of one specimen, 13-15. of another; both show asymmetric lobation of sutures, suggesting distortion. 16-17. is another specimen, viewed laterally, venter on right, and ventrally. 18-19. are two small fragments showing variation in curvature and rate of expansion. 20-21. are adoral and lateral views of a rapidly expanding portion, the anterior cross section somewhat distorted. These are labeled *Clelandoceras* sp., No. 12725, University of Missouri. 22-24. are adoral, lateral, and ventral views of the specimen figured as *Clelandoceras elongatum,* University of Missouri, No. 12724.	92
25.	*Wolungoceras valcourense* Flower n. sp. Thinsection through siphuncle wall, about × 8. From the holotype, No. 339. *See* Pl. 19, fig. 15. Thinsection lost. Fort Cassin beds, Valcour, New York.	110


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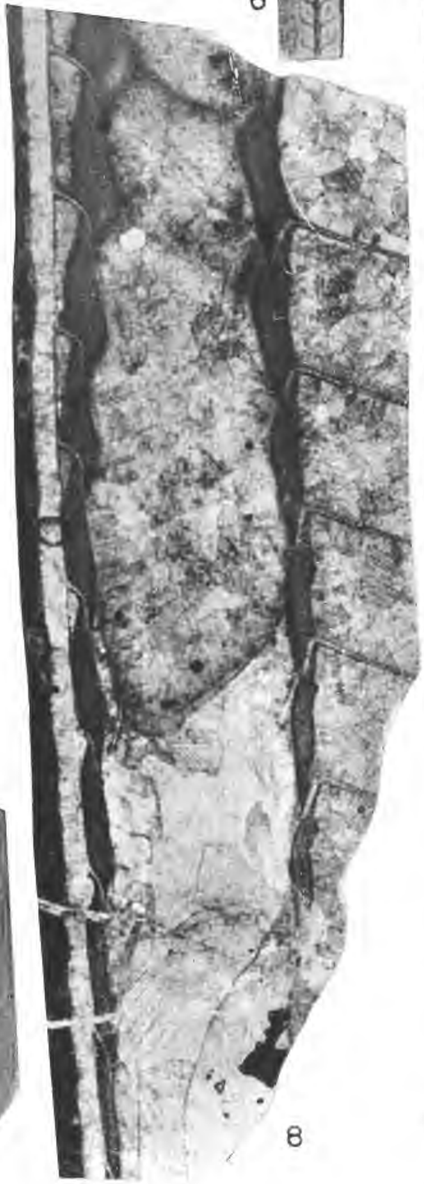
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PLATE 28

Figures		Page
1-6.	*Murrayoceras multicameratum* (Emmons)	121

1, 2. Opposite sides of a vertically sectioned portion of phragmocone, × 1, showing a calcitic rod in the siphuncle. Fig. 1 shows a central section, with the rod largely filling the siphuncle; in Fig. 2, the anterior surface of the rod is more apparent in an eccentric section. 3. Enlargement × 2 of Fig. 2, showing more clearly the anterior limit of the ventral rod and the siphuncle segments. 4. Thinsection, made from the surface shown in Fig. 1, showing a part of the ventral wall of the siphuncle from the anterior portion. Calcite in the siphuncle represents the rod; that in the camerae was probably a ventrally concentrated cameral deposit. Septa, steeply inclined, at aneuchoanitic, their tips somewhat obscure, supplemented by rings of moderate thickness with faintly sinuate outlines; × 12. 5. A more apical part of the ventral wall of the siphuncle, showing more uniformly concave segments outlined by rings, light centrally, with a thin, dark outer border and a thicker dark inner border, here obscured somewhat by carbonaceous material within the calcite of the ventral rod. 6. Portion of the dorsal wall of the siphuncle, here with matrix in camerae and siphuncle, and material of necks and rings extensively recrystallized and presenting the effect of relatively long necks. Collection of the writer; No. 394. From the Lowville of Margaret's quarry, Ottawa, Ontario.

7.	*Eremoceras multicameratum* Flower	50

Enlargement of the siphuncle from the apical part of the holotype, × 5, designed especially to show the calcite in the siphuncle and to accentuate the several diaphragms, which show only faint color contrast. *See also* Pl. 6, fig. 1, 2, and Pl. 10, fig. 14.

PLATE 29

Figures		Page
1, 4, 5.	*Protocycloceras (?)* sp. 1. Ventral view, × 2, of a portion of a phragmocone before sectioning. 4. Portion of thinsection taken longitudinally and horizontally through the siphuncle, × 13. 5. Same section, × 10, showing both sides of the siphuncle wall. Note in 4. and 5. calcite on the outside of the rings extending onto the adoral surfaces of septa. Collection of the writer; No. 400. From the highest five feet of the El Paso, equivalent of C of Cloud and Barnes, from the east side of the Florida Mountains, New Mexico.	133
2, 3.	*Catoraphiceras* sp. 2. Lateral view, × 2, prior to etching, venter on right; 3. ventral view; anterior part lost through etching, × 2. From the Cassinian, B2b of Cloud and Barnes, southern Franklin Mountains, at El Paso, Texas. No. 399.	134
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8-10.	*Catoraphiceras vaginatum* (Schlotheim) 8. Dorsal view of anterior part of specimen, × 2. 9. Thinsection × 4, taken from a piece belonging apicad of Fig. 8. 10. Enlargement of siphuncle wall from the same section, × 11, showing long necks, thick apparently homogeneous rings. Collection of the writer; No. 404, Glauconitkalk, Öland, Sweden.	134


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PLATE 30

Figures *Page*

1-4. *Endocycloceras gracile* Flower, n. sp. 130
The holotype, a specimen anteriorly incomplete from weathering, × 1; 1. dorsal view; 2. lateral view, dorsum on left; 3. ventrolateral view; 4. ventral view. NMBM No. 653, from the reef above the oolite of the El Paso limestone, from the section at Mud Springs Mountain, New Mexico.

5-6. *Walcottoceras* cf. *obliquum* UFM&U 128
A portion of a living chamber, × 2, lateral view, dorsum at right in Fig. 5; dorsal in Fig. 6 showing compressed section and strongly oblique prominent annuli. Collection of the writer; No. 396. From the Smith Basin limestone, from the section just east of Smith Basin, New York.

7-8. *Kyminoceras* sp. 130
A small incomplete specimen, × 2; 7. lateral view, venter on left, 8. apical view, venter below. The only representative of this genus so far found in the first endoceroid zone of the El Paso group, from Rhodes Canyon, San Andres Mountains, New Mexico. No. 397.

9-12. *Protocycloceras* cf. *whitfieldi* Ruedemann 133
Sections from the apical part, evidently, of a specimen, with well-developed cameral deposits and diaphragms in the siphuncle. Fig. 9 is one side of the horizontally sectioned specimen, showing eccentric sections of the siphuncle apically and adorally, but wanting centrally, an indication of slight curvature. Fig. 10, an enlargement of Fig. 9, about × 4, shows the concave siphuncle segments cut almost tangentially and indication of cavities surrounded by cameral deposits. Fig. 11, × 2, is the surface opposing Fig. 9; here the siphuncle is present except in the apex. In Fig. 12, the same section, × 5, shows diaphragms of the siphuncle, septa and cameral deposits are shown in greater detail. Collection of the writer; No. 401. From the Fort Cassin beds of Valcour, New York, on the shore of Lake Champlain.

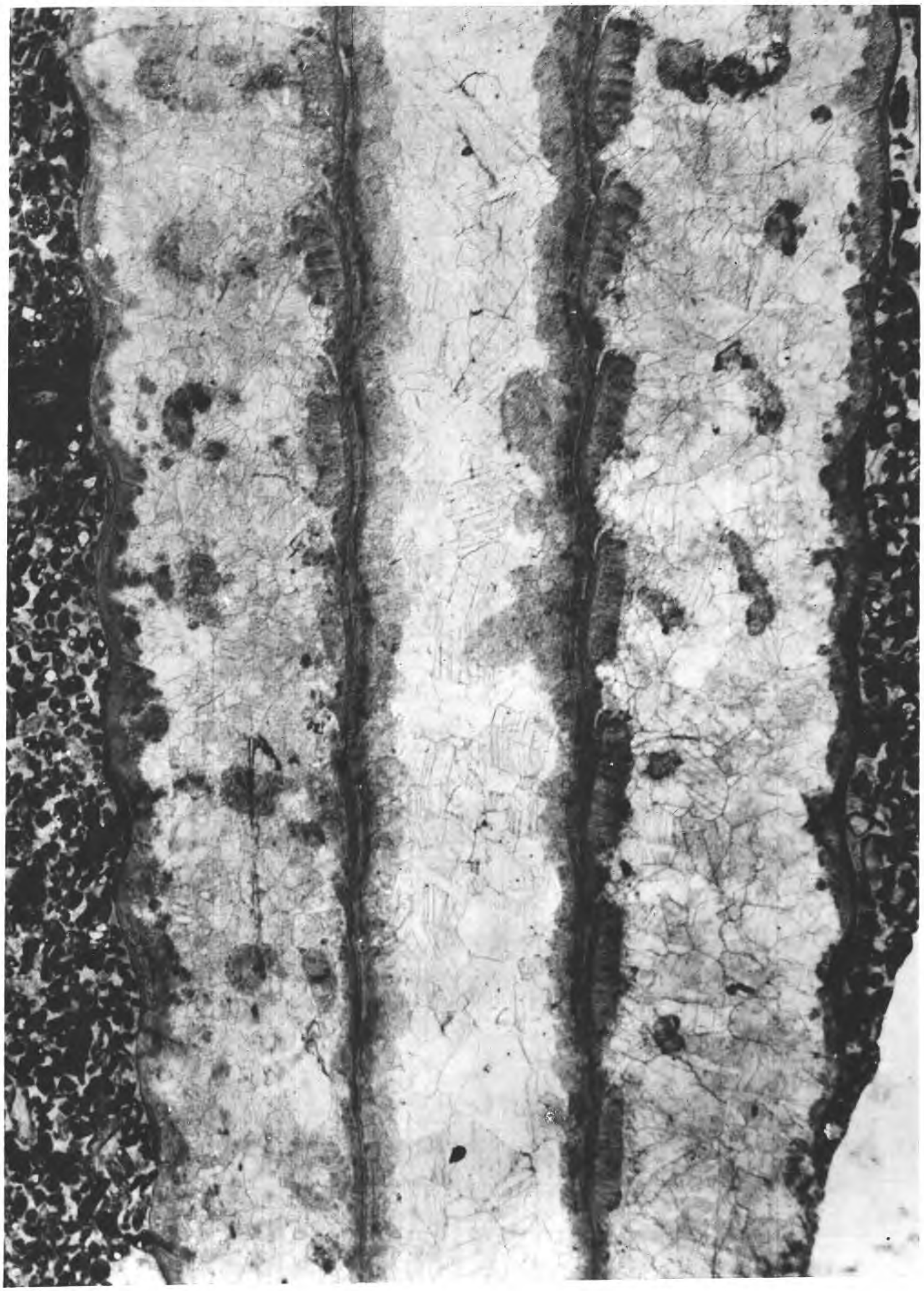
13. *Protocycloceras* cf. *whitfieldi* Ruedemann 133
Section of another individual, × 3.5, showing the siphuncle empty anteriorly, but with calcite in the apical part, where several diaphragms are seen, dark and contrasting with the calcite strongly. The siphuncle is slightly curved normal to the plane of the section. Cameral deposits, holoseptal, are shown thinning anteriorly. Collection of the writer; No. 402. Anterior portions of the same specimen, showing only an empty siphuncle and the adoral disappearance of cameral deposits and part of the living chamber, are not shown. Same locality and horizon as the preceding form.

14. *Protocycloceras* cf. *whitfieldi* 133
Section × 1 of portion of a phragmocone orad of thinsection shown on Plate 31. The section is oblique, the left near the venter. Calcite in the siphuncle is apparently adventitious. Same occurrence as Figures 9-13.

PLATE 31

Protocycloceras cf. *whitfieldi* Ruedemann 133
A horizontal longitudinal thinsection, × 13, showing a portion of a phragmocone with calcite of the camerae recrystallized and the septa largely obscured, but the septal necks are retained throughout most of the illustrated length. Coarse calcite in the sides, rhythmically repeated, is apparently a vestige of that filling the centers of the cameral spaces. Rings, though of only moderate thickness, show fine layering and outline concave siphuncle segments. Dark calcite lying against the rings, both on their cameral and siphonal surfaces, and better developed on the left than on the right side of the siphuncle, is apparently adventitious, but the carbon may have come from vestiges of cameral and siphonal tissues.

Figured specimen, collection of the writer; No. 403. The section lies just apicad of the portion shown × 1 in opaque section on Pl. 30, fig. 14. From the Fort Cassin beds, from the shore of Lake Camplain at Valcour, New York.

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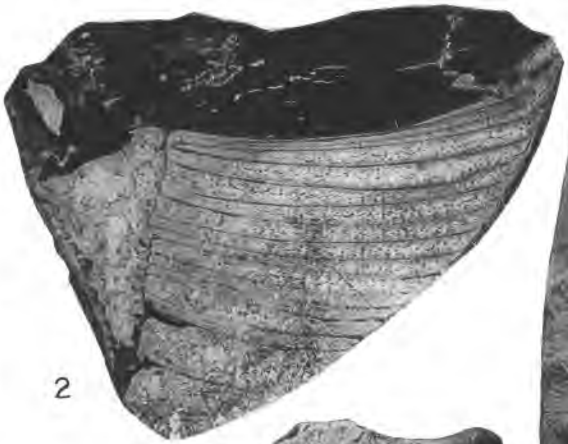
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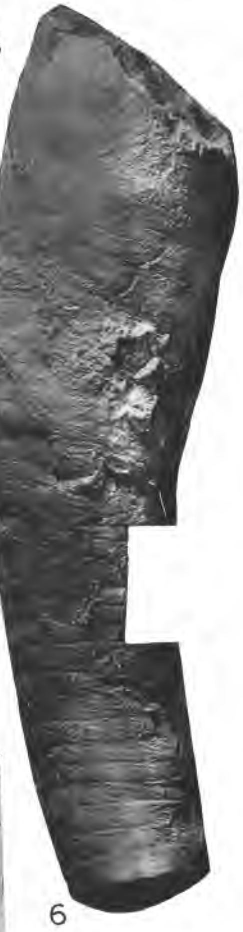
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PLATE 32

1-3. *Cyrtocerina madisonensis* (Miller) 138
1. Lateral view, × 1. 2. Thinsection from the same specimen, venter on left, × 2.5. 3. Enlargement, about × 16, of a portion of the ventral wall of the siphuncle, showing the thickening of the rings. University of Cincinnati Museum, from the Hitz layer, upper Whitewater, of Madison, Indiana.

4-5. *Cyrtocerina crenulata* Flower 138
Two views of the holotype, one of the larger species known of the genus, showing general aspect of the internal mold; 4. ventral view, with part of the siphuncle exposed; 5. lateral view, venter on left, U.S. National Museum No. 15696, from the Platteville limestone, Beloit, Wisconsin. Both × 1.

6-8. *Shideleroceras sinuatum* Flower 125
6. Lateral view of the holotype, dorsum on left; 7. dorsal view of holotype. Both × 1. 8. Horizontal longitudinal section ground from the ventral side of the holotype at midlength, exposing the tubular siphuncle and showing probably adventitious linear material within. The section was ground roughly, and details are unfortunately somewhat obscured. Shideler collection, Miami University, Oxford, Ohio, from the lower Whitewater of Ohio.

9-16. *Bathmoceras linnarsoni* Angelin and Lindstrom 138
Reproduction of the figures of Holm (1899) showing the general aspect and essential morphological features of the species and genus. 9. *B. linnarsoni,* Angelin's holotype, about × 0.5. 10, 11. Block diagrams of the siphuncle, after Holm, 10. viewed from the dorsal side, 11. viewed from the ventral side, showing the lobose extensions of the connecting rings. 12, 13. Two sections of the siphuncle showing the calcareous material lying between the lobes of the rings apparently springing from the tip of the septal necks, with the dark rings themselves obscure. 14. An interpretation of the preceding, showing the true rings as dark material, the lobed structures of Figs. 12 and 13 as calcareous material formed between the true rings. 15, 16. Two drawings showing the lobed extensions of the rings extending into the siphuncle cavity (after Holm, 1899).

17-20. *Bathmoceras praeposterum* Barrande 138
17. Ventral view of a living chamber with the anterior part of the phragmocone, showing the steep apparent saddles of the suture on the venter; sutures and anteriorly pointing rings are easily confused, but may be distinguished by the spacing here. 18. Ventral view of a specimen weathered and showing the chevronlike pattern produced by the extended rings. 19. Another, more fragmentary specimen showing the ventral part of the anterior portion of the phragmocone. 20. Cross section, from the base of the preceding, oriented with the venter and siphuncle above. All after Barrande (pl. 246) about three-fourths natural size.

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Numbers in **boldface** indicate main references